United States Department of the Interior

FISH AND WILDLIFE SERVICE
3761 Georgetown Road
Frankfort, Kentucky 40601

June 9, 2006

Mr. Jose Sepulveda
Division Administrator
Federal Highway Administration
330 West Broadway
Frankfort, Kentucky 40601

Subject: FWS #06-0466; Final Programmatic Biological Opinion on minor road construction projects in Kentucky and their effects on the Indiana Bat.

Dear Mr. Sepulveda:

This document sends the U.S. Fish and Wildlife Service's (Service) informal consultation and programmatic biological opinion based on our review of the U.S. Federal Highway Administration's (FHWA) proposed construction of minor road construction projects in Kentucky, implementation of the April 2006 Indiana Bat Habitat Assessment Manual (HAM), and their related effects on the Indiana bat (*Myotis sodalis*) under section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq*.). Your May 8, 2006, request for formal consultation was received on May 9, 2006.

This informal consultation and biological opinion is based on information provided in the April 2006 Biological Assessment (BA) and the April 2006 HAM for the Kentucky Transportation Cabinet (KYTC), meetings (see consultation history), other available literature, personal communications with experts on the federally listed species considered in this biological opinion, and other sources of information available to us and/or in our files. A complete administrative record of this consultation is on file at the Service's Kentucky Field Office in Frankfort, Kentucky.

Introduction

The FHWA and KYTC are proposing to address section 7 consultation issues related to the Indiana bat for minor road construction projects through the use of a 2-tiered programmatic approach. Tier 1 involves the use of the HAM to determine if habitat for Indiana bats is present within a proposed project site. If habitat is not present within a proposed project site (as determined by the process contained in Sections II, III, and Appendix A of the HAM), the project would be considered to have "no effect" on Indiana bats (Table 1). If potential summer roosting habitat is present within the proposed project site, but the habitat is marginal, project effects are discountable, or the habitat is unlikely to be occupied by Indiana bats (as determined by the process contained in Section IV and Appendix B of the HAM), the project effects would be considered "not likely to adversely effect" Indiana bats (Table 2). The process for making the

Table 1. **Species that were evaluated where a "no effect" determination was made for the proposed action.**

Scientific Name	Common Name	Listing Status	In Action Area	Not in Action Area
Myotis sodalis	Indiana bat	endangered	+	

Table 2. **Species that were evaluated where a "not likely to adversely affect" determination was made for the proposed action.**

Scientific Name	Common Name	Listing Status	In Action Area	Not in Action Area
Myotis sodalis	Indiana bat	endangered	+	

determinations in Tier 1 are provided in the HAM and are supported by information contained in the BA and HAM developed by the FHWA and KYTC. Tier 2 involves the use of this programmatic biological opinion to account for adverse effects to Indiana bats that may occur in association with proposed minor highway development projects where a "no effect" or "not likely to adversely effect" determination cannot be made during the project evaluations outlined in the Tier 1 analyses. This biological opinion would, thus, provide KYTC with a streamlined option for proceeding with the specific types of minor highway projects identified in the BA where it is probable that adverse effects are unavoidable.

The Service has reviewed the BA, HAM, and all of the supporting and supplemental information that evaluates the effects of the proposed action on the Indiana bat. This document represents our (a) concurrence with the effects determinations stated in the BA for the Indiana bat associated with the Tier 1 analysis; and (b) biological opinion on the effects of the proposed action on the Indiana bat associated with the Tier 2 analysis in accordance with Section 7 of the Act. The Indiana bat was the only species for which the FHWA made a "may affect - likely to adversely affect" determination.

According to the BA, Tier 1 review involves trained KYTC personnel utilizing the HAM to determine if any habitat for Indiana bats is present within a proposed project site. Sections I, II, and III of the HAM, respectively, provide: a) suitable Indiana bat habitat descriptions and examples; b) a specific list of projects that do not require alteration of Indiana habitat; and c) procedures for determining if a project requires the alteration of Indiana bat habitat. As determined by the aforementioned Tier 1 process, only those projects where no Indiana bat habitat was identified within the project site will be considered to have "no effect" on the Indiana bat. Upon this determination, KYTC personnel will document their finding by completing Appendix A of the HAM. Therefore, the Service concurs that projects that (a) are reviewed according to Sections II and III of the HAM and (b) lead to a documented "no effect" finding in Appendix A of the HAM will have no effect on the Indiana bat, because these projects will not involve the removal of Indiana bat habitat or result in other potential adverse effects. As a result, further consultation on these "no effect" projects is not necessary.

For those projects that do not meet the criteria for a "no effect", further analysis by trained KYTC personnel utilizing the HAM would be conducted to determine (a) if the habitat present within the project area is marginal and/or isolated and unlikely to be occupied by Indiana bats or (b) if project effects would be discountable or insignificant. This analysis would be conducted using Section IV and Appendix B of the HAM and was developed to identify those situations where the Service considers effects to not be reasonably likely to occur. As determined by the process in Tier 1, only those projects that meet the specific criteria in Section IV and Appendix B of the HAM will be considered to be "not likely to adversely affect" the Indiana bat. Upon this determination, KYTC personnel will document their finding by completing Appendix B of the HAM.

The Service has reviewed the process for making and documenting a "not likely to adversely affect" determination. Based on the information contained in the BA, HAM, and the other information on the Indiana bat that is available to the Service, the Service concurs with FHWA's determination for projects that are reviewed in accordance with Section IV of the HAM and that lead to a documented "not likely to adversely affect" finding for the Indiana bat in Appendix B of the HAM, because the potential adverse effects of these projects have been evaluated and meet the criteria of Section IV of the HAM. As a result, further consultation on these "not likely to adversely affect" projects is not necessary.

Based on this, the Service believes that the FHWA has fulfilled its section 7 consultation requirements relating to the implementation of the Tier 1 process. However, the FHWA's obligations under section 7 of the Act relative to the Indiana bat must be reconsidered for any "no effect" or "not likely to adversely affect determination" made under the HAM if (1) new information reveals impacts of the proposed action that may affect listed species or critical habitat in a manner not previously considered, (2) the proposed action is subsequently modified to include activities which were not considered during this consultation, or (3) new species are listed or critical habitat designated that might be affected by the proposed action.

Consultation History

January 2005	A meeting was held between the Service, FHWA, and KYTC to discuss Indiana bat issues and other options of satisfying Section 7 for small projects.
March 4, 2005	A meeting was held between the Service, FHWA, and KYTC to discuss Section 7 consultation process and the ability of action agencies to make "No Effect" determinations with consulting with the Service.
December 15, 2005	A meeting was held between the Service, FHWA, and KYTC. Discussions included ways to streamline the Section 7 process regarding Indiana bats and what would be required during a programmatic consultation process.
January 4, 2006	The Service sent a letter to KYTC and FHWA providing technical assistance on what information would be needed in a programmatic

	biological assessment that would support an Indiana bat programmatic biological opinion for transportation projects
March 23, 2006	A meeting was held between the Service, FHWA, and KYTC to discuss the need and development of a programmatic consultation to address Indiana bat issues.
March 31 thru May 8, 2006	The Service, FHWA, and KYTC worked to develop a Habitat Assessment Manual and Programmatic Biological Assessment. Several meetings were held in order to comment on the documents' contents, implementation, and provide revisions. Specific meeting dates and draft documents are on file in the administrative file located in the Service's Kentucky Field Office.
May 9, 2006	The Service receives a request from the FHWA, dated May 8, 2006, to initiate formal consultation on the proposed action. The FHWA's request includes the final BA dated March 31, 2005.
May 9, 2006	The Service sent a letter to the FHWA acknowledging that the FHWA's May 8, 2006, request for initiation of formal consultation was received, that the information contained in the BA and HAM was complete, and that formal consultation had been initiated.
May 25, 2006	The Service sent a Draft Biological Opinion (BO) to the FHWA for review via electronic mail.
June 6 & 7, 2006	The Service received comments regarding the draft BO from KYTC and FHWA.
June 7, 2006	The Service receives a request from KYTC via electronic mail to amend the formal initiation package to amend the HAM. This amendment was noted and has been reflected in this biological opinion.
June 9, 2006	The Service provided the FHWA with the Final Biological Opinion on the proposed action.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

As defined in the Service's section 7 regulations (50 CFR 402.02), "action" means "all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas." The "action area" is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The direct and indirect effects of the actions and activities must be considered in conjunction with the effects of other past and present Federal, State, or private activities, as well as the cumulative effects of reasonably certain future State or private activities within the action area. This biological opinion addresses only those actions for which the Service believes adverse effects may occur. In their BA, the FHWA outlined those activities associated with minor road construction projects that may result in adverse effects on the Indiana bat. This biological opinion addresses whether minor road construction projects and the implementation of Tier 2 of the programmatic analysis for these projects is likely to jeopardize the continued existence of the Indiana bat.

Project Area

The KYTC maintains and constructs a wide variety of transportation infrastructure needs within 120 counties in Kentucky that are identified and scheduled in a master plan occurring in six year increments. Project priorities and time schedules, within the six year plan, vary pending several factors (i.e., purpose, safety, funding, etc.). However, one factor remains consistant in that the proposed action area is located within the Commonwealth of Kentucky.

Kentucky is divided into six distinctive physiographic regions that include the Appalachian or Cumberland Plateau, Knobs, Bluegrass, Pennyroyal, Shawnee Hills, and the Coastal Plain. Mountain forests of the eastern Cumberland Plateau extend westward to the Knobs, Bluegrass and karst areas of the Pennyroyal of central Kentucky. The geography then turns into the hilly uplands of the Shawnee Hills, which finally reach the coastal plain of the Mississippi River known as the Jackson Purchase region of west Kentucky. A wide range of habitat types are found in Kentucky, including numerous wetlands and streams, deciduous and evergreen forests, karst and cave features, and prairie habitat.

Land use in Kentucky varies across the state and includes: agricultural farmland, livestock farmland, forest, streams and wetlands, residential, industrial, mining for natural resources, infrastructure, urban development, and others. Today, much of Kentucky's natural habitat has been disturbed; however, about 2,070,434 acres land has been conserved to be publicly managed fish and wildlife habitat. The remaining 95 percent of Kentucky remains privately owned and plays an important role in the overall landscape of Kentucky providing natural and semi-natural habitats to support wildlife diversity.

Proposed Action

The proposed action involves the construction of minor road projects within the Commonwealth of Kentucky. Appendix B of the BA includes a specific list and description of project types that are being considered as part of this action. Various steps are involved in the development of these types of projects, and these projects are conducted in phases that are tied directly to funding authorization. The phases used for project development are: Planning (P), Preliminary Design and Environmental (D), Right-of-Way (ROW), Utilities (U), and Construction (C). The type of funding source (state or federal) does not affect these phases of project development.

Project development phases do not necessarily apply to every project. For example, a Planning phase is typically reserved for those projects where a large number of solutions for a transportation need may be feasible. The Right-of-Way phase is only programmed where additional land acquisition or easements would be required to complete the work. Utilities phase is only necessary where relocation of existing utilities is required for construction. A complete description of each project phase is provided in the BA and is considered to be incorporated as part of the proposed action.

As stated previously, FHWA and KYTC have developed an Indiana bat HAM to support a two-tiered programmatic review process in order to address potential adverse effects on the Indiana bat that result from specific types and levels of transportation projects. A description of each tier of this process relating to the proposed action is provided below.

Tier 1 of the Programmatic Review Process

Tier 1 involves the use of the HAM during the preliminary design and environmental phase to determine if habitat for Indiana bats is present within a proposed project site. This process involves a Division of Environmental Analysis (DEA) biologist or District Environmental Coordinator(DEC) utilizing information available to them to determine if any Indiana bat summer or winter habitat exists within a proposed project area. If the DEA biologist or DEC determines that habitat is not present within a proposed project site (as determined by the process contained in Section II and III of the HAM), then the appropriate documentation would be prepared and the project would be considered to have "no effect" on Indiana bats. However, if habitat is present within the proposed project site, a DEA biologist or DEC would use the information necessary to conduct a further review. This additional review of the project by the DEA biologist or DEC would include the data used previously during the analysis in Section III of the HAM and the analysis contained in Section IV of the HAM. If the DEA biologist or DEC (whomever conducts the review) determines that the habitat is marginal, project effects are determined to be discountable, or the habitat is unlikely to be occupied by Indiana bats (as determined by the process contained in Section IV and Appendix B of the HAM), then the project is considered to "not likely to adversely effect" Indiana bats. The Service has reviewed and concurred with these effects determinations previously in this biological opinion; therefore, further consultation with the Service would not be required and section 7(a)(2) responsibilities for those projects would be fulfilled.

Two criteria within the Tier 1 review process would trigger additional informal consultation with the Service. These criteria are described in the HAM and involve situations where the proposed project may impact: a) occupied and/or potential Indiana bat wintering habitat (i.e., caves, mine adits, or other karst features exhibiting cave like characteristics) or b) a known Indiana bat maternity colony. If any of these two criteria exist during the review of a road construction project, then KYTC would follow the process contained in Section V of the HAM. The only exceptions would be for those projects found to have "no effect" on the Indiana bat. If it is determined by KYTC, as defined in Section V of the HAM, that a species survey is needed in order to determine if the project would result in adverse effects to the Indiana bat, then KYTC will coordinate the findings and effects determination for concurrence with the Service.

Tier 2 of the Programmatic Review Process

Tier 2 involves the use of this programmatic biological opinion to account for adverse effects to Indiana bats that are likely to occur and that do not result in a "no effect" or "not likely to adversely affect" determination under Tier 1. If KYTC determines that a species survey or other minimization factors are impractical for a project where it is probable that adverse effects to the Indiana bat could occur, then KYTC would use the incidental take provided in this biological opinion's incidental take statement to account for adverse affects to the Indiana bat. However, if a proposed project may impact Indiana bat wintering habitat (i.e., caves, mine adits, or other karst features exhibiting cave like characteristics) then a species survey and BA must be prepared for coordination with the Service. In other words, Tier 2 would only apply on specific projects that could affect Indiana bat summer habitat outside of the range of a known maternity colony and where no potential or occupied winter habitat occurs.

As discussed previously, if it is determined that a specific road project listed in Appendix B of the BA does not meet the criteria of Tier 1, then KYTC may account for adverse effects to Indiana bats by utilizing the incidental take provided in this programmatic biological opinion. However, impacts for road projects in Appendix B of the BA that exceed 25 acres of summer habitat removal would not be considered for authorization of incidental take. Projects of this scope would undergo analysis in Section V of the HAM and would be coordinated with the Service.

KYTC has analyzed project impacts from previous years to estimate Indiana bat summer habitat losses. There are about 1,500 projects in the KYTC Six Year Plan, an average of 250 projects per year. Of these projects, about 80 percent (200) are considered "small" projects that are sufficiently documented with a Categorical Exclusion during the NEPA process. It is estimated that as many as half of these projects will result in "no effect" or "not likely to adversely affect" determinations. Of the remaining projects (100), it is estimated that an average of five (5) acres of habitat removal may occur, resulting in a net habitat loss estimate of 500 acres in 2006. Based on this analysis, KYTC estimates that the amount of Indiana bat summer habitat loss in 2006 would not exceed 500 acres. It is anticipated that this projection would increase 20 percent each year for the remaining duration of the current six-year plan. At the end of the current six-year plan (FY 2010), KYTC's estimate of summer habitat losses would be reevaluated. Therefore, the amount of incidental take requested for the current six-year plan is 500 acres of Indiana bat summer habitat in FY 2006, 600 acres in FY 2007, 720 acres in FY 2008, 864 acres in FY 2009, 1,037 acres in FY 2010. The aforementioned figures will be based upon KYTC's Fiscal Year beginning July 1 through June 30.

In order to ensure the consideration of all direct, indirect, and cumulative effects of the proposed actions on the Indiana bat, the action area under consideration in this Biological Opinion will include those areas within the right-of-way disturbance limits for each proposed project, as described in Appendix B of the BA, within the Commonwealth of Kentucky. The Service has described the action area to include the previously described area for reasons that will be explained and discussed in the "EFFECTS OF THE ACTION" section of this consultation.

STATUS OF THE SPECIES/CRITICAL HABITAT

The Indiana bat was listed as an endangered species on March 11, 1967 (32 FR 4001), under the Endangered Species Preservation Act of October 15, 1966 (80 Stat. 926; 16 U.S.C. 668aa(c)). It is currently included as an endangered species under the Endangered Species Act of 1973, as amended. Critical habitat was designated on September 24, 1976 (41 FR 41914), and included caves in Kentucky, Tennessee, Illinois, Indiana, Missouri, and West Virginia. At the time of critical habitat designation, the Service estimated that about 75 percent of the known population of Indiana bats hibernated at the 13 sites that were designated as critical habitat. Since routine surveys began in 1980, populations of Indiana bats at hibernacula, including many of the previously designated critical habitat caves, have witnessed a significant decrease in numbers followed by recent stabilization and an increase over the last decade. No summer roosting habitat has been designated as critical habitat for the Indiana bat.

The primary objective of the 1980 Indiana Bat Recovery Plan is to remove the Indiana bat from endangered status. The important features of the recovery plan are: (A) to determine the cause(s) of observed declines during both non-hibernation and hibernation seasons, and (B) to control access to important Indiana bat hibernacula, thus protecting the bats from human disturbance. In addition, summer foraging habitat must be maintained, protected, and restored. Lastly, in order to evaluate the success of protection efforts, a monitoring program is needed to document changes in Indiana bat populations.

Criteria for reclassification from endangered to threatened status will be based upon the status of the Indiana bat throughout its range, as determined through a 12 year, two-stage process. The species will be evaluated for reclassification following documentation of stable or increasing populations for three consecutive census periods (six years) and permanent protection [i.e., public ownership or long- term easement/lease, and gate/fence (where necessary and feasible)] at all Priority One hibernacula. To delist, the above criteria must be met, in addition to protection and documentation of stable or increasing populations for three consecutive census periods at 50% of the Priority Two hibernacula in each state, and the overall population level must be restored to that of 1980. This level is believed to be sufficient to maintain enough genetic diversity to enable the species to persist over a large geographic area and avoid extinction.

The Service (USFWS 1999) completed an agency draft of a revised recovery plan for the Indiana bat. The recovery plan is being revised to: (A) update information on the life history and ecology of the Indiana bat, especially information on summer ecology gathered since 1983; (B) highlight the continued and accelerated decline of the species; (C) continue site protection and monitoring efforts at hibernacula; and (D) focus new recovery efforts toward research in determining the factor or factors causing population declines. The main recovery actions identified in the revised recovery plan are to:

1. Conduct research necessary for the survival and recovery of the Indiana bat.
2. Obtain information on population distribution, status, and trends for the Indiana bat.
3. Protect and maintain Indiana bat populations.
4. Provide information and technical assistance outreach.
5. Coordinate and implement the conservation and recovery of the Indiana bat.

To date, conservation efforts have concentrated on protection of winter habitat, although there has been some research into the life history of the Indiana bat. Active programs by state and federal agencies have led to the acquisition and protection of a number of Indiana bat hibernation caves. Of 127 caves/mines with populations greater than 100 bats, 54 (43%) are in public ownership or control. Most of the 46 (36%) that are gated or fenced are on public land. Given the divergent population trends throughout the range of the Indiana bat, however, it is evident that these measures have not yet produced the desired result of recovery of the species, although there has been some improvement in population numbers.

Threats

Indiana bats have been described as "once one of the most common mammals in the Eastern United States" (Tuttle et al 2004). Between 1960 and 2002, a 56 percent population decline has been documented (Clawson 2002; see below). A variety of factors have contributed to rangewide Indiana bat population decline including flooding and ceiling collapse in winter hibernacula (Service 1983). This often resulted in the adverse changes to the hibernaculum microclimate by affecting temperature and humidity. Other documented cases of Indiana bat declines include: (1) blocking cave entrances or installation of gates that do not allow for bat ingress and egress, or disrupt cave air flow; and (2) human disturbance during hibernation. These changes resulted in either die-off during hibernation due to freezing, or starvation as the higher temperatures increases the bats metabolism. This can result in the utilization of limited fat reserves that are required to survive hibernation and emergence in the spring. In this situation, the Indiana bat does not have the ability to awake from hibernation, leave the cave, forage for additional sustenance, and return to the cave to complete its hibernation cycle. It simply starves.

Because many known threats are associated with hibernation, protection of hibernacula has always been a management priority; however, disturbance to hibernacula continues to be a threat to the Indiana bat. For example, the largest hibernacula in Indiana (50,941 Indiana bats in 2003) is not gated, and based on electronic monitors in the cave, unauthorized visits to this cave occur. Also, at the only large hibernacula in Ohio (9,436 Indiana bats in 2004 – a decrease from the previous two counts), there are still tours, as well as other commercial and residential activities, taking place in and adjacent to the Lewisburg Limestone Mine during the hibernation period.

Despite the protection of about half of the known major hibernacula (Currie 2002), range-wide population declines continued until recent years when numbers of hibernating Indiana bats stabilized and then began showing an increase in numbers over the last few years. In the last fifteen years, appropriately constructed bat gates have been correctly installed in caves, allowing for protection of hibernating bats and restoration of the microclimate. Although most of these efforts were completed by 1990 and resulted in some recolonization of traditional hibernacula, there have not been corresponding overall population increases (Clawson 2002). Possible reasons for this are that the species' reproductive capacity will take much longer than 10-20 years to show population gains and/or other environmental factors continue to negatively affect the species.

Because of the migratory behavior of this species and other reasons described below, it is not prudent to differentiate between different geographical ranges with regard to wintering populations. The range-wide declines have led some to conclude that additional information on Indiana bat summer habitat is needed (3D/E 1995).

Land use practices have been identified as a suspected cause in the decline of the Indiana bat, particularly because habitat in the Indiana bats' maternity range has been changed dramatically from pre-settlement conditions in the following ways: the vast majority of mature forests have been harvested and remaining forests are fragmented to varying degrees; fires have been suppressed; prairies have been replaced with agricultural systems; native plants have been replaced with exotics; and diverse plant communities have been simplified. These changes can have profound effects through factors such as loss of suitable roosting habitat caused by the removal of large trees, and by a reduction of the diversity and abundance of insects on which the Indiana bats prey (Service 1983; Kurta and Murray 2002; Kurta et al. 2002; McCracken 1988; Racey and Entwistle 2003).

In addition to an increased focus on Indiana bat summer habitat, attention has also being directed to pesticide contamination (Clark et al. 1987; Clawson 1987; Garner and Gardner 1992; Callahan et al. 1997; 3D/E 1995; O'Shea and Clark 2002; Kurta and Murray 2002). Insecticides have been known or suspected as the cause of a number of bat die-offs in North America, including endangered gray bats in Missouri (Mohr 1972; Reidinger 1972; Clark and Prouty 1976; Clark et al. 1978). The insect diet and longevity of bats also exposes them to persistent organochlorine chemicals that may bioaccumulate in body tissue; however the use of organochlorine insecticides has decreased over the last 20 years (O'Shea and Clark 2002).

Summary - In general terms, the overall population decline of the Indiana bat is the result of mortality exceeding recruitment (i.e., deaths are outpacing recruitment). The specific reasons for this dynamic remain unknown. However, it is likely that higher mortality rates occur during migration and hibernation due to the energy demands of these events than during routine foraging and roosting activities in summer habitat.

Loss of breeding females can occur at any point in the annual cycle of hibernation, spring migration, parturition, lactation, fall migration, mating, and hibernation. Healthy females are capable of producing only one pup per year. At some point(s) in this annual cycle, the species experienced higher mortality rates or lower recruitment than it did historically, causing the species' population to decline steadily (i.e., a 19 percent decline was noted between 1990 and 2000). The vulnerable point(s) in this cycle may very well differ by geographic area, and even within the same area. Ransome (1990) further identifies the limiting factors that control overall bat population as the number of maternity colonies and the proximity and quality of foraging areas surrounding each maternity site. He also concludes that a reduction in the number of maternity colonies contributing to a hibernaculum is a prime factor that should be considered when evaluating the causes of population declines in bats. The number of bats found in individual caves is regulated by the number and sizes of maternity colonies that contribute to those caves (Ransome 1990). MacGregor (Service 2005) clarifies that many other factors affect cave populations. Unless a change in these environments occurs to allow recruitment to exceed mortality, the species will decline.

Distribution
The Indiana bat is a migratory species whose range encompasses much of the eastern half of the United States. As of January 2001, the Indiana bat had been recorded in 311 counties, scattered across 27 states (Gardner and Cook 2002). Preliminary genetic studies indicate that, the species appears genetically uniform throughout its range with the exception of New York and Vermont (Bob Currie, personal communication, Service). The winter/summer populations in Vermont and New York appear to be isolated in that the majority of individuals followed from hibernacula appear to be migrating short distances to establish maternity colonies in close proximity to the hibernacula. Elsewhere throughout the range, rather than one large meta-population, the Indiana bat functions as hundreds or thousands of smaller sub-populations. Because mating takes place randomly at the hibernaculum during fall swarming, genetic exchange is a result of the contribution of many smaller populations, or maternity colonies, congregating at one hibernaculum (Service 1999b).

The distribution of Indiana bats is generally associated with limestone caves in the eastern U.S. (Menzel et al. 2001). Within this range, the bats occupy two distinct types of habitat. During winter, the Indiana bat hibernates in caves (and occasionally mines) referred to as hibernacula. Less is known about the abundance and distribution of the species during the summer maternity season, and even less is known about its migratory habits and associated range.

Indiana Bat Population Status
Due to the colonial nature of Indiana bats, conducting censuses of hibernating bats is the most reliable method of tracking population/distribution trends range-wide, and provides a good representation of the overall population status and distribution. As such, winter distribution of the Indiana bat is well documented.

For several reasons, interpretation of the census data must be made with caution. First, winter census data is broken down by state due to the nature of the data collection. As described below, each state does not represent a discrete population center. Nevertheless, the range-wide population status of the Indiana bat has been organized by state. Second, as will be further discussed, available information specific to the "reproductive unit" (i.e., maternity colony) of the Indiana bat is limited. While winter distribution of the Indiana bat is well documented, little is known as to the size, location and number of maternity colonies for the Indiana bat. As described below, it is estimated that the location of about 90 percent of the maternity colonies are unknown.

Additionally, the relationship between wintering populations and summering populations is not clearly understood. For example, while it is known that individuals of a particular maternity colony come from one to many different hibernacula, the source (hibernacula) of most, if any, of the individuals in a maternity colony is not known. As discussed in the "Spring Emergence/Migration" section, Indiana bats have been documented to travel up to 300 miles from their hibernaculum to their maternity areas (Gardner and Cook 2002).

Range-wide Hibernacula Censuses
Based on the 2005 winter census, Indiana has four Priority I hibernacula and Kentucky and Missouri each contain three Priority I hibernacula. Priority II hibernacula are known from the

aforementioned states, in addition to Arkansas, Illinois, New York, Ohio, Tennessee, Virginia, and West Virginia. Priority III hibernacula have been reported in 17 states, including all of the aforementioned states. In the 2005 hibernacula census, the total known Indiana bat population was 458,332, down from about 880,000 bats in 1960 (Table 3), and about half of these hibernated in eight Priority I hibernacula (excluding Dixon Cave, Kentucky, which did not reach the Priority I threshold) (King, personal communication, 2005). Censuses began in the late 1950s, and since then many winter counts have decreased, especially in Kentucky and Missouri. Overall, the population has declined 48 percent since the 1960s (King, personal communication 2005). Caves in Kentucky suffered dramatic losses because of changes in microclimate due to poor cave gate design in two of the three most important hibernacula (Humphrey 1978), and Indiana bat numbers in Kentucky hibernacula continued to decline until 2005 when a increase was observed (King, personal communication 2005). Despite recovery efforts, Indiana bats in Missouri caves have declined with a loss of more than 80 percent of the population (Clawson 2002). The ten-year population trend of the Indiana bat has steadily declined (Table 3). It should be noted that the results of winter hibernacula censuses completed in 2001, 2003, and 2005 all have shown population increases. Therefore, the 2000-2010 trend may represent an improvement in the range-wide population.

Table 3. Ten-year, range-wide population trend for the Indiana bat.

Approximate Time Period	Population Estimate	Approximate Percent Change
1960 – 1970	883,300	N/A
1980	678,750	-23
1980 – 1990	473,350	-30
1990 – 2000	382,350	-19

Although slight increases in 2001 and 2003, as well as the more substantial 2005 increase was seen in the range-wide population, we are hesitant, at this time, to extrapolate long-term trends from changes between individual survey periods, because the species' reproductive capacity may take longer than 10-20 years to show sustained population gains. Also, small fluctuations from year-to-year may be attributed to such factors as weather affecting the success of reproduction for a given year (Humphrey et al. 1977; Ransome 1990).

One known major cause of Indiana bat decline has been human disturbance and vandalism of hibernating bats during the decades of the 1960s through 1980s. Some hibernacula have been rendered unavailable to Indiana bats by erection of solid gates in the entrances (Humphrey 1978). Although some hibernacula have been restored in order to support future wintering populations, and Indiana bats have returned to traditional hibernation sites, in some cases, population gains have not yet materialized. It appears that by the 1990s, vandalism and improper installation of cave gates had been reduced. Despite these efforts to reduce threats and restore traditional hibernacula, the range-wide population of Indiana bats continues to be well-below historic levels with only recent signs of stabilization or population increases. A hypothesis for documented early population declines is that warmer winter temperatures have resulted in less conducive microhabitat conditions (warmer temperatures) at hibernacula, particularly in the southern part of the species range (Rick Clawson, personal communication, Missouri Department of Conservation).

Range-wide Maternity Colony Information
Early researchers considered floodplain and riparian forest to be the primary maternity roosting and foraging habitats for the Indiana bat, and these forest types unquestionably are important (Humphrey et al. 1977). More recently, Indiana bats have been shown to use upland forests for maternity roosting (Clark et al. 1987; Gardner et al. 1991b; Callahan et al. 1997; Kiser et al. 2002; Apogee 2003); and upland forest, old fields, and pastures with scattered trees have been shown to provide maternity foraging habitat (Gardner et al.1991b).

The first Indiana bat maternity colony found was in the Midwest region. As a result, the majority of studies of maternity colonies and their associated habitats have been conducted in glaciated regions of the Midwest region (southern Iowa, northern Missouri, northern Illinois, northern Indiana, and southern Michigan). Remaining woodlands in this glaciated region are mostly fragmented with small bottomland and upland forested tracts of predominantly oak-hickory forest types and riparian/bottomland forests of elm-ash-cottonwood associations. These forested areas exist in an otherwise agricultural dominated (non-forested) landscape (Forest Service 1997). Nevertheless, the small amount of forested area in this region appears to have a relatively high density of maternity colonies, especially when compared to the unglaciated forested landscapes similar to the action area. While the majority of maternity colonies have been discovered in the glaciated areas of the Midwest, some have been discovered as far northeast as Vermont's Lake Champlain valley and as far south as the Cherokee and Nantahala National Forests in eastern Tennessee and western North Carolina, respectively.

Despite the large expanse of forested habitat in the unglaciated portions of the Midwest (southern Missouri, southern Illinois, southern Indiana, and southern Ohio), Kentucky and most of the eastern and southern portions of the species' range (including Pennsylvania and West Virginia) appears to have fewer maternity colonies per unit area of forest. However, such conclusions may be premature, given the lack of search effort and large areas of forested habitat in these areas. The recent discovery of maternity colonies in these areas has led to expanded search efforts and habitat studies.

Based on published literature and correspondence with Service or State biologists throughout the range of the Indiana bat, maternity activity has been documented at about 225-250 locations throughout the species' range (Table 4) (Service 2004). The majority of confirmed maternity areas are in the "core" of the range, in the glaciated Midwest in pockets of remaining forested habitat within a predominantly agricultural landscape in close proximity to known hibernacula. Because the Indiana bat is philopatric, there is no evidence to suggest that maternity colonies are located in optimal foraging and roosting habitat. A possible explanation for the species' decline is that existing maternity colonies are senescent (i.e. recruitment < death). This could be caused by pups being produced but not surviving their first hibernation period; or maternity areas are no longer providing a sufficient supply of suitable prey, resulting in an increase in the age of first reproduction and increasing fecundity schedules. Proof of at least several years of successful reproduction and recruitment would be needed to verify long-term survival of the Indiana bat in these highly altered and fragmented landscapes. Although data at a few maternity sites indicate

Table 4. **Documented Indiana bat maternity areas (or maternity activity).**

STATE	NUMBER OF MATERNITY COLONIES[1]
Illinois	38
Indiana	83
Iowa	21
Kentucky	31
Michigan	10
Missouri	17
Ohio	9
Pennsylvania	1
New Jersey	1
North Carolina / Tennessee	5
Vermont / New York	7
Virginia	1
West Virginia	2
TOTAL	**218 (227-252)**

[1] Estimates are based on the capture of a reproductive female or juveniles in a discrete area during the maternity season (15 May – 15 August), or telemetry tracking reproductive females from hibernacula to maternity roost sites. This number is based on correspondence through the 2003 field season. In order to allow for new maternity colonies discovered in 2004, it is assumed that approximately 227-252 maternity colonies have been discovered.

that reproduction is occurring (exit counts nearly double a month after birth), long term monitoring of maternity sites is limited. Long term monitoring has been conducted at a maternity colony located near the Indianapolis Airport (Indianapolis Airport Authority 2003; Indianapolis Airport Authority 2004). This colony continues to persist, and shows evidence of reproduction, although additional monitoring is needed to make a determination regarding whether the colony is stable, increasing, or decreasing at this site.

Monitoring data, including extensive exit counts to estimate maternity colony population size and structure over more than one-year, is available for only a few of the maternity colonies discovered (Humphrey et al. 1977; Garner and Gardner 1992; Callahan 1993; Gardner et al. 1991b; Kurta et al. 1996; Indianapolis Airport Authority 2003; Indianapolis Airport Authority 2004). Additionally, because the vast majority of the Indiana bat maternity colonies have not been discovered, let alone studied, what little demographic data that is available, represent a fraction of the range-wide maternity activity.

Because so little is known regarding the population size and structure of maternity colonies, the Service used the same assumption as Whitaker and Brack (2002) to determine the average maternity colony size to give an approximation of the number of potential maternity colonies range-wide for the Indiana bat. The Service recognizes that maternity colonies are not static in size, and the numbers of individuals that comprise a maternity colony likely vary widely as a colony adjusts to current conditions, including the availability and quality of roosting and foraging habitat, and variable climatic conditions. Therefore, these figures should not be used to make extrapolations regarding the densities or distribution of maternity colonies present within portions of the species range (Racey and Entwistle 2003); however, these figures do serve to provide a rough estimation regarding the number of maternity colonies that might be present across the landscape. The "Maternity Colony Size – Population" section found in the "Life History" section of this biological opinion provides more information with regard to the size of a maternity colony.

Recognizing the inherent deficiency in such an assumption, these calculations illustrate that the vast majority of maternity colonies for the Indiana bat have not been documented (Table 5). The location of most maternity colonies may always remain unknown because of the difficulty in detecting maternity activity for the Indiana bat. This places these colonies at risk when land use practices, such as timber harvesting and development, are carried out. Therefore, another possible cause for the decline of this species and the level of activity occurring across the landscape is that maternity colonies are being reduced in numbers, and in some cases extirpated, prior to their discovery.

Table 5. Estimated number of Indiana bat maternity colonies range-wide.

YEAR HIBERNATING	POPULATION	PERCENT CHANGE	NUMBER OF MATERNITY COLONIES[1]	NUMBER OF KNOWN MATERNITY AREAS[2]	PERCENT OF KNOWN MATERNITY COLONIES
1960/1970	883,300		5,500	-	-
~1980	678,750	-23	4,200	-	-
~1990	473,550	-31	2,900	-	-
2003/2004	388,829	-18	2,400	~ 227-252	~10

[1] Total rounded to the nearest 100. Estimates of the number of maternity colonies range-wide (Table 5) were developed based on the following assumptions: 1) the known hibernating population is the source of the entire summer population; 2) there is a 50:50 sex ratio (Humphrey et al. 1977); 3) average maternity colony size of 80 adult females (Whitaker and Brack 2002); and 4) the trend in decline of the total number of maternity colonies follows that of the hibernating population.

[2] This is the number of areas where reproductive females have been captured during the maternity season.

Indiana Bat Status in Kentucky

Several documented as well as other unverified Indiana bat records exist for the last 60 years in Kentucky. According to records available to the Service, the Indiana bat has been documented from 53 counties distributed throughout the Commonwealth. Summer habitat for the species is found throughout Kentucky. Two of the eleven caves, range-wide, that are designated as Critical Habitat for the Indiana bat occur in Kentucky [Bat Cave (Carter County) and Coach Cave (Edmonson County)]. In addition to these caves, Dixon Cave (Edmonson County) is also listed as a Priority I hibernacula (> 30,000 individuals). There are also 21 Priority II hibernacula (> 500 but < 30,000 individuals) and 78 Priority III hibernacula (< 500 individuals) documented from the Commonwealth.

Historic hibernating population levels within Kentucky were estimated to be at 241,335 individuals in the Agency Draft Indiana Bat Revised Recovery Plan (USFWS 1999). Between 1960 and 1975, Kentucky had the greatest Indiana bat hibernating population decline among the states, an estimated 145,000 bats. Losses were attributable to exclusion and changes in microclimate at two of the three most important hibernation sites; most were caused by poorly designed cave gates (Humphrey 1978) and by construction of a building over the upper entrance to one of the hibernacula (John MacGregor, pers. comm., October 1996). Although not as dramatic as earlier losses, many of the most important remaining hibernating populations declined steadily from 1980 to 2003. However, hibernacula survey data from 2005 indicate that things may be improving. The winter of 2005 saw population numbers of hibernating Indiana bats increase from 41,498 in 2003 to 63,339.

<u>Previous Incidental Take Authorizations</u>
Summary- All previously issued Service biological opinions involving the Indiana bat have been non-jeopardy. These formal consultations (about 20-25) have involved (a) the Forest Service for activities implemented under various Land and Resource Management Plans on National Forests in the eastern United States (50-75%), (b) the Federal Highway Administration for various transportation projects (10-15%), (c) the Corps for various water-related projects (5-10%), and (d) the Department of Defense for operations at several different military installations (20-30%). Additionally, an incidental take permit has been issued under section 10 of the Endangered Species Act to an Interagency Taskforce for expansion and related development at the Indianapolis Airport in conjunction with the implementation of a Habitat Conservation Plan.

National Forests- Within the past several years, nearly all National Forests within the range of the Indiana bat have requested formal consultation in order to receive incidental take statements. This has been a result of uncertainty due to agency inability to discount the chance of take of the Indiana bat as a result of forest management activities during the non-hibernation period. Consequently, the Service has prepared non-jeopardy biological opinions and issued incidental take statements for at least fifteen different National Forests throughout the species' range. Despite incidental take authorization for these National Forests, the confirmed loss of a maternity colony on a National Forest has never been authorized because effects to known maternity colonies have been avoided. These opinions analyzed continued implementation of each of the respective forest's Land and Resource Management Plans at the programmatic level. This established the framework to undergo formal consultation more efficiently at the project level.

Over 95 percent of previously authorized habitat loss on National Forests is not permanent loss. Rather, it is varying degrees of temporary loss (short-term and long-term) as a result of timber management activities. The analysis found in the Service's biological opinion for forest management and other activities authorized, funded, or carried out by the Mark Twain National Forest provides a thorough analysis as to the expected impacts on the Indiana bat on several different National Forests (Service 1999a). Although this analysis does not include all National Forests that, to date, have received an incidental take statement, the concepts of the analysis are consistent, regardless of the location. Conservation measures provided by the USFS as part of the proposed action, as well as reasonable and prudent measures provided by the Service to minimize the impact of the annual allowable take for each of the National Forests, have been designed to: (1) ensure an abundance of available remaining Indiana bat roosting and foraging habitat on all National Forests; and (2) ensure persistence of any known or newly discovered maternity colonies to the maximum extent practicable.

Although Indiana bat presence has been verified on most, if not all, National Forests within the range of the species, confirmation of maternity activity on these lands is scant. There have been less than five maternity colonies documented on National Forests. It must be noted that maternity activity was confirmed for the first time on two national forests (Monongahela National Forest [West Virginia] and Hoosier [Indiana]) in 2004. Incidental take has been authorized in the form of habitat loss because of the difficulty of detecting and quantifying take of the Indiana bat due to the bat's small body size, widely dispersed individuals under loose bark or in cavities of trees, and unknown spatial extent and density of their summer roosting population range within the respective National Forests. For some incidental take statements, take has also been extrapolated to include an estimated number of individual Indiana bats. The estimate of the number of individual Indiana bats likely to be incidentally taken has been wide-ranging and based on various assumptions. Legal coverage has included the incidental take, by kill, of individual Indiana bats; or incidental take, by harm through habitat loss, or harassment.

Other Federal Agencies or Non-federal Entities- Several incidental take statements (e.g., construction of a reservoir involving the Corps in Marion, Illinois [Service 1995]; Fort Knox military operations [Service 1999c]; Camp Atterbury military operations [Service 1998]; Newport Military Installation [Service 1999d]; I-69 Highway [Service 2003]) and an incidental take permit (e.g. Six Points Road Interchange) have been issued to other federal agencies and a non-federal entity, respectively. These projects involved impacts to known maternity colonies - at least one known maternity colony within the action area of the project. For these projects (with the exception of Fort Knox; see below), conservation measures, included as part of the proposed action, were designed to minimize impacts to the colony with the goal of ensuring persistence of the colony after implementation of the project. These measures included: seasonal clearing restrictions to avoid disturbing female Indiana bats and young; protection of all known primary and alternate roost trees with an appropriate buffer; retention of adequate roosting and foraging habitat to sustain the maternity colony into the future; and permanent protection of areas and habitat enhancement or creation measures to provide future roosting and foraging habitat opportunities.

With the exception of Fort Knox, none of these biological opinions and associated incidental take statements has authorized the loss of a maternity colony. There are three examples in Indiana (Camp Atterbury, Newport Military Installation, and Indianapolis Airport) where monitoring has confirmed that the colony persisted through the life of the project and continues to exist today, and recent unpublished information at Fort Knox appears to indicate that the maternity colony there has also persisted. However, the full extent of the anticipated impacts may not yet have occurred and overall effect on this maternity colony are difficult to discern. While several other biological opinions have been prepared with the same ultimate goal of maintaining colony persistence, project implementation is not complete. The Fort Knox biological opinion [1999c] did authorize the loss of two potential maternity colonies and 8 Indiana bats, although Indiana bat maternity activity had not been confirmed in the action area. In subsequent surveys, maternity activity was confirmed in two different areas at Fort Knox. The biological opinion did not specify whether the "take" consisted of loss of the colonies or take in the form of harm and harassment.[1] The Army prepared a biological assessment (BA) that outlined that known roost trees would be cut and bats would be displaced from the habitat. The BA also proposed conservation measures that included seasonal clearing restrictions to avoid disturbing female Indiana bats and young; retention of some known roost trees; maintaining riparian buffer zones around waterways; creation and retention of snags; permanent protection of adjacent areas to provide sufficient habitat to support Indiana bat foraging and roosting; and monitoring of colonies in the area. However, the Service has been unable to locate any records of monitoring being conducted after construction of the project.

INDIANA BAT LIFE HISTORY

Colonial roosting behavior and site fidelity are two important features of Indiana bat behavioral biology to consider when analyzing the effects of the modification of assumed summer and maternity Indiana bat habitat. These behaviors are believed to improve Indiana bat reproduction success by improving survivorship of the young (i.e., females are capable of producing only one pup per year even under ideal circumstances).

Indiana bats exhibit colonial behaviors in nearly every stage of their life history. Such colonial traits may substantially affect both survival and productivity. Maintenance of functional colonies with relatively large numbers of bats may be critical to thermoregulation at both the hibernaculum and the maternity colony. It is probable that bat aggregation during winter hibernation helps minimize the metabolic cost of thermoregulation during hibernation. Another colonial aspect to clustering behavior occurs when the same individuals return yearly to not only the same cave, but often to the same discrete area of the cave ceiling (MacGregor, personal communication, 2005). During work in Indiana at a major Indiana bat hibernacula, towards the end of the hibernation season, several bats appeared to warm up just long enough to move to the nearest cluster when the departure of their cohorts left them alone. Swarming prior to hibernation may play a role in the detection and/or attraction of mates, so that low numbers of Indiana bats result in lower rates of successful mating even at mixed-species hibernacula where overall bat numbers (all species) are sufficient for thermoregulation. Migration for any species is considered to be a vulnerable life stage. The Indiana bat is no exception, particularly: in the spring when fat reserves are low; over long distances; or for juveniles migrating for the first time in the fall. While it is not known, successful migration for the Indiana bat may depend on large numbers of conspecifics using the same routes at the same time.

Reproductively active females return to and congregate at maternity colonies to give birth and raise their young. While very little is known about the potential social structure of these colonies, these groupings may allow for better thermoregulation, predator avoidance, and foraging efficiency. Research has shown that members of the colony may communicate regarding foraging areas (Murray and Kurta 2004). Thermoregulation provides a physiological advantage to the raising of a pup. When lactating adult female Indiana bats and pups congregate, both expend less energy. Therefore, more energy can be expended on nurturing the pups and enabling their young to achieve maturity faster.

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[1] "Harm" in the definition of "take" in the Act means an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. "Harass" in the definition of take means an intentional or negligent act or omission which creates the likelihood of injury to wildlife annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.

Site fidelity to summer habitat has also been documented in male Indiana bats in eastern Kentucky. Two studies (Gumbert 2001, Gumbert et al. 2002) observed site fidelity in males for roost trees (primary and alternate areas) and foraging areas. Social interaction between males was also documented from these studies.

Life Cycles

The Indiana bat's annual life cycle consists of hibernation, spring migration, birthing (parturition), raising of young by females (lactation), fall migration, mating (swarming), and hibernation. Each of these critical stages in this annual cycle is integral to species survival and recovery (See Appendix E). While the following information provides a general overview of the life cycle of the Indiana bat, the "Life Stages" section provides additional information.

During winter, Indiana bats are restricted to suitable hibernacula (mostly caves, but also a few abandoned mines, and even a tunnel and hydroelectric dam) that are located primarily in karst areas of the east-central United States. Hibernation facilitates survival during winter when prey (i.e., insects) are unavailable. Indiana bats cluster and hibernate on cave ceilings in densities of about 300-484 bats per square foot. Clusters may protect central individuals from temperature change and reduce sensitivity to disturbance.

During spring, Indiana bats emerge from hibernacula and move to their summer habitat. Females can migrate hundreds of miles from their hibernacula. Kurta and Murray (2002) documented female Indiana bats migrating over 200 miles from their hibernacula to their maternity area and Gardner and Cook (2002) documented migratory distances in excess of 300 miles for females traveling from hibernacula to maternity areas. Some male Indiana bats have been documented to remain near hibernacula throughout the summer, while other males have been captured throughout various summer habitats. Female bats from different hibernacula are known to navigate to maternity sites (Kurta and Murray 2002), at least in part by physical cues on the landscape. Several species of North American bats, including the Indiana bat, show high fidelity to maternity roosts (Kurta and Murray 2002). Females form maternity colonies with other females to give birth and raise young. Migration is stressful for pregnant Indiana bats when their fat reserves and food supplies are low. In the northeastern part of their range, female Indiana bats may migrate shorter distances in order to maximize energy reserves by arriving at their summer habitat quickly.

After grouping into maternity colonies, females give birth to a single young in June or early July (Easterla and Watkins 1969, Humphrey et al. 1977). As will be further discussed, colonial behavior is well documented for females at maternity colonies. This life history strategy reduces thermoregulatory costs, which, in turn increases the amount of energy available for birthing and the raising of young (Barclay and Harder 2003). Studies by Belwood (2002) show asynchronous births among members of a colony. This results in great variation in size of juveniles (newborn to almost adult size young) in the same colony. In Indiana, lactating females have been recorded from June 10 to July 29 (Whitaker and Brack 2002). Young Indiana bats are capable of flight within a month of birth. Young born in early June may be flying as early as the first week of July (Clark et al. 1987), others from mid- to late July.

Indiana bats begin to return to their respective hibernacula as early as August. Females from the same maternity colony do not necessarily go to the same hibernaculum. Breeding takes place and fat reserves are replenished as bats congregate at hibernacula and prepare for hibernation. A particular ratio of fat to lean mass is normally necessary for puberty and the maintenance of female reproductive activity in mammals (Racey 1982). Racey (1982) suggests that the variation in the age of puberty in bats is due to nutritional factors, possibly resulting from the late birth of young and their failure to achieve threshold body weight in their first autumn. Additionally, once puberty is achieved, reproductive rates frequently reach 100 percent among healthy bats of the family Vespertilionidae, as is the Indiana bat (Racey 1982). Limited data suggest that young, healthy female bats can mate in their first autumn so long as their prey base is sufficient to allow them to reach a particular fat to lean mass ratio (Racey 1982). Limited mating activity occurs throughout the winter and in late April as the bats leave hibernation (Hall 1962).

General Roosting Behavior

While roosting behavior specific to the various life stages of the Indiana bat is discussed in the "Maternity colony – roost tree selection" section, the following information provides a general overview of Indiana bat roosting behavior. Within the range of the species, the existence of Indiana bats in a particular area may be governed by the availability of natural roost structures, primarily standing dead or live trees with loose bark (Carter 2003; Kurta et al. 2002; Kurta et al. 1993a; 3D/E 1995; Gardner et al 1991b). The suitability of any tree as a roost site is determined by: (1) its condition (dead or alive); (2) the quantity of loose bark; (3) the tree's solar exposure and location in relation to other trees; and (4) the tree's spatial relationship to water sources and foraging areas. Indiana bats use interstitial spaces within trees, or parts of trees as roost sites. For example, the following have been documented as providing roosts for Indiana bats: tree cavities or hollow portions of tree boles (Gardner et al. 1991a; Kurta et al. 1993b); a crevice in the top of a lightning-struck tree (Gardner et al. 1991a); and splits below splintered, broken tree tops (Kurta, et al. 1996; Callahan et al. 1997; Gardner et al. 1991b; Garner and Gardner 1992). Morphological characteristics of the bark of a number of trees make them suitable as roosts for Indiana bats; that is, when dead, senescent, or severely injured (e.g., lightning-struck) the trees possess bark that springs away from the trunk upon drying. Additionally, the shaggy bark of some living hickories (*Carya* spp.) and large white oaks (*Quercus alba*) also provide roost sites. The most important characteristics of trees that provide roosts are not species but structure: exfoliating bark with space for bats to roost between the bark and the bole of the tree. The length of persistence of peeling bark varies with the species of tree and the severity of environmental factors to which it is subjected. Tree species reported to be used as roosts by Indiana bats include, but are not limited to: American beech (*Fagus grandifolia*), ashes (*Fraxinus* spp.), black gum (*Nyssa sylvatica*), black locust (*Robinia pseudo-acacia*), cottonwood (*Populus deltoides*), elms (*Ulmus* spp.), hickories, maples (*Acer* spp.), oaks (*Quercus* spp.), pines (*Pinus* spp.), sassafras (*Sassafras albidum*), sourwood (*Oxydendrum arboreum*), sweet birch (*Betula lenta*), and yellow buckeye (*Aesculus octandra*) (Cope et al. 1978; Humphrey et al. 1977; Gardner et al. 1991a, b; Garner and Gardner 1992; Kurta et al. 1993a; 3D/E 1995; Kiser and Elliott 1996; Kurta et al. 1996; Callahan et al. 1997).

General Foraging Behavior

While foraging behavior specific to the various life stages of the Indiana bat is discussed in the "Non-reproductive females and males" and "Maternity Colony foraging behavior" sections, the following information provides a general overview of Indiana bat foraging behavior. Because most Indiana bats caught in mist-nets are captured over streams and other flyways at heights greater than 6 ft (2 m) (Gardner et al. 1989), it is believed that Indiana bats usually forage and fly within an air space from 6 - 100 ft (2 - 30 m) above ground level (Humphrey et al. 1977). Indiana bats feed solely on flying insects (Brack and LaVal 1985; Kurta and Whitaker 1998; Belwood 1979; Service 1983). They are habitat generalists and their selection of prey items reflects the environment in which they forage (LaVal and LaVal 1980). Because of the large and variable distribution of the Indiana bat (Gardner and Cook 2002; Brack et al. 2002), it is not surprising that differences in foraging habitat have been recorded between different parts of the summer range, or between bats on the maternity range and near hibernacula.

For example, in the southern part of the range, terrestrial-based prey (moths and beetles) are more common in the limited number of dietary studies completed. This may be a result of Indiana bats predominantly foraging near treetops in these areas (Brack and LaVal 1985). However, none of the data collected to date was collected during peak emergence periods for aquatic insects in Appalachia. Thus, it would be inappropriate to infer that Indiana bats in the southern part of their range would not select for aquatic insects during the peak summer activity period when temperatures are greater than 60° F. In the northern region where foraging areas are more limited to riparian zones, aquatic-based prey are dominant in the diet. Diet varies seasonally and variation is observed among different ages, sexes, and reproductive-status groups (Belwood 1979). It is probable that Indiana bats use a combination of both selective and opportunistic feeding to their advantage (Brack and LaVal 1985). Reproductively active females and juveniles exhibit greater dietary diversity than males and non-reproductively active adult females, perhaps due to higher energy demands. Studies in some areas have found that reproductively active females eat more aquatic insects than do juveniles or adult males (Kurta and Whitaker 1998), this may be the result of habitat differences (Brack and LaVal 1985).

Differences in habitat availability and competition with other species may be two explanations for such seasonal or geographic differences in selection of foraging habitat (Sparks el al. in press). Preliminary analysis of data collected in Pennsylvania (Butchkoski and Hassinger 2002), Missouri (Romme' et al. 2002), and Indiana (Sparks et al. in press) show no clear association between size of foraging area and sex, age, or reproductive class (Sparks et al. in press). Indiana bats show fidelity to foraging areas between years by bats in different reproductive classes (Sparks et al. in press).

Moths (Lepidoptera) are major prey items identified in several studies (Belwood 1979; LaVal and LaVal 1980; Brack and LaVal 1985), but caddisflies (Trichoptera) and flies (Diptera) are also documented (Kurta and Whitaker 1998). A fourth major prey group includes mosquitoes and midges (Belwood 1979; Whitaker 2004), especially species that form large mating aggregations above or near water (Belwood 1979). Other prey include bees, wasps, and flying ants (Hymenoptera), beetles (Coleoptera), leafhoppers (Homoptera), treehoppers (Homoptera), stoneflies (Plecoptera), and lacewings (Neuroptera) (Whitaker 1972; Belwood 1979; Whitaker 2004). Caddisflies are irregularly available, but are apparently highly desirable for many bat species, because they appear to be preferentially eaten when available (Whitaker 2004). This trend may also be true of other aquatic insects that have concentrated emergences. Brack and

LaVal (1985) examined fecal pellets of 140 male Indiana bats and identified 83 percent of the prey items from taxa from the genera Lepidoptera and seven percent as Coleoptera.
Drinking water is essential when bats actively forage. Throughout most of the summer range, Indiana bats frequently forage along riparian corridors and obtain water from streams. However, natural and anthropogenic ponds and water-filled road ruts in the forest uplands are also used as water sources for Indiana bats in these regions.

Longevity
Mortality between birth and weaning has been estimated at eight percent (Humphrey et al. 1977). Humphrey et al. (1977) determined that female survivorship in an Indiana population of Indiana bats was 76 percent for ages one to six years, and 66 percent for ages six to 10 years; for males, survivorship was 70 percent for ages one to six years, and 36 percent for ages six to 10 years. The maximum ages for banded individuals were 15 years for females and 14 years for males. There is limited data available regarding current survival rates, or rates previously experienced by other groups of Indiana bats.

Life Stages
As previously summarized, the Indiana bat's annual life cycle of hibernation, spring migration, parturition, lactation, fall migration, mating, and hibernation is further discussed below.

Winter Hibernation
A majority of bats of both sexes hibernate by the end of November (by mid-October in northern areas) (Hall 1962; LaVal and LaVal 1980), but hibernacula populations may increase throughout the fall and even into early January (Clawson et al. 1980). Generally, Indiana bats hibernate from October through April (Hall 1962; LaVal and LaVal 1980), depending upon local weather conditions. They hibernate in large, dense clusters, ranging from 300 to 484 bats per square foot (Clawson et al. 1980). Indiana bats must store sufficient fat to support metabolic processes until spring. Substantial risks are posed by events (e.g., human disturbance) during the winter that interrupt hibernation and increase metabolic rates, potentially leading to starvation. While it is generally accepted that Indiana bats, especially females, are philopatric to hibernacula, meaning they return annually to the same hibernation site (LaVal and LaVal 1980), populations in several hibernacula have doubled between subsequent surveys (two years). As described in the *Indiana Bat Status in Kentucky* section above, this is evidence that individuals do change hibernacula occasionally.

The Indiana bat requires specific roost sites in caves or mines that attain appropriate temperatures for hibernation (Tuttle and Taylor 1994). In southern parts of the bat's range, hibernacula trap large volumes of cold air and the bats hibernate where resulting rock temperatures drop; in northern parts of the range, however, the bats avoid the coldest sites. In both cases, the bats choose roosts with a low risk of freezing. Ideal sites are 50° F or below when the bats arrive in October and November. Early studies identified a preferred mid-winter temperature range of 39-46° F, but a recent examination of long-term data suggests that a slightly lower and narrower range of 37-43° F may be ideal for the species (Hall 1962; LaVal and LaVal 1980; LaVal et al. 1976). Only a small percentage of available caves provide for this specialized requirement. Stable low temperatures allow the bats to maintain a low rate of metabolism and conserve fat reserves through the winter (Humphrey 1978; Richter et al. 1993). However, Indiana bats will occasionally use sites other than caves or mines if microclimate conditions are favorable.

Relative humidity at roost sites during hibernation usually is above 74 percent, but below saturation (Hall 1962; Humphrey 1978; LaVal et al. 1976; Kurta and Teramino 1994), although relative humidity as low as 54 percent has been observed (Myers 1964). Humidity may be an important factor in successful hibernation (Thomas and Cloutier 1992).

Specific cave configurations determine temperature and humidity microclimates, and thus suitability for Indiana bats (Tuttle and Stevenson 1978; LaVal and LaVal 1980). Indiana bats select roosts within hibernacula that best meet their needs for cool temperatures; in many hibernacula, these roosting sites are near an entrance, but may be deeper in the cave or mine if that is where cold air flows and is trapped (Tuttle and Stevenson 1978; Hall 1962; LaVal and LaVal 1980). Indiana bats often hibernate in the same hibernacula with other species of bats, and are occasionally observed clustered with or adjacent to other species, including gray bats (*M. grisescens*), Virginia big-eared bats (*Plecotus townsendii virginianus*), little brown bats, and northern long-eared bats (Myers 1964; LaVal and LaVal 1980; Kurta and Teramino 1994). Kurta and Teramino (1994) found a single Indiana bat roosting with a large colony of 15,000 bats (mostly little brown and northern long-eared bats) at a hydroelectric dam in Manistee County, Michigan, and noted that the temperature was about 40.5° F.

Spring Emergence/Migration
Female Indiana bats emerge first from hibernation in late March or early April, followed by the males (Hall 1962). The timing of annual emergence may vary across their range, depending on latitude and annual weather conditions; however, most Indiana bats have left their hibernacula by late April (Hall 1962). Indiana bats in the Barton Hill Mine hibernaculum in northeastern New York have been observed to move in clusters towards the entrance as they ready for emergence in early April. During a two-year radio-telemetry study for spring emerging Indiana bats, (Susi von Oettingen, personal communication, Service) observed little cluster activity in the hibernaculum on April 1; however, by April 9 clusters were observed near the mine entrance and general emergence was estimated to occur within the week. By the end of April no clusters were observed near the entrance and it was assumed most females had left. Males have been observed leaving as late as the end of May in the same hibernaculum (Susi von Oettingen, personal communication). About 200 miles south of the Barton Hill Mine, at the Mt. Hope mine complex in New Jersey, peak spring emergence of females was documented in early April. No females were captured in mid-April and only a single female was captured at the end of April. Emergence of males peaked at the end of April (Service 2000). Exit counts from several hibernacula in southern Pennsylvania and Big Springs Cave in Tucker County, West Virginia, suggest that peak emergence from hibernation is mid-April for these two areas (Butchkoski and Hassinger 2002; Mark Ford, personal communication, 2004).

Indiana bats offset the process of mating from that of gestation through delayed fertilization (Kurta in press). Shortly after emerging from hibernation, females become pregnant via delayed fertilization from sperm stored in their reproductive tracts through the winter (Hall 1962; Cope and Humphrey 1977; LaVal and LaVal 1980; Ransome 1990). The period after hibernation but prior to spring migration is typically referred to as "staging." During this staging period, which can last for as little as one day or as long as a few weeks, most female Indiana bats emerge, and forage near their hibernaculum before migrating to their previous summer roosting (maternity) areas to give birth and raise young. Data collected during a two-year study tracking spring emerging females to their summer roost sites in the Lake Champlain valley of New York and in a separate Vermont study suggest that females do not remain in the area surrounding the hibernacula after emerging from hibernation, but leave for summer habitat soon after emergence from hibernation (Britzke et al. 2004).

Data indicate that the area within an approximate 5-mile radius of a hibernaculum is important foraging and roosting habitat for the Indiana bat at the time of spring emergence (staging) and prior to hibernation (swarming), although males have been found almost 10 miles from the hibernacula in Indiana (U.S.D.A 2000). Indiana bat tree roosts used in the spring and fall are similar in physical structure to those selected during the summer.

Little or no information is available to determine habitat use and needs for the Indiana bat during migration. In the core of their range, most pregnant Indiana bats migrate north for the summer (Gardner and Cook 2002). In the northeastern part of their range, Indiana bats may migrate in other directions. In the Lake Champlain valley of New York and Vermont, female Indiana bats migrated east and southeast to their summer habitat. In Pennsylvania, Indiana bats migrated south-southwest to their summer habitat (Butchkoski and Hassinger 2002). In general, a stronger homing tendency has been observed along a north-south axis, rather than east-west (Gardner and Cook 2002).

Females dispersing from a Kentucky hibernaculum in the spring moved 4-10 miles within 10 days of emergence, eventually traveling more than 300 miles from the hibernaculum to the maternity area (Gardner et al. 1996; Gardner and Cook 2002). However, maternity colonies have been also located within 10 to 25 miles of the hibernaculum (Butchkoski and Hassinger 2002; Britzke et al. 2004). As previously discussed, migration is stressful for pregnant Indiana bats, particularly in the spring when their fat reserves and food supplies are low. In the northeastern part of their range, female Indiana bats may migrate shorter distances in order to maximize energy reserves by arriving at their summer habitat quickly (Britzke et al. 2004). Colder spring temperatures in the northeast may force the bats into temporary torpor, although some females were observed switching roosts when nighttime temperatures were below freezing. Cold temperatures may also increase the likelihood of mortality. Adult mortality may be highest in late March and April (Tuttle and Stevenson 1977). Springtime temperatures were unusually cold during a 2002 spring emergence study in New York, and two Indiana bats were found dead in or near their roosts (Britzke et al. 2004).

Less is known about the male migration pattern, but many males summer near the hibernacula (Whitaker and Brack 2002). Some males disperse throughout the range and roost individually or in small numbers in the same types of trees and in the same areas as females.

Non-reproductive Females and Males - Upon emergence from hibernation in the spring, some adult male Indiana bats form colonies in caves in summer, but most are solitary and roost in trees. Males remaining near hibernacula roost and forage in mature forest. Movements of 2.5-10 miles have been reported in Kentucky, Missouri, and Virginia (Gumbert et al. 2002; Hobson and

Holland 1995; 3D/International 1996). Other males leave the area entirely. Regardless, roosting habitat for non-reproductive females and males is similar to that used by maternity colonies (Gardner et al. 1991b). The exception is that these solitary individuals are not as selective in trees used for roosting as that of reproductively active females attempting to rear young (e.g., they may use smaller trees with fewer crevices, less exfoliating bark, etc.), largely because of their disassociation from raising young.

During summer, male Indiana bats that remained near their Missouri hibernacula flew cross country or upstream toward narrower, more densely wooded riparian areas during nightly foraging bouts, perhaps due to interspecific competition with gray bats. Some male bats also foraged at the edges of small floodplain pastures, within dense forest, and on hillsides and ridgetops; maximum reported distance was 1.2 miles (LaVal et al. 1976; LaVal et al. 1977; LaVal and LaVal 1980). In Kentucky, MacGregor reported that the maximum distance males moved from their hibernaculum in the summer was about 2.6 miles (Menzel et al. 2001). In the fall, male Indiana bats tend to roost and forage in upland and ridgetop forests, but may also forage in valley and riparian forest; movements of 1.8 - 4.2 miles have been reported in Kentucky and Missouri (Kiser and Elliott 1996; 3D/International 1996).

Maternity Colony
Overview - Females form maternity colonies with other females to give birth and raise young. Females may arrive in their maternity habitat as early as April 15 in Illinois (Gardner et al. 1991a, Brack 1983). Work in the Lake Champlain valley of Vermont and New York showed similar results (Britzke et al. 2004). Indiana bats were found at known maternity areas by March 29 at a site in Indiana (John Whitaker, personal communication, Indiana State University). Humphrey et al. (1977) determined that Indiana bats first arrived at their maternity roost in early May in Indiana, with substantial numbers arriving in mid-May.

While there has been extensive effort to study the roosting ecology of the Indiana bat during the maternity season (May 15 – August 15), data on spring (April 1 – May 15) roosting in maternity areas are limited. One recent study was conducted in the Lake Champlain valley of Vermont and New York (Britzke et al. 2003) where one or more spring roosts were identified for 15 radiotagged females. During emergence counts of roost trees occupied by the radio-tagged female bats, additional untagged bats were seen emerging from adjacent trees on a number of occasions (Britzke et al. 2004). Data from this work and studies conducted in Indiana suggest that some female Indiana bats start congregating in the same area and eventually form a primary maternity area, or roost, by early to late April (Indiana Airport Authority 2004; Britzke et al. 2003; Britzke et al. 2004;). Follow-up surveys confirmed the presence of maternity colonies at three of four spring roost sites. Moreover, based on analysis of summer roosts from the Lake Champlain valley, and other roost tree data, Britzke et al. (2003) determined that spring roost trees were similar in structure and characteristics to those used during summer (trees with exfoliating bark and high sun exposure).

After grouping into maternity colonies, females give birth to a single young in June or early July (Easterla and Watkins 1969, Humphrey et al. 1977). This life history strategy reduces thermoregulatory costs, which, in turn increases the amount of energy available for birthing and the raising of young (Barclay and Harder 2003). There are no documented occurrences in which a female Indiana bat has successfully given birth and raised a pup alone without the communal benefits, particularly thermoregulation, offered by establishment of a maternity colony. As will be further discussed, colonial behavior is well documented for females at maternity colonies. Studies by Belwood (2002) show asynchronous births among members of a colony. This results in great variation in size of juveniles (newborn to almost adult size young) in the same colony. In Indiana, lactating females have been recorded from June 10 to July 29 (Whitaker and Brack 2002). Young are capable of flight within a month of birth. Young born in early June may be flying as early as the first week of July (Clark et al. 1987), others from mid- to late July.

Roosting ecology of the Indiana bat when young become capable of flight (early to late July) is similar to behavior in the early summer. However, the maternity colony begins to disperse and use of primary maternity roosts diminishes, even though bats stay in the area prior to migrating back to their respective hibernacula. Bats become less gregarious and the colony uses more alternate roosts, possibly because there is no longer the need for the adult females to cluster to thermoregulate and nurture the young (Indianapolis Airport Authority 2003 and 2004). Indiana bats spend the latter part of the summer accumulating fat reserves for fall migration and hibernation. Indiana bats begin to return to their respective hibernacula as early as August. Females from the same maternity colony do not necessarily go to the same hibernaculum. A particular ratio of fat to lean mass is normally necessary for puberty and the maintenance of female reproductive activity in the mammals (Racey 1982). Racey (1982) suggests that the intrasexual variation in the age of puberty in bats is due to nutritional factors, possibly resulting from the late birth of young and their failure to achieve threshold body weight in their first autumn. Additionally, once puberty is achieved, reproductive rates frequently reach 100 percent among bats of the family Vespertilionidae, as is the Indiana bat (Racey 1982). Limited data suggest that young, healthy female bats can mate in their first autumn as long as their prey base is sufficient to allow them to reach a particular fat to lean mass ratio (Racey 1982). Limited mating activity occurs during winter and in late April as the bats leave hibernation (Hall 1962).

Social Structure
The following information describing a fission-fusion society is taken directly from Barclay and Kurta (in press): Recurrent roost switching and fluctuating composition of the group at any particular tree suggest the existence of a fission-fusion society (Kurta et al. 2002). In this type of society, members frequently coalesce to form a group (fusion), but composition of that group is in perpetual flux, with individuals frequently departing to be solitary or to form smaller groups (fission) for a variable time before returning to the main unit. Individuals may preferentially associate with some members of the larger group and may avoid associating with other members.

This type of colonial behavior is common among many other animals, such as cetaceans (Conner 2000) and primates (McGrew et al. 1996; Terborgh and Janson 1986), but also occurs in other mammals, such as spotted hyenas (*Crocuta crocuta*—Holekamp et al. 1997) and kinkajous (*Potos flavus*—Kays and Gittleman 2001). In whales, all individuals in the society are members of a pod, and in hyenas, this society is termed a clan; in bats, however, members of the fission-fusion society collectively form what biologists historically have called the "colony." Although many members of a colony may reside in one tree at any one time, other members roost elsewhere as solitary individuals or in small subgroups of fluctuating composition. Such a fission-fusion society has been suggested for a few species of forest bat (Kerth and König 1999;

O'Donnell 2000; Kurta et al. 2002; Willis and Brigham 2004), and further research may show that this type of social organization is common.

For example, research has shown that members of the colony **may** communicate regarding foraging areas (Murray and Kurta 2004). Short bouts of solitary night roosting by an individual may also serve to allow assessment of potential day roosts. In Michigan, when a tree used by a maternity colony the year before had fallen over, many bats of the colony shifted the center of their activity to a new tree about 2 km away that had previously been used as a night roost by a single animal bearing a transmitter the summer before (Kurta et al. 2002). As a result of colonial roosting behavior, thermoregulation provides a physiological advantage to the raising of a pup. When lactating adult female Indiana bats and pups congregate, both expend less energy. Therefore, more energy can be expended on nurturing the pup and enabling the young to achieve maturity faster.

Colonial Roosting Behavior
A capture of a reproductive (pregnant, lactating or post-lactating) female indicates that a colony of females is in the area, because Indiana bats are obligate colonial roosters (Humphrey et al. 1977; Clark et al. 1987; Gardner et al. 1996, Britzke 2002). Maternity colonies must have some biological advantage for bats because "...animals travel to the colony from a wide geographical area and stubbornly persist in returning to the same nursery roost for decades" (Neuweiler 2000).

Colonial behavior is well documented for females at maternity colonies. At a recent symposium regarding forest-dwelling bats, Barclay and Kurta (2004) suggested four potential explanations to cause female aggregation (establishment of maternity colonies) in the summer: (1) roosts are limited; (2) foraging efficiency – members of a colony communicate regarding good foraging areas; (3) anti-predator mechanism; and (4) thermoregulation. Although there are probably many advantages to colonial roosting, the likely most important factor for Indiana bats is for the thermoregulatory benefits (Humphrey et al. 1977; Kurta et al. 1996). Support for this is that pups and adults in late pregnancy are poor thermoregulators (Speakman and Thomas, 2003), and pre- and postnatal growth is controlled by rate of metabolism and body temperature (Racey 1982). Without clustering together, the strict thermal conditions needed to support prenatal and postnatal growth would not be available. Thus, colonial roosting is a life history strategy adopted by Indiana bats (like many other temperate zone bats) to improve their reproductive success (Barclay and Harder 2003). There may be a loss of these communal benefits below a threshold colony size (Racey and Entwistle 2003). While the relationship between viable population size and species colonality is poorly understood, it is an important component of their behavior (Racey and Entwistle 2003; Callahan 1993; Gardner et al. 1991b).

Site Fidelity
Indiana bats exhibit site fidelity to their traditional summer maternity and foraging areas. This life history strategy is thought to provide an advantage to the Indiana bat by increasing the probability of successfully reproduction. In turn, site fidelity may also inhibit the ability of Indiana bats to pioneer new areas (Sparks *in* Service 2005). This concept of philopatry is based on the documentation of female Indiana bats returning to the same general area to establish maternity colonies from year-to-year (Humphrey et al. 1977; Gardner et al. 1991a, b; Callahan et al. 1997; Indianapolis Airport Authority 2003, 2004; Kurta and Murray 2002; Butchkoski and

Hassinger 2002; Gardner et al. 1991a, Gardner et al. 1996) and the same roost tree so long as that tree is available, given the ephemeral nature of the roost trees. It is recognized that due to the ephemeral nature of roosting sites, site fidelity is not limited to specific trees. Instead, Indiana bats also exhibit site fidelity to their general maternity roosting and foraging areas (Rick Clawson, personal communication, Missouri Department of Conservation; Kurta in press).

Available data supports the hypothesis that individual Indiana bats are faithful to their foraging areas between years. Gardner (1991a; 1991b) observed that females returned to the same foraging areas between years regardless of whether these bats were initially captured as juveniles and then studied again as adults, or if these bats were adults during both seasons they were tracked. In Michigan, Indiana bats have been recaptured and tracked to the same sites where they were initially captured (Kurta and Murray 2002; Murray and Kurta 2004). At the Indianapolis Airport, data has been collected for the same bat in two different years on one occasion. Roosting and foraging habitat were remarkably consistent between years including occasional nocturnal visits to a day roost on the opposite end of the colony's foraging range, despite the fact that the bat was pregnant when tracked in 2003 and lactating in 2004 (Sparks et al. in press). Additionally, 43 bats have been tracked at the Indianapolis Airport between 1997 and 2004; all these bats foraged in the same general areas, although home ranges were distinct (Sparks et al. in press). In this ongoing study, bats have been found to move through their foraging habitat so predictable that researchers have been able to move into an area prior to the bat arriving (Sparks et al. in press). According to discussions at a recent meeting (Service 2005), Kurta has experienced the same situation.

Gumbert et al. (2002) differentiated between roost tree and roost area fidelity in Indiana bats, and found that bats are faithful to both areas and particular trees within those areas. Indiana bats also show a high degree of site fidelity to foraging ranges. Kurta and Murray (2002) documented recapturing 41 percent of females when mist netting at the same area in subsequent years. Indiana bat maternity colonies in Illinois, Indiana, Michigan, and Kentucky have been shown to use the same roosting and foraging areas year after year (Gardner et al. 1991b; Humphrey et al. 1977; Kurta and Murray 2002; Kurta et al. 1996, 2002). Telemetry studies of a maternity colony in Indiana have shown that bats are still returning to areas that were formerly part of their foraging range even after those areas are cleared and in industrial use (John Whitaker, personal communication). Roosting/foraging area fidelity may serve to maintain interactions between members of the colony. Bats using familiar foraging and roosting areas may have decreased susceptibility to predators, increased foraging efficiency, and the ability to switch roosts in case of emergencies or alterations surrounding the original roost (Gumbert et al. 2002).

Due to the ephemeral nature of their roost trees, so long as adequate roosting opportunities are available in the general area, bats are probably not dependant on the continued suitability of a specific tree. There is evidence that colonies are able to relocate after the loss of a roost tree. In Michigan, the focal point of a colony's maternity activity shifted 1.24 mile over a three-year period after the primary roost tree fell down. The area that they shifted to had been previously used by a single radio-tracked female for roosting during the summer prior to loss of the roost tree (Kurta et al. 2002). This is consistent with a number of other situations, where the bats moved to nearby roosts but retained the same commuting corridors and foraging areas once a primary roost tree of a maternity colony had been lost, (Humphrey 1977; Service 2002).

All Indiana bat experts do not accept the site fidelity in Indiana bats (Service 2005; see also "Bat Movements Among Maternity Roosts" section), and some suggest that Indiana bats do not exhibit site fidelity in parts of their range (Currie *in* Service 2005; Clawson *in* Service 2005). Some experts suggest that maternity colonies have vanished from one year to the next (MacGregor *in* Service 2005) despite no apparent changes to the maternity habitat. In other words, survey efforts in subsequent years after confirmation of Indiana bat presence have failed to capture Indiana bats in the same area. For instance, four reproductive female Indiana bats were captured on the Wayne National Forest in southern Ohio during a presence-absence survey for the species (Kiser and Bryan 1997). While the Service has not received any reports, it has been suggested that there were intensive efforts the following year with no Indiana bats captured (MacGregor, personal communication, 2005). At Blevins Valley in Bath County Kentucky, presence of a maternity colony was documented in 2000 (East Kentucky Power Cooperative 2000), but no Indiana bats were captured during limited efforts (one night of netting) in 2001 (Joe Settles, personal communication, East Kentucky Power Cooperative). Also, according to personal communication with John MacGregor, the following year, the roost tree was not used, and no Indiana bats could be caught or recorded (Anabat II). On the south half of the Cherokee National Forest in Tennessee, a reproductive female Indiana bat was captured. The following year, the area was netted intensively in an effort to track Indiana bats to roost trees. While efforts were unsuccessful in recapturing Indiana bats (John MacGregor, personal communication), the Service has been unable to obtain a report confirming negative data in follow-up surveys. At Picatinny Arsenal in New Jersey, a post-lactating female Indiana bat was captured during the first night of a survey for evidence of local reproduction. Efforts to catch reproductive females at Picatinny Arsenal in subsequent years were unsuccessful although male Indiana bats were captured (Annette Scherer, personal communication, Service). These occurrences in which maternity activity cannot be located despite confirmed or suspected presence of reproductive female Indiana bat(s) do not negate the apparent site fidelity of the Indiana bat in the use of maternity habitat. These cases may indicate the difficulty involved in capturing Indiana bats. The mist net guidelines indicate that there have been some situations when additional effort above and beyond the level of effort described in the guidelines was required to detect the presence of the species (Service 1999b). However, in some cases listed above, follow up surveys were conducted in sufficient numbers to meet the mist net guidelines. In other cases, initial surveys did not gather information on the location of roost trees that would have assisted in relocating the colony.

Maternity Roosting Behavior

Roost Tree Selection- Female Indiana bats prefer older forests with large trees, scattered canopy gaps, and open understory (Gardner et al. 1991b; Callahan et al. 1997; Forest Service 2000). Roost trees are larger in diameter than near-by apparently suitable trees (Kurta in press). Miller (1996) compared habitat variables for sites in northern Missouri where surveys for Indiana bats had been conducted and noted that significantly larger trees [>12 inches in diameter at breast height (dbh)] were found where reproductively active Indiana bats had been netted, than at sites where bats had not been captured. The average diameter of trees used by females is 36 percent greater that that of tree occupied by males (Kurta in press).

A variety of suitable roosts are needed within a colony's traditional summer range for the colony to continue to exist. One of the factors that influence the suitability of an area for habitat is the availability of individual roost trees within that area. Gardner et al. (1991b), and Garner and Gardner (1992) suggested the optimal density of roost trees within an area is 6.9 potential roost trees per acre in uplands and 10.9 potential roost trees per acre in floodplains. Because they are frequently associated with dead or dying trees (Kurta in press), Indiana bat roosts are ephemeral. Roost longevity may vary due to factors such as the bark sloughing off or the tree falling down. Most roost trees may be habitable for only 2-8 years (depending on the species and condition of the roost tree) under natural conditions. Gardner et al. (1991b) evaluated 39 roost trees and found that 31 percent were no longer suitable the following summer, and 33 percent of those remaining were unavailable by the second summer. The presence of smaller live roost trees within a forested area is important to the long-term sustainability of the area as habitat.

Indiana bat colonies select roost trees based on structural characteristics, diameter of the tree, solar exposure and position in the canopy (Kurta et al. 2002; 3D/E 1995). Maternity roost trees in the core of the range as well as at the edge of the range apparently share these characteristics. Roost tree structure is probably more important than the tree species in determining whether a tree is a suitable roost site (Farmer et al. 1997). Maternity roosts are generally found in dead or dying trees with exfoliating bark, or live trees of species known for exfoliating or shaggy bark, such as hickories or white oaks. Occasionally, female Indiana bats may roost in crevices or tree cavities, but maternity colonies are rarely found in these situations (Menzel et al. 2001). Most maternity roost trees generally receive a high amount of solar exposure, either as larger canopy trees or trees located near forest edges or openings with open canopy and an open understory (Callahan et al. 1997; Menzel et al. 2001). Solar exposure at northeastern maternity colonies may be a more important factor in roost tree selection than for colonies in the core of the range. In Vermont, Palm (2003) determined that maternity roost trees were more likely to be dominant in the canopy and farther from the nearest large canopy tree than randomly selected potential roost trees, and Kurta et al. (1996) documented roost trees in unshaded wetlands in Michigan.

Indiana bat maternity roosts can be described as "primary" or "alternate," based upon the proportion of bats in a colony occupying the roost site, and location in relation to forest canopy cover (Callahan et al. 1997; Kurta et al. 1996). Maternity colonies have at least one primary roost (up to five have been identified for a single colony in Vermont) used by the majority of the bats throughout the summer. Primary roosts must be able to provide a roosting site for many female Indiana bats with young. A colony's alternate roost sites may be used less frequently, and by smaller numbers of bats.

Primary roosts are located in openings or at the edge of forest stands, while alternate roosts can be in the open or in the interior of forest stands. Thermoregulatory needs may be a factor in roost site selection. Primary roosts are generally in open canopy and can be warmed by solar radiation, thus providing a favorable microclimate for growth and development of young during normal weather. Alternate roosts tend to be more shaded, frequently are within forest stands, and are selected when temperatures are above normal or during periods of precipitation. Shagbark hickories seem to be particularly good alternate roosts because they provide cooler roost conditions during periods of high heat, and their tight bark shields bats from the encroachment of water into the roost during rain events (Callahan et al. 1997).

Most primary roosts are found in large, dead trees, generally ranging in size from 12.2 to 29.9 inches dbh (3D/E 1995). In Vermont, maternity roosts ranged from 19 inches to 36 inches dbh (Palm 2003, Britzke et al. 2004). Alternate roost trees also tend to be large, mature trees, but the range in size is somewhat wider than that of primary roosts (7.1 to 32.7 inches dbh) (3D/E 1995). The smallest documented alternate roosts used by a reproductively active female Indiana bat ranged from 5.3 inches dbh to 10.5 inches dbh (Apogee 2003).

Bat Movements Among Maternity Roosts
Bats move among roosts within a season and when a particular roost becomes unavailable from one year to the next. Kurta et al. (1996) studied a maternity colony in northern Michigan over a three-year period, noting that roosting bats changed roost trees every 2.9 days, and that the number of roosts used by the colony ranged from 5 to 18. Other studies have shown that adults in maternity colonies may use as few as two and as many as 33 alternate roosts (Humphrey et al. 1977; Gardner et al. 1991a; Garner and Gardner 1992; Callahan 1993; Kurta et al. 1993a; 3D/E 1995).

Humphrey et al. (1977) observed that each night after the sunset peak of foraging activity, the bats left the foraging areas without returning to the day roosts, which indicated the use of "night" roosts. When young are present but not yet volant (capable of flight), the female bats will return occasionally throughout the night, presumably to care for the young.

Maternity colony movements among multiple roosts, particularly from primary roosts to alternate roosts, seem to depend on weather changes, particularly solar radiation (Humphrey et al. 1977) or periods of precipitation. Maternity movement between primary roosts from season to season is dependent upon roost availability. Kurta et al. (1993a) suggests movement between roosts may be the bats' way of dealing with a roost sites as ephemeral as loose bark. A bat that is aware of alternate roost sites is more likely to survive the sudden, unpredictable destruction of its present roost than a bat that has never identified an alternate roost (Kurta et al. 2002; Kurta and Murray 2002).

Due to the ephemeral nature of their roost trees, Indiana bats are not dependant on the continued suitability of a specific tree. As such, female Indiana bats have evolved to move over the landscape in response to the ephemeral nature of maternity roosts (i.e., large, dead trees). This coordinated relocation of a maternity colony is only known to occur in a slow, methodical manner, into familiar habitat (Kurta et al. 2002). In this Michigan study, the focal point of a colony's maternity activity shifted 1.24 miles over a three-year period after the primary roost tree fell down. The area that bats shifted to had been previously used by a single radio-tracked female for roosting during the summer prior to loss of the roost tree (Kurta et al. 2002). This is consistent with a number of other situations where the primary roost tree of a maternity colony had been lost and the bats moved to nearby roosts but retained the same commuting corridors and foraging areas (Humphrey 1977; Service 2002). Although Carter (2003) recognizes that female Indiana bats are faithful to a colony site, he suggests that, in the long term, Indiana bat maternity colonies must be "nomadic" because of their dependence on an ephemeral resource such as large, dead trees. Despite this theory, there is no evidence to suggest that bats are able to adapt to a sudden, abrupt loss of familiar roosting and foraging habitat, but there is also no evidence that shows that they cannot adapt quickly. However, the availability and quality of adjacent habitat is certainly important to the maintenance of a maternity colony (Service 2005).

Maternity Foraging Behavior

After Indiana bats emerge from hibernation and migrate to their summer maternity areas, fat stores are likely depleted. Fat stores in most bat species decline rapidly during hibernation (Fleming and Eby 2003). Migration subsequently can use between 10 and 25 percent of a bats' body weight in fat reserves (Fleming and Eby 2003). Upon arrival at summer maternity habitat, bats must restore their body weight and increase their food intake to prepare for giving birth. Reproductively active bats need to elevate biosynthesis in order to support pregnancy and lactation (Speakman and Thomas 2003). For example, basal metabolism of brown long-eared bats (*Plecotus auritus*) is nearly double for pregnant and lactating bats as compared to non-reproducing individuals (Speakman and Thomas 2003). However, the foraging efficiency of bats declines during pregnancy: a time when energy demands increase (Barclay and Harder 2003). Female little brown bats (*M. lucifugus*) spend 66 percent of their daily energy on foraging (Barclay and Harder 2003).

Streams, associated floodplain forests, and impounded bodies of water (e.g., ponds, wetlands, reservoirs) are preferred foraging habitats for pregnant and lactating Indiana bats, some of which may fly up to 1.5 miles from upland roosts (Gardner et al. 1991*b*). In riparian areas, Indiana bats primarily forage near riparian and floodplain trees (e.g., sycamore [*Platanus occidentalis*], cottonwoods [*Populus spp.*], black walnut [*Juglans nigra*], black willow [*Salix nigra*], and oaks [*Quercus spp.*]), and along forest edge on the floodplain (Belwood 1979; Cope et al. 1978; Humphrey et al. 1977; Clark et al. 1987; Gardner et al. 1991*b*). Within floodplain forests where Indiana bats forage, canopy closures range from 30 to 100 percent (Gardner et al. 1991b). Cope et al. (1978) characterized woody vegetation within a width of at least 30 yards of a stream as excellent foraging habitat. Indiana bats also forage within the canopy of upland forests, over clearings with early successional vegetation (*e.g.*, old fields), along the borders of croplands, along wooded fencerows, and over farm ponds in pastures (Clark et al. 1987; Gardner et al. 1991b). Seidman and Zabel (2001) documented the use of intermittent and perennial streams by bats to forage. While this did not include Indiana bats, four of the seven species studied were of the genus myotis. Sparks et al. (in press) suggest that in heavily forested landscapes, the edges of open spaces may provide important foraging habitats.

In a recent study in the Allegheny Mountains (habitat similar to that of the Action Area), bat activity levels in non-riparian upland forest and forests in which timber harvest had occurred were low relative to forested riparian areas (Owen et al. 2004). Similar results have been reported in the Southeast (Menzel 1998), New England (Krusic et al. 1996; Zimmerman and Glanz 2000) and the Pacific Northwest (Grindal et al. 1999; Seidman and Zabel 2001). High levels of bat activity observed in riparian areas elsewhere often were related to the increased foraging efficiency associated with foraging in areas where insect abundances are greater (Barclay 1991; Grindal et al. 1999). Owen et al. (2004) speculates that the same is true in the Allegheny Mountains. The recent work of Owen et al. (2004) illustrates and further supports the biological importance of forested riparian habitats in the Appalachians. While this study was not specific to maternity activity, it stands to reason that riparian areas are all the more important for reproductive Indiana bats to increase foraging efficiency.

Maternity Colony Size
It is difficult to depict the size (population and geographic area) of a maternity colony, particularly if the Indiana bat maternity colony exhibits the fission-fusion society as described in the "Social Structure" section of this biological opinion. Nonetheless, the following sections summarize the best available scientific data with regard to the size of known maternity colonies.

Area
Indiana bats are known to occupy distinct home ranges during the summer (Garner and Gardner 1992) and return nightly to their foraging areas (Gardner et al. 1991b). Individual adult female Indiana bats in the same maternity colony show site fidelity to foraging areas throughout the summer and in subsequent years (Gardener et al. 1991b; Humphrey et al. 1997; Kurta and Murray 2002; Kurta et al. 1996 and 2002; Sparks el al. in press). While limited data imply that adults are solitary in their foraging activity (Kurta and Murray 2002; Murray and Kurta 2004), data on foraging bats has been limited to a small number of individuals relative the entire maternity colony.

Linear distances between roosts and foraging areas for females ranged from between 0.3 miles to 5.2 miles, although most distances were less then half that maximum distance (Murray and Kurta 2004; Sparks et al in press). For example, the maximum distance listed above was reported for one individual at a colony in Indiana. However, when 41 bats from this colony were tracked, the mean distance was 1.86 miles. Given the large and variable range of this species, it was not unexpected that there are large differences in home ranges. Murray and Kurta (2004) and Sparks et al (in press) speculated that the variations in distances to forage areas were due to differences in habitat type, interspecific competition, and landscape terrain. Therefore,'studies from areas near the action area and in forested or mountainous habitats (Canoe Creek, PA) may be more representative of the bats' behavior in the action area. In Canoe Creek, Pennsylvania, an area with significant changes in elevation, reported distances between roosts and foraging areas ranged from 1.5 miles to 2.8 miles, with an average distance of 2.1 miles (Butchkoski and Hassinger 2002). During that study, no Indiana bats traveled over adjacent mountains (Brush and Lock Mountains). Seventy-eight percent of the area within the 2.8-mile radius was forested, with all bats foraging in the largest block of contiguous forest (3,212 acres). Areas of more fragmented habitat were not used.

Roosts occupied by individuals ranged from 0.33 miles to more than 1.6 miles from preferred foraging habitat, but are generally within 1.2 miles of water (e.g., stream, lake, pond, natural or man-made depression). In Illinois, the mean nightly foraging distance from a roost ranged from 0.34 miles to 0.65 miles (Garner and Gardner 1992). Average foraging areas for individual Indiana bats varied from about 70 acres (juvenile males) to over 525 acres (post lactating adult females)(Andy King, personal communication). The foraging area used by an Indiana bat maternity colony has been reported to range from a linear strip of creek vegetation 0.5 miles in length (Belwood 1979; Cope et al. 1978; Humphrey et al. 1977), to a foraging area 0.75 miles in length, within which bats flew over the wooded river or around the riverside trees. The mean foraging area of three individual, reproductive female Indiana bats were 128 acres (pregnant), 232 acres (lactating), and 526 acres (post-lactating) (Garner and Gardner 1992). In Illinois, foraging area for a lactating female was reported to be 850 acres, while a post-lactating female that had been subject to timbering activities used 625 acres (Gardner et al. 1991a,b).

Maternity colonies have often been found within forests that are streamside ecosystems or are otherwise within 0.6 miles of permanent streams. Garner and Gardner (1992) suggested that suitable Indiana bat roosting and foraging habitat be within 0.62 mile of water. Indiana bat roosts in Illinois were less than 0.68 miles from perennial streams (Gardner et al. 1991). Kurta et al. (2002) found that 38 roosts in Michigan were on average 0.409 + 0.36 miles from lakes or ponds and 0.258 + 0.45 miles from perennial streams. These water sources and associated forested riparian habitat, not only provide drinking water and food items, but also serve as flight corridors to suitable foraging habitat. A telemetry study in Illinois found most maternity roosts within 1,640 feet of a perennial or intermittent stream (Hofmann 1996). Bats in Illinois selected roosts near intermittent streams and far from paved roads (Garner and Gardner 1992).

Foraging areas for six female Indiana bats in a Pennsylvania maternity colony were 96.4-276.8 acres in size (Butchkoski and Hassinger 2002). Core areas, where a bat spent 50 percent of its time while in main foraging areas, were located along intermittent streams or within hollows containing an intermittent stream. For the six female bats, only two core areas overlapped. Within the foraging areas (< 2.8 miles) of radio-tagged bats in the Pennsylvania study, there were "large amounts of riparian and lakeside forests and especially forested mountainsides" (Butchkoski and Hassinger 2002). Indiana bats restricted foraging to within the largest island of upland forest (3,038 acres) with slopes less than 10. Additionally, these foraging areas had a southerly aspect and were located along intermittent streams or within hollows containing an intermittent stream. This study was the first to occur in an area with significant changes in elevation, which is similar to the action area.

Sparks et al. (in press) suggest that the perfect foraging habitat for the Indiana bat would include forested streams interspersed with grasslands, croplands, or shrublands). 3D/E (1995) identified essential summer habitat as including at least 30 percent forested cover on a landscape scale. Farmer et al. (1997) indicated that optimal summer habitat has 20-60 percent forest cover, and that areas with less than 5 percent forest cover are not suitable for Indiana bats, while Garner and Gardner (1992) indicate that if over 11 percent of the area within 0.6 miles of a roost site is strip mine or barren land then the area should be considered unsuitable for the Indiana bat.

Maternity Colony Size

A single Indiana bat maternity colony can vary greatly in size, and has usually been discovered with the capture of just one or two reproductively active female bats during the first year of survey efforts. The number of bats comprising a maternity colony is difficult to determine because colony members are dispersed among various roosts (Kurta in press). While most of the documented maternity colonies have contained 100 or fewer adult bats (Harvey 2002), as many as 384 bats have been reported emerging from one maternity roost tree in Indiana (Lori Pruitt, personal communication [c], Service). Recent counts at well-studied colonies (with at least three years of data) in Indiana and Vermont resulted in 104, and 200+ adult female individuals, respectively (Indianapolis Airport Authority 2003; Susi von Oettingen, personal communication). Based on twelve study results compiled by Kurta (in press), the mean maximum emergence count after young began to fly is 119 bats. This information suggests 60-70 adults in a primary roost at any one time (Kurta in press). Whitaker and Brack (2002) indicated that average maternity colony size in Indiana was about 80 adult bats.

There are limited data available that provide estimates of the size of maternity colonies in forested mountainous habitat similar to the action area. It must be noted that an exit count is the minimum number of individual Indiana bats that comprise a maternity colony. The following discussion is based on exit count data from a roost(s) because this represents the best available data. Gumbert (2001) observed 19 bats emerging from a roost in eastern Kentucky. Two years later, a colony of 34 bats was documented in another area of the same county (Apogee 2004a). Britzke et al. (2003) recently located three maternity colonies in the Nantahala National Forest in western North Carolina and Great Smoky Mountains National Park in Tennessee. The maximum numbers of bats exiting primary roosts were 28, 23 and 81 bats for the three different colonies. The maternity colonies discovered in the Britzke et al. (2003) study are at much higher elevations than that of the action area. Consequently, the climatic regime during the maternity season, especially mean minimum nighttime low temperature and maximum daytime high temperature, may be cooler than that of the action area. One of the confirmed maternity colonies in Kentucky is located in Hardin County on Fort Knox and consists of about 300 adult females (James Widlak, personal communication). The climate in this area is more similar to that of the action area. Based on these conflicting data, we are unable to make any conclusions regarding whether climatic or topographic factors within the action area are likely to result in maternity colonies that are consistently larger or smaller than the average colony size.

Summary

In summary, there are four apparent advantages to site fidelity and colonial roosting behavior: 1) maintaining interactions between members of the population (members of a colony have an established area to regroup each year to re-establish a maternity colony); 2) increasing foraging efficiency (site familiarity enables individuals to reduce energy expenditure to forage); 3) decreasing susceptibility to predators and other catastrophic events by being familiar with a multitude of roosting opportunities in a specific area; and 4) providing thermoregulation, as a result of colonial roosting, provides a physiological advantage to the raising of a pup.

These advantages increase the chance of survival for adults and young by allowing the adult to expend more energy for gestation, which in turn allows for more rapid development of fetuses, which increases the chance of an adult successfully bearing a pup. Once young are born, so long as the mother is nutritionally fit, she can expend more energy into lactation and development of young which improves the chance of: survival of young throughout the summer period and during migration back to the hibernaculum; young reaching puberty and breeding in their first fall and building appropriate fat reserves to survive hibernation. In addition, increased foraging efficiency improves the fitness of the adult at the end of the maternity period, which in turn, improves the chance of: survival of the adult during summer and migration back to the hibernaculum; breeding during the fall; and building appropriate fat reserves to survive hibernation. Once site familiarity is altered, it is not known how individuals of a maternity colony, let alone the entire colony would react.

Although female Indiana bats have evolved to move over the landscape in response to the ephemeral nature of maternity roosts (i.e., large, dead trees), the relocation of a maternity colony is only known to occur in a slow, methodical manner, into familiar habitat (Kurta et al. 2002). While Carter (2003) recognizes that female Indiana bats are faithful to a colony site, he suggests that, in the long term, Indiana bat maternity colonies must be "nomadic" because of their dependence on an ephemeral resource such as large, dead trees. Despite this theory, there is no evidence to suggest that bats are or are not able to adapt to a sudden, abrupt, or large-scale loss of familiar gathering places and familiar roosts and habitat. It is apparent that a variety of roosts within a colony's occupied summer range should be available to assure persistence of the colony in that area (Kurta et al. 1993a, Callahan et al. 1997).

Although maternity colonies continue to exist in highly fragmented habitats, it is not known whether this suggests adaptability, or conversely, the inability to move large distances over relatively short time periods while maintaining cohesiveness of the maternity colony. Given the dramatic and indeterminate population declines of the species, there is little support that the Indiana bat is highly adaptable to large landscape level changes to their maternity habitat. Murray and Kurta (2004) observed that Indiana bats in a maternity colony never crossed open areas (open wetland or agricultural fields), and followed tree lines or fencerows to reach foraging areas, even though it required more energy and increased commuting distance by 55 percent. This behavior may also relate to increased foraging efficiency near the tree lines or fencerows.

Limited evidence suggests that the Indiana bat may tolerate some degree of habitat disturbance. In northern Missouri, maternity roosts were found in areas that were near disturbances such as residences or cattle pastures (Callahan 1993; Miller 1996). Selective timber harvest activities neither directly damaged known roosts nor discouraged bats from continuing to forage in an area that had been harvested in Illinois (Gardner et al. 1991a) so long as the currently used roosts were not removed and foraging habitat remained intact. However, there were no data collected to evaluate reproductive success before or after disturbance and given the philopatric nature of this species, the continuing return of the Indiana bat to an area does not translate to maintenance of a maternity colony.

If the summer range is modified such that females are required to search for new roosting habitat or foraging areas, it is assumed that this effort places additional stress on pregnant females at a time when fat reserves are low or depleted and they are already stressed from the energy demands of migration (Kurta et al. 2002; Kurta and Murray 2002). This, in turn, could affect the reproductive fitness and productivity of the bats. It is not known what degree of disturbance female Indiana bats in a maternity colony can, collectively, tolerate and continue to maintain the maternity colony. As mentioned previously, a possible cause for the declining trend of this species is that habitat alterations are causing reduced numbers of bats within maternity colonies, and in some cases these maternity colonies may be extirpated, prior to their discovery (Service 1983; Kurta and Murray 2002; Kurta et al. 2002; McCracken 1988; Racey and Entwistle 2003).

Fall Swarming

Upon arrival at hibernation caves in August through September, Indiana bats "swarm," a behavior in which "large numbers of bats fly in and out of cave entrances from dusk to dawn, while relatively few roost in the caves during the day" (Cope and Humphrey 1977). Very little is known about behavior and habitat use by Indiana bats during the fall swarming period, and the little information that is known is based primarily on studies conducted on males.

Swarming continues for several weeks (August through October) and mating occurs during the latter part of the period. Fat supplies are replenished as the bats forage prior to hibernation. Indiana bats tend to hibernate in the same cave in which they swarm (LaVal et al. 1976), although swarming has occurred in caves other than those in which the bats hibernated (Cope and Humphrey 1977). Male Indiana bats may make several stops at multiple caves during the fall swarming period. During swarming, males remain active over a longer period of time at cave entrances than do females (LaVal and LaVal 1980), probably to mate with the females as they arrive. The time of highest swarming activity in Indiana and Kentucky has been documented as early as September (Cope et al. 1978). After mating, females enter directly into hibernation.

During the fall, when Indiana bats swarm and mate at their hibernacula, male bats roost in trees nearby during the day and fly to the cave during the night. In Kentucky, Kiser and Elliott (1996) found male Indiana bats roosting primarily in dead trees on upper slopes and ridgetops within 1.5 miles of their hibernaculum. During September in West Virginia, male Indiana bats roosted within 3.5 miles in trees near ridgetops, and often switched roost trees from day to day (Ford, et al. 2002). Fall roost trees tend to be exposed to sunshine rather than shaded (Menzel et al. 2001).

Indiana Bat Status Summary

Historic Conditions- Prior to European settlement, deciduous hardwood forest was the dominant land cover in the Eastern and Midwestern United States, and "...millions of now endangered Indiana and gray bats lived in single caves, and their overall abundance likely rivaled that of the now extinct passenger pigeon" (Tuttle et al. 2004). For example, estimates based on staining in hibernacula suggest that as many as 9 to 13 million Indiana and/or gray bats may have hibernated in one hibernaculum (Mammoth Cave System) historically (Tuttle 1997). An Indiana bat colony in Bat Cave, Edmonson County, Kentucky, was catastrophically eliminated by a flood event in the mid 1900's. Analysis of bone deposits revealed remains of an estimated 300,000 individual Indiana bats (Hall 1962).

Throughout the Indiana bat's range, a substantial amount of the forested habitats that would have provided foraging and maternity sites for these bats has been destroyed in the past 300 years. The region that includes the Action Area lost about 60 percent of its forested habitat since pre-Colonial times (Powell and Rappole 1986, see "Table 6"). Although the amount of forest cover in the eastern United States stabilized from 1987 to 2002, and overall has increased since the low point of 1945, lowland hardwoods in the east experienced their greatest declines between 1963 and 2002, losing about 15 million acres of cover over this 39-year period (Heinz Center 2002).

In addition, the states within the historic distribution of Indiana bats have also lost substantial portions of their wetlands, including forested wetlands, since pre-Colonial times (Dahl 1990). West Virginia lost about 24 percent of its wetlands between the 1780s and 1980s; Ohio lost about 90 percent of its wetlands; Virginia lost about 42 percent; Kentucky lost about 81 percent; and Illinois lost about 85 percent (Dahl 1990).

While we do not know precisely how many Indiana bats existed during the pre-colonial period, limited information, as described above, suggests that Indiana bats were numerous. However, we do not have information on the population sizes and trends of Indiana bats that would allow

Table 6. **Forest area in the United States by Region, from Pre-Colonial Times to 1977 (in thousands of acres). Adapted from Powell and Rappole 1986.**

Region	Pre-Colonial	1872	1920	1945	1963	1977	%Remaining
Central	421,500	200,100	148,710	171,170	173,150	167,290	40
Mid Atlantic	172,000	60,310	70,865	84,658	86,924	96,413	56
South	738,000	503,080	439,510	431,520	510,020	478,680	65

Central Region includes: Ohio, Indiana, Illinois, West Virginia, Kentucky, Tennessee, Iowa, Missouri, eastern Kansas, and eastern Nebraska; Mid Atlantic Region includes: New York, New Jersey, Pennsylvania, Delaware, and Maryland; South Region includes: Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Arkansas, Louisiana, eastern Texas, and eastern Oklahoma.

us to correlate changes in the total abundance of the bats, generally, or the abundance at particular hibernacula, with changes in forest cover throughout the bats' range. We also do not know whether or to what degree Indiana bats have been affected by changes in forest cover throughout their range.

Current Conditions

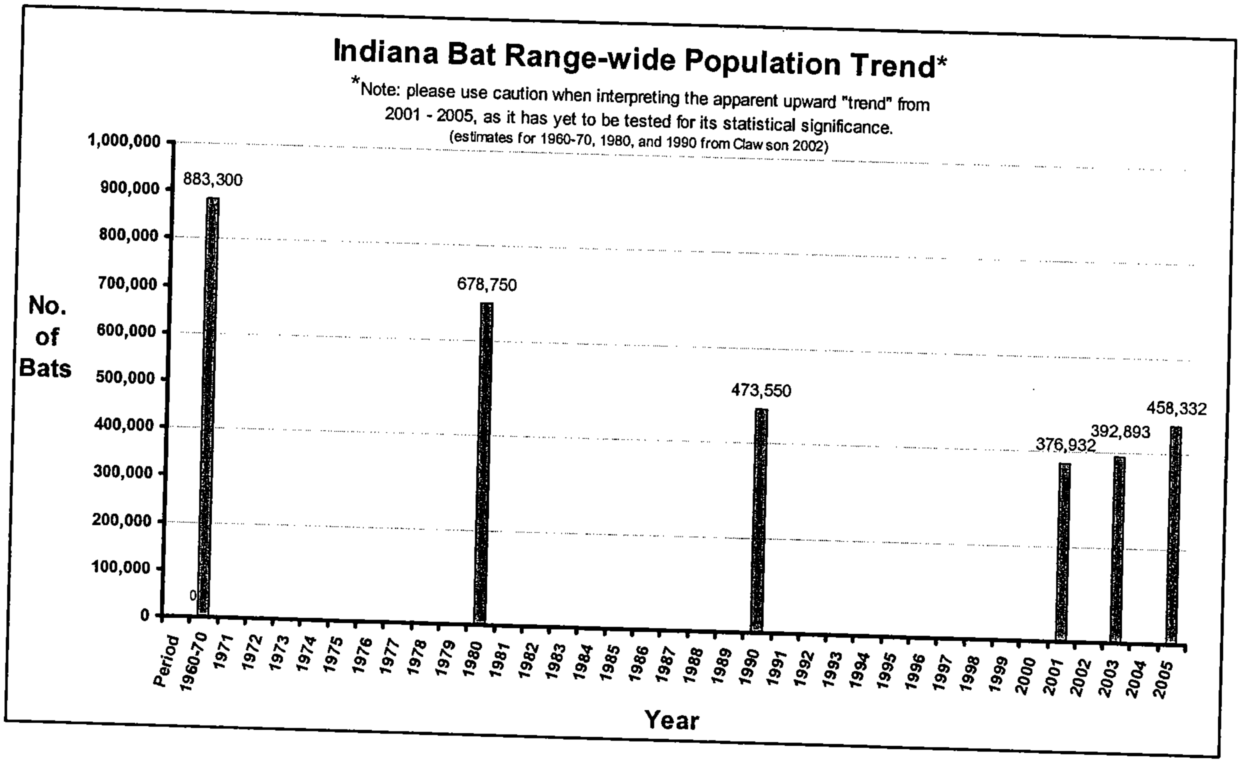
Bats comprise one-fifth of all mammal species and only rodents are more numerous (Harvey et al. 1999). Several North American bat species, including the little brown bat, Northern longeared bat (*M. septentrionalis*), Eastern pipistrelle (*Pipistrellus subflavus)*, and Brazilian (Mexican) free-tailed bat (*Tadarida brasiliensis)*, have large geographic ranges and number in the tens or hundreds of millions. Additionally, bats are the most gregarious of all mammals (Hill and Smith 1986). For example, an estimated 100 million Mexican free-tailed bats summer in central Texas, and this is a fraction of the species range (Bat Conservation International 2004).

While the Indiana bat continues to have a large geographic range (27 states), the range-wide population of the Indiana bat has declined 48 percent from about 883,300 Indiana bats in 1960/1970 to 458,332 in 2005 (King, personal communication 2005). Although the most recent census (2005) shows a 17 percent population increase from the last monitoring period (2003) (388,829 to 455,567) (King, personal communication 2005), we are hesitant, at this time, to extrapolate long-term trends from changes between individual survey periods because the species' reproductive capacity will take much longer than 10-20 years to show population gains. Also, population fluctuations from year to year can be attributed to such factors as weather affecting the success of reproduction for a given year (Humphrey et al. 1977; Ransome 1990) as well as the discovery of new hibernacula.

Outlook

In an effort to provide context for evaluating the effects of actions that impact the Indiana bat, we have graphed the range-wide population trends from 1960 through 2005 (Figure 1). This allows us to visualize the historic and current population growth/decline trends. As discussed in the "Range-wide Hibernacula Censuses" section, care must be taken when extrapolating survival rates from short-term or individual studies as age structure and survival rates can vary greatly among hibernacula and maternity colonies and from year to year (Ransome 1990; Humphrey and

Figure 1. Indiana Bat Range-wide Population Trend (1960-2005).



Cope 1977). Also, population fluctuations from year to year can be attributed to such factors as weather affecting the success of reproduction for a given year (Humphrey et al. 1977; Ransome 1990) as well as the discovery of new hibernacula. Therefore, trends over the entire 45-year period, rather than between individual survey years must be the focus of any discussion regarding the future outlook for the species. As is evident on Figure 1, this data does include the upward population trend that has been documented in 2001, 2003, and 2005; however, this data should interpreted with caution because it has yet to be tested for its statistical significance. Also, we do not have an estimated confidence interval for the 2005 range-wide estimate (or previous estimates) at this time, and there were some methodology changes from 2003 to 2005. We hope to improve and further standardize the winter survey protocol so that standard errors can be more easily calculated and as a means of further reducing variability within and among future hibernacula surveys.

Figure 1 clearly shows the long-term decline that occurred from the 1960/70's through the mid-1990's. Since this decline, Indiana bat range-wide winter numbers appear to have increased or at least remained stable. However, this stabilization/increase does not signify the impending recovery of the species. In our opinion, it is premature to make such predictions.

There are several reasons why the outlook for the Indiana bat may be even more precarious than suggested by Figure 1:

1. Indiana bats exhibit colonial behaviors in nearly every stage of their life history. Such colonial traits may substantially affect both survival and productivity. Unfortunately,

accelerating declines in survival or productivity due to collapse of these types of interactions are usually impossible to detect until after the fact. While there is no way to prospectively determine the risk of crossing a threshold, beyond which population declines may be subject to rapid acceleration that are increasingly difficult to reverse, this risk must be considered, especially for such a colonial species (Racey and Entwistle 2003; Callahan 1993; Gardner et al. 1991b).

2. The Indiana bat has a low reproductive rate and slow population growth, which inhibit the opportunity to recover from population declines (Racey and Entwistle 2003). Bats are the slowest reproducing mammals on earth for their size with most producing only one young per year.

3. The declining trend in Indiana bat numbers through 1990 was both long-standing and widespread. A sustained decline of more than 30 years over the four states that once supported more than three-quarters of the entire population likely cannot be attributed to short-term reversible perturbations in species abundance or to local environmental conditions.

These issues are particularly important given the fact that basic bat population dynamics indicate that if this species' numbers begin to decline again, the opportunity for both survival and recovery in the wild may be precluded.

Conservation Needs of the Indiana Bat

Species With Similar Life History Strategies

Indiana bats are not unique in having wintering areas that are spatially separated from summer, breeding habitats. Humpback (*Megaptera novaeangliae)* and northern right whales (*Eubalaena glacialis*) migrate between northern feeding areas and tropical rearing areas. In the Atlantic Ocean, loggerhead sea turtles (*Caretta caretta*) will migrate from the coast of Florida to the Mediterranean Sea and back to complete their life cycles. In the Pacific Ocean, Pacific salmon (*Oncorhynchus* sp.), migrate between freshwater spawning habitat and marine rearing habitat to complete their life cycle. Monarch butterflies (*Danaus plexippus)* migrate between wintering habitat in Mexico and rearing habitats in temperate North America. Whooping cranes (*Grus Americana*) migrate between wintering habitat along coastal Texas and nesting habitat in northern Alberta and Northwest Territories in Canada. Most North American songbirds (including endangered species like golden-cheeked and Kirtland's warblers) and many species of shorebirds, waterfowl and raptors migrate from wintering areas in Mexico, the Caribbean, Central America, and South America to reproduce in temperate North America. With all of these species, scientists have debated the relative importance of the different habitats for the conservation of these species (for examples, see Hagan III and Johnston 1992, National Research Council 1996, Rappole 1995, Terborgh 1989). When puddle ducks and diving ducks declined by about 40 percent in Chesapeake Bay between the 1950s and 1980s, many investigators blamed the declining condition of the bay, which supports wintering populations of these species, others blamed the loss of the wetlands in the Prairie Pothole region in which large numbers of these species breed, while others recognized that losses in both areas contributed to the decline (Terborgh 1989). Similar debates have surrounded the decline of sea turtles in the Atlantic and Pacific Oceans, whales, Pacific salmon, shorebirds, raptors, and songbirds (Askins et al. 1990, Bohning-Gaese et al. 1992, Finch 1990, Hagan III and Johnston 1992, Myers et al. 1987, Rappole 1995, Robbins et al. 1989).

The Service has consistently recognized the necessity of protecting species throughout their entire life cycle rather than focusing all conservation efforts in one habitat for a particular life stage, over all others. At least two fundamental principles underlie this strategy. First, declines due to impaired survival and/or reproduction at one stage in the life cycle do not preclude concurrent irreversible loss of habitat functionality at other life stages that may ultimately become the major determinant of a species survival and recovery. More immediately, however, a species that is experiencing a serious decline is placed at further risk by losses at any other stage in the life cycle. Indeed, a serious on-going population decline requires immediate implementation of available measures to increase survival and reproduction at all stages in the life cycle or, at the very least, to avoid compounding the downward trend.

Indiana bat

The annual cycle of hibernation, spring migration, summer activity (e.g., foraging, parturition, lactation, fall migration, mating, and hibernation can be broken at any point, resulting in the loss of that individual from the population, and its remaining reproductive potential in the population. The vulnerable point(s) in this cycle may very well differ by geographic area, and even within the same area. Ransome (1990) further identifies the limiting factors that control the overall bat population as the number of maternity colonies and the proximity and quality of foraging areas surrounding each maternity site. He also concludes that a reduction in the number of maternity colonies contributing to a hibernaculum is a prime factor that should be considered when evaluating the causes of population declines in bats. Unless a change in these environments occurs to allow recruitment to exceed mortality, the species will continue to decline.

Many authors have established that protecting the Indiana bats' winter hibernacula is necessary to prevent further declines of this species and that the quality of these habitats can be limiting for the bats (for example, see "Service 2005"; "Service 1983"; "Service 1999b"). This is widely accepted largely because the declines can be readily observed through hibernacula censuses. The response of Indiana bat populations to changes in the availability of habitat that supports maternity colonies and summer roost sites is not as clear (for example, see Service 2005; Service 1983; Service 1999b), particularly because Indiana bats in summer habitat are widely dispersed, difficult to track, and demographic data is not readily collected. Despite this uncertainty, any impairment of survival or reproduction will compound losses at the hibernacula. Further, Racey and Entwistle (2003) suggest that an effective conservation management unit for temperate bats should be at the maternity colony level. Indiana bats show fidelity to summer habitat areas, but there are questions about whether this habitat might be limiting to Indiana bat populations and/or whether disrupting these individuals and/or colonies comes at some cost to reproduction and/or survival. Despite this uncertainty, protection of only one life stage (hibernacula) is not adequate to ensure the survival and recovery of this species. All other life stages, particularly the birth and care of young, must be managed or protected as well to allow for adequate recruitment. Given the magnitude of the destruction of forest cover throughout the historic range of Indiana bats, if we assume that the availability of the habitat necessary to support summer colonies for these bats has had (and will continue to exert) no effect on the Indiana bats' population trend (or the trend of some of the hibernacula, if not all of them) and this assumption later proves false, we will have failed to protect Indiana bats when protection was warranted and necessary to prevent further declines. Worse, we will have precluded the species' chances of recovering from endangerment.

Based on experiences with species of similar life history strategies as the Indiana bat, this Opinion assumes that preventing Indiana bats from becoming extinct will require efforts that conserve the habitats that support the three major stages of the bats' life cycle: winter hibernacula, summer habitat, and the migratory habitats that connect the two. Adequate summer habitat (e.g., roosts with appropriate microclimatic conditions for raising young, adequate foraging area, etc.) is crucial to ensure successful recruitment and reduce the mortality rate. Given the colonial nature and site fidelity of this species, the capability for a female Indiana bat to only give birth to one pup annually, and considering that summer colonies and hibernacula form an interdependent meta-population, it is imperative that summer maternity colonies are adequately protected or managed to ensure their contribution to the population.

Summary

The debate over the relative importance of habitats that support one portion of the Indiana bat's life history (winter hibernacula) over another portion (summer habitat) of their life history is similar to that of the aforementioned species with similar life history strategies (Service 2005). The reality is that Indiana bats evolved a life history strategy that leads them to migrate from hibernacula to summer foraging habitat where they gain the energy they need to reproduce and rear their young, then they gain additional energy during the swarming period that helps them survive the winter. As a result of natural selection, only the phases of life history strategies that improve the species' chances of survival are developed (Stearns 1992). To successfully complete its life cycle, each bat needs to complete each stage of this life history strategy. The probability of successfully completing this life cycle is the combined probability of completing each component of the cycle; if an individual bat has a low probability of success in one phase of its life cycle, it has a low probability of successfully completing the entire, annual cycle (Myers et al. 1987).

In order for the Indiana bat to have a reasonable chance for survival and recovery, the current population must be initially stabilized and then increased, and there is some evidence that this is occurring. The only options available for stabilizing and increasing the population are to increase its recruitment (birth and survival of young to breeding age) or reduce its mortality rate. The resilience of Indiana bats to adverse environmental conditions is severely limited by the species' relatively low reproductive capability (Humphrey et al. 1977; Racey 1982; Barclay and Harder 2003; Racey and Entwistle 2003). Some species that experience declines during unfavorable periods are capable of quickly responding to improvements with rapid population growth. However, the Indiana bat cannot. Even if survival at each life stage increases dramatically, the Indiana bat population growth will be constrained by a maximum fecundity of one pup per female per year (Humphrey et al. 1977; Racey 1982; Barclay and Harder 2003; Racey and Entwistle 2003). Thus, depleted populations are likely to remain vulnerable for long periods of time.

Analysis of the species/critical habitat to be affected

Because the proposed action is programmatic and not specific, listed species other than the Indiana bat could occur within a project area. If it is determined that other listed species may occur within an individual project area, KYTC will conduct additional consultation with the

Service to address potential adverse affects to those species and/or potential adverse modification of designated critical habitat for those species.

This biological opinion considers the effects of the proposed action on the Indiana bat. In this biological opinion, the Service has concurred with the FHWA's "no effect" and "not likely to adversely affect" determinations for the Indiana bat for actions that meet the requirements of Tier 1 of the programmatic review process. Critical habitat has been designated for the Indiana bat, and is within the action area. However, measures contained in the HAM for both Tier 1 and 2 of the programmatic review process avoid modification of those critical habitat areas. Therefore, no Indiana bat designated critical habitat would be adversely modified as a result of the proposed action.

ENVIRONMENTAL BASELINE

Under section 7(a)(2) of the Act, when considering the "effects of the action" on federally listed species, the Service is required to take into consideration the environmental baseline. The environmental baseline includes past and ongoing natural factors and the past and present impacts of all Federal, State, or private actions and other activities in the action area (50 CFR 402.02), including Federal actions in the area that have already undergone section 7 consultation, and the impacts of State or private actions that are contemporaneous with the consultation in process.

Status of the species within action area

The Indiana bat ranges over an area of about 580,550 square miles in the eastern one-half of the United States (Service 1983). The Commonwealth of Kentucky lies near the center of the species range and numerous records of the species occupying summer and winter habitat within Kentucky exist. Occurrences of the species are clearly tied to the availability of the suitable summer and winter habitat. Potential winter habitat is static in the landscape because the caves and other underground features the species relies on for winter habitat do not change locations. However, the species will move from one winter habitat area to another to take advantage of better conditions in hibernacula, to take advantage of new hibernacula (e.g., mines), or to abandoned hibernacula that humans or other factors have altered or disturbed. Populations of Indiana bats that use Kentucky hibernacula have demonstrated population trends that are similar to the range-wide trends, and the species has been observed using hibernacula in each of the karst regions of Kentucky.

Conversely, Indiana bat summer habitat in Kentucky is typically ephemeral and is affected by factors such as land use, forest age structure, and other factors that deal with the quality, location, and availability of potential summer habitat. Summer records for the species occur across Kentucky, and 31 maternity colonies have been documented along with a number of locations for solitary males. Based on this distribution and the availability of summer habitat across Kentucky, Indiana bats can be expected to occur at any location where its habitat needs can be met. Further discussion on the status of the Indiana bat is provided in the Status of the Species/Critical Habitat (Indiana bat status in Kentucky) portion of this biological opinion.

Factors affecting the species' environment within the action area

It is difficult to identify specific factors affecting the species environment within the action area because the action area has been defined as the entire state of Kentucky and this biological opinion is based on analysis at a programmatic level rather than a specific project level. However, we are able to determine that there are a number of current and long-term land use and demographic trends could affect the Indiana bat within the action area. As a result of these trends, an increase in conversion of forested land to agricultural and/or residential development would further fragment and eliminate forested blocks of habitat used by the Indiana bat. In addition, natural factors such as, but not limited to, loss and/or lack thereof suitable maternity roost trees, reduction in the prey base, or loss and/or reduction in foraging acreage due to invasive species could negatively affect the Indiana bat. Further discussion on the factors affecting the species environment within the action area is provided in the Status of the Species/Critical Habitat (Threats) portion of this biological opinion.

We are aware of actions within the action area that are currently under review by the Service that have the potential to negatively affect the Indiana. However, these actions are undergoing individual review to minimize and avoid potential negative effects to the Indiana bat. It is not unreasonable to believe that further State and/or private actions occur within the action area. However, when applicable, the Service also provides technical assistance on those actions to minimize and avoid potential negative effects to the Indiana bat.

EFFECTS OF THE ACTION

Factors to be considered

Proximity of the action: As stated in the environmental baseline, the Commonwealth of Kentucky lies near the center of the species range and numerous records of the species occupying summer and winter habitat within Kentucky exist. The proposed action (construction of minor road projects) occurs within the entire state; therefore, it is reasonable to assume that Indiana bats may use the habitat within a specific project area being considered in this biological opinion. Due to this, it is likely that the proposed project will have a variety of effects on individual Indiana bats and/or Indiana bat maternity colonies. In particular, the proposed project activities are expected to (a) eliminate occupied and potential foraging and roosting habitat through removal and/or conversion of that habitat (e.g., summer roost trees, and foraging habitat); (b) alter habitat (e.g., fragmentation of foraging habitat, modification of travel corridors; (c) alter and/or modify normal Indiana bat behaviors (e.g., reproduction effects, foraging effects, and sheltering behaviors); and (d) potentially cause the mortality and/or injury of individual bats.

Again, this biological opinion considers only those actions that are in Indiana bat summer habitat. As discussed in the Description of the Proposed Action, there are two criteria within the review process of Tier 1 that would trigger additional informal consultation with the Service.

These criteria are described in the HAM and would require additional consultation when the proposed project may impact Indiana bat wintering habitat, including designated critical habitat (i.e., caves, mine adits, or other karst features exhibiting cave like characteristics), or known Indiana bat maternity colonies, with the exception of those projects found to have "no effect" on the Indiana bat. If either of these two criteria exist during the review of a minor road construction project, then KYTC will contact the Service for further assistance in order to fulfill Section 7 responsibilities.

Distribution: Based on the information contained in the previous paragraph and in the Environmental Baseline, it is probable that Indiana bats exist within and/or use the habitat within proposed project areas across Kentucky (i.e., action area). Construction of minor road projects occurs statewide; therefore, impacts to Indiana bat summer habitat would likely occur statewide.

Timing: Removal or destruction of habitat during the summer roosting period would cause the removal of habitat during a time that the species need and/or use the habitat. In addition, Indiana bats have been shown to show some site affinity to their roosting trees, so, if these trees are removed while the bats are not present, this is anticipated to cause a modification in the behavior of any bats that return to those areas. This could also cause those bats to use additional energy to locate a new roost, which may affect reproductive success.

Removal or destruction of habitat during the swarming period may also result in adverse effects to the species. Typically, Indiana bats swarm within a 5-mile radius of hibernacula, which is an area of over 50,000 acres. However, the maximum amount of habitat that could be removed for one of these minor projects is 25 acres or less than one-tenth of one percent of the potential acreage surrounding a hibernaculum. Therefore, we have considered the removal of habitat on one of these minor road projects that lies within a swarming area to be discountable as long as other suitable foraging habitat is present within the swarming area.

Nature of the effect: Construction of minor road projects may cause the removal of occupied and/or potential roosting and foraging habitat used by Indiana bats. In particular, the proposed project(s) could remove suitable roost trees, including an undetermined number of primary and secondary roosts. In addition, the proposed project(s) may further fragment existing habitat, which could alter habitat availability and quality.

Duration: The proposed action will cause the permanent destruction, alteration, and fragmentation of available summer habitat for the Indiana bat in Kentucky at sites where the minor road projects are constructed.

Disturbance frequency: Due to the nature of the minor road construction projects being considered in this biological opinion, the disturbance per proposed project will likely be a one-time disturbance that will likely occur during less than one summer roosting season. After completion of the construction, the disturbance will be continuous, because the habitat will be lost permanently.

Disturbance intensity: The intensity of the disturbance is difficult to estimate, because we do not know how much occupied habitat will be removed, how the bats will adjust to the habitat removal, or if the effects will cause changes in the population levels of the species.

Disturbance severity: The disturbance severity cannot be determined, because we do not have any idea about how Indiana bats will respond to this level of habitat alteration and destruction and how that response would affect the ability of the species to recover.

Analyses for effects of the action

Beneficial effects: The only beneficial effect that we can determine is the probable creation of an unknown number of potential roost trees that would result from construction activities near the periphery of the construction limits for the proposed projects.

Direct Effects:
During the summer roosting (i.e., non-hibernation) season Indiana bats often roost in live, damaged, and/or dead trees with or without naturally exfoliating bark. The presence of these trees, especially those of high quality (e.g., large with exfoliating bark), within a bat's home range is important, especially for females because they group together to give birth and rear their young until the juveniles become volant in these trees. Construction of proposed highway projects that are covered by Tier 2 (i.e., this biological opinion) will result in the direct removal of roosting trees and other summer habitat (i.e., foraging habitat) that are used or may be used by Indiana bats in the future, which would cause the bats to modify their normal behavior patterns in order to locate and use new roosting trees. Also, construction activities will result in the fragmentation of the Indiana bat foraging habitat, possibly making individuals more susceptible to predation. The noise and other disturbances caused by the action will also harass any Indiana bats that would forage close to the construction corridor, which would also modify their foraging behaviors.

Indirect Effects
The proposed project could indirectly cause the alteration and/or removal of additional Indiana bat habitat that results from residential and/or commercial development that is supported by construction of proposed Tier 2 projects. Also, placement of new highway improvements within a bat's home range could result in mortality of those individuals that attempt to cross the highway. However, these effects would likely occur after construction of the proposed project.

Species' response to a proposed action
After full consideration of the effects of the proposed action, the Service believes that any Indiana bats that would be adversely affected by the proposed action may continue to use the remaining habitat and/or relocate or shift to existing adjacent suitable habitat following implementation of the proposed project. While Indiana bats, and especially maternity colonies, have a strong roost affinity, it is not unreasonable for loss of and/or alteration of maternity roost trees and foraging habitat to occur naturally causing the mortality of adults and/or young and the maternity colony to seek additional roost trees or relocate to other forested areas. Considering that the habitat removed as a result of the proposed action would occur during the time of year when Indiana bats would occupy the area, it is reasonable to assume that Indiana bats would be

adversely affected, but we would expect that Indiana bats would be able to identify new roosting areas nearby, because other potential habitat it typically present throughout Kentucky. There is a general lack of scientific information regarding the locations of summer roosting Indiana bats and the ability of these bats, especially maternity colonies, to respond to habitat disturbance, either naturally or as a result of disturbance. This, coupled with our limited knowledge of the locations of all maternity colonies in Kentucky, makes it difficult to determine if the species would recover to levels that approximate their present levels once a minor road project is completed. However, due to the small size and scattered distribution of these projects in Kentucky, we believe it is highly unlikely that one or more of these projects would result in the loss of a significant number of Indiana bats including maternity colonies.

CUMULATIVE EFFECTS

Cumulative effects include the combined effects of any future State, local, or private actions that are reasonably certain to occur within the action area covered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section, because they require separate consultation under section 7 of the Act.

Potential impacts on the Indiana bat should be considered due to the potential for future development (i.e., residential, commercial, etc.) occurring adjacent to a new or improved infrastructure. However, the BA addresses only specific, minor road construction projects at a programmatic level throughout Kentucky; this type of development is generally associated with larger more complex new highway construction but also occurs for smaller road projects. In either case, however, the type and amount of additional impact on Indiana bats cannot be determined. Further, it is difficult to determine if any future actions are reasonably certain to occur because the action is programmatic rather than a specific project. Therefore, we have determined that there are no additional State, local, or private actions that are reasonably likely to occur as a result of proposed minor road construction projects.

CONCLUSION

After reviewing the current status of the Indiana bat; the environmental baseline for the action area; the effects of the proposed minor road construction projects; and the cumulative effects, it is the Service's biological opinion that proposed project, as defined in Appendix B of the BA, is not likely to jeopardize the continued existence of the Indiana bat. Critical habitat for the Indiana bat has been designated at a number of locations throughout its range, however, this action does not affect any of those designated critical habitat areas and no destruction or adverse modification of that critical habitat is expected.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulations under section 4(d) of the Act prohibit the taking of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the Act, provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the FHWA so that they become binding conditions on the KYTC for the exemption in section 7(o)(2) to apply. The FHWA has a continuing duty to regulate the activity covered by this Incidental Take Statement. If the FHWA (A) fails to assume and implement the terms and conditions or (B) fails to require the KYTC to adhere to the terms and conditions of the Incidental Take Statement through enforceable conditions, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the FHWA and/or KYTC must report the progress of the action and its impact on the species to the Service as specified in the Incidental Take Statement. 50 CFR 402.14(i)(3)

AMOUNT OR EXTENT OF TAKE ANTICIPATED

The Service anticipates incidental take of the Indiana bat will be difficult to detect for the following reasons:

1. The individuals are small and occupy summer habitats where they are difficult to find;

2. Indiana bats form small (i.e., 25-100 individuals), widely dispersed maternity colonies under loose bark or in the cavities of trees, and males and non-reproductive females may roost individually which makes finding the species or occupied habitats difficult;

3. Finding dead or injured specimens during or following project implementation is unlikely;

4. The extent and density of the species within its summer habitat in the action area is unknown;

5. Most incidental take that could occur is expected to be non-lethal and undetectable.

However, incidental take of Indiana bats can be expected as described in the effects analysis that was provided in the BA. We have reviewed FHWA's effects analysis and agreed that these are the effects of the proposed action on the Indiana bat. These effects are listed below:

Right-of-Way (ROW) and Utilities Phases

Direct effects of right-of-way investigations on the Indiana bat for each project will be the same and are listed below:

1. Harm of Indiana bats due to removal and destruction of summer foraging habitat;
2. Harm of Indiana bats due to removal and destruction of summer roost trees;
3. Harm and/or mortality of roosting Indiana bats, especially non-volant young, due to the removal and destruction of roost trees;
4. Harm of Indiana bats resulting from alteration of normal behavior patterns caused by the removal and destruction of summer habitat; and
5. Harm of Indiana bats due to alteration of occupied travel corridor habitat.

The indirect effects of the right-of-way phase on the Indiana bat for each project will be the same and are listed below:

1. Harassment of nearby Indiana bats due to disturbances and noise generated by human presence and/or the operation of equipment necessary for investigations;
2. Harm of Indiana bats due to predation or increased mortality as a result of disturbing its normal behavioral patterns;
3. Harm of Indiana bats due to alteration of potential travel corridor habitat;
4. Harm of Indiana bats due to loss of trees that exhibit the necessary characteristics that a Indiana bat could use for maternity roosting habitat; and
5. Harm of Indiana bats due to loss of trees that exhibit the necessary characteristics that an Indiana bat could use for summer roosting habitat.

Construction

The direct effects of road construction on the Indiana bat for each project will be the same and are listed below:

1. Harm of Indiana bats due to removal and destruction of summer foraging habitat;
2. Harm of Indiana bats due to removal and destruction of summer roost trees;
3. Harm and/or mortality of roosting Indiana bats, especially non-volant young, due to the removal and destruction of roost trees;
4. Harm of Indiana bats resulting from alteration of normal behavior patterns caused by the removal and destruction of summer habitat; and
5. Harm of Indiana bats due to alteration of occupied travel corridor habitat;

The indirect effects of road construction on the Indiana bat for each project will be the same and are listed below:

1. Harassment of nearby Indiana bats due to disturbances and noise generated by human presence and/or the operation of equipment necessary for construction;

2. Harassment of Indiana bats due to disturbances and noise generated by vehicle traffic on proposed minor road projects that include new alignments;
3. Harm of Indiana bats due to predation or increased mortality as a result of disturbing its normal behavioral patterns;
4. Harm and/or mortality associated with future traffic mortalities
5. Harm of Indiana bats due to alteration of potential travel corridor habitat
6. Harm of Indiana bats due to loss of trees that exhibit the necessary characteristics that a Indiana bat could use for maternity roosting habitat
7. Harm of Indiana bats due to loss of trees that exhibit the necessary characteristics that an Indiana bat could use for summer roosting habitat; and
8. Beneficial effects from the creation of potential roost trees at the edge of the construction limits once construction is completed.

The level of take identified below may result, because the FHWA anticipates that Indiana bat habitat would be removed as a result of project implementation. Because of the difficulty in determining a level of take based on the number of Indiana bats that will be adversely affected, the Service has decided that it is appropriate to base the level of authorized incidental take on the Indiana bat summer habitat acreage that will be affected by the proposed project. Therefore, the level of take authorized in this biological opinion is for those wooded areas of Indiana bat habitat within the construction limits of a proposed project covered by Tier 2 during KYTC FY 2006 through KYTC FY 2010, which was determined to be 500 acres of Indiana bat habitat as described in the HAM in KYTC FY06, 600 acres in KYTC FY07, 720 acres in KYTC FY08, 864 acres in KYTC FY09, 1,037 acres in KYTC FY10.

Incidental take of Indiana bats is expected to be in the form of harm (including mortality) and harassment and is expected to occur as a result of the phases discussed above that are associated with a proposed project. "Harm", as defined within the definition of "take" in the Act means an act that actually kills or injures wildlife. Such acts may include significant habitat loss and/or alteration where the act actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering. "Harass", as defined within the definition of "take" in the act means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Although mortality is the least likely form of take to occur, adult or juvenile Indiana bats may be killed as a result of removal of roosts trees and foraging habitat impairing natural breeding, feeding or sheltering activities. Harm may also occur through the habitat alterations that are anticipated to occur as a result of the action which include, but are not limited to, removal of potential roost trees and foraging habitat. Harassment may also occur as a result of the indirect effects outlined in previous sections of this biological opinion. However, likely sources of harassment to Indiana bats include, but are not limited to, noise and other disruptions (e.g., operations of personnel and equipment) within occupied habitat.

The level of take identified above is authorized from Kentucky FY06 to the end of KYTC FY10 or until information on adverse effects and/or incidental take of Indiana bats arises that would cause the re-initiation of the consultation on this action at an earlier date. The Service believes that re-initiation of consultation on this action is necessary after the end of KYTC FY10, because there is little specific information on the amount of incidental take that is likely to occur as a result of the action. In particular, specific information is lacking that would estimate the number of Indiana bats taken due to the proposed action. If available, these data would help estimate adverse effects to Indiana bats. Because of this, it is prudent for the FHWA and the Service to re-visit this action.

KYTC has limited abilities to provide measures that would minimize the effect of the anticipated take. Unlike many other state and federal agencies that own land, KYTC's focus is not on management of natural lands and/or habitats. KYTC owns very little land that would be suitable for management of Indiana bats and does not have staff that are trained and available to conduct management activities and other measures that could minimize the effect of the take authorized by this biological opinion. As a result, FHWA and KYTC have chosen to establish an Indiana Bat Conservation Fund (IBCF) as the only incidental take minimization measure associated with this programmatic consultation process. Funding for the IBCF would come from each project that uses the incidental take provided by this biological opinion and would be provided as specified in the BA. The funding would then be used to implement projects across Kentucky that would provide tangible conservation benefits to Indiana bats or that would provide important information on the species that would assist in management of the species.

EFFECT OF THE TAKE

In the accompanying biological opinion, the Service determined that this level of expected take is not likely to result in jeopardy to the Indiana bat or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measure(s) are necessary and proper to minimize the effect of incidental take of the Indiana bat:

1. The FHWA will ensure that any minor highway projects listed in Appendix B of the BA that are evaluated for effects on the Indiana bat using the Tier 1 and Tier 2 process will be evaluated according to the processes outlined in the HAM.

2. The FHWA will ensure that the minimization measure outlined in the BA that would establish an Indiana Bat Conservation Fund associated with the Tier 2 process is accomplished and operated in the manner specified in the BA.

3. The FHWA must monitor its activities associated with minor road construction projects to determine if the Terms and Conditions of this biological opinion are being implemented adequately in order to ensure that take is minimized and provide an annual report of those activities to the Service.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the FHWA must comply with the following Terms and Conditions, which carry out the Reasonable and Prudent Measures described above and outline required reporting/monitoring requirements. These Terms and Conditions are non-discretionary.

1. The FHWA shall ensure that the staff responsible for conducting the evaluations in Tier 1 and Tier 2 are adequately trained to implement and document the process. An initial training session shall be held in KYTC FY06 and additional sessions shall be held as necessary to train new staff and/or to address any modifications to the process that may occur. This Term and Condition is associated with Reasonable and Prudent Measure 1.

2. The FHWA shall use the formula and guidance contained in the BA to determine the amount of funding that will be provided to the Indiana Bat Conservation Fund. FHWA shall coordinate with KYTC and the Service to review the accuracy of the calculations used to determine Indiana Bat Conservation Fund funding on at least 10 projects annually. If fewer than 10 projects use the Indiana Bat Conservation Fund in any year, all calculations will be reviewed. This Term and Condition is associated with Reasonable and Prudent Measure 2.

3. The FHWA shall ensure that the following monitoring and reporting requirements are met to demonstrate FHWA's and KYTC's compliance with the process. This Term and Condition is associated with Reasonable and Prudent Measure 3.

    a. With respect to "no effect" projects in Section III of the HAM, the FHWA shall provide the information required by Section III, Item no. 9, in an annual report to be submitted by no later than January 31 for the previous calendar year of each year this biological opinion is in-effect.

    b. With respect to "not likely to adversely affect" projects in Section IV of the HAM, the FHWA shall provide the information required by Section IV, Item no. 4, in an annual report to be submitted by no later than January 31 for the previous calendar year of each year this biological opinion is in-effect.

    c. FHWA will require that KYTC maintain adequate records of each project that is subject to the programmatic consultation process through the end of KYTC FY10. If the project has not been constructed by the end of KYTC FY10, the records must be maintained until the project construction has been completed. Project records shall include, but not be limited to: (i) all completed, signed, and dated appendices from the HAM for the individual projects, (ii) any written descriptions and/or photographs of project sites and habitat conditions, and (iii) any relevant correspondence among the KYTC District offices, KYTC Division of Environmental Analysis, and the Service.

d. Annually, the FHWA will randomly select at least three (3), cleared "no effect" and at least three (3), cleared "not likely to adversely affect" projects from each KYTC district and the KYTC Division of Environmental Analysis (i.e., at least 78 projects per year) and perform an audit of the determinations that were made to ensure compliance with the Tier 1 process. The audit shall be conducted jointly with KYTC and the Service. The annual audits may be suspended at the Service's sole discretion and only upon KYTC's satisfactory performance in implementing and documenting the programmatic consultation process.

e. With respect to "may affect" projects that are covered by Tier 2 (i.e., this biological opinion), FHWA shall provide the following information - (i) KYTC item number, (ii) county (ies), (iii) project type, (iv) route number, (v) date of documentation utilizing incidental take, (vi) amount of incidental take used (i.e., in number of acres of habitat), and (vii) amount of required contribution to the Indiana Bat Conservation Fund – in a report on a semi-annual, calendar year basis no later than July 30 and January 31, respectively, of each year this biological opinion is in-effect. Each semi-annual report will identify those projects that were cleared by Tier 2 section 7 consultation during the previous 6-month period for which KYTC intends to use the incidental take of Indiana bats authorized by this biological opinion.

f. The reports in Term and Condition 3(a-c) above that are due on January 31 of each year can be submitted as one report. All reports shall include the Table below.

Table X. **Estimate of Indiana bat incidental take that occurred during [*Insert Year Monitoring Was Conducted*] as a result of the implementation of the [*Insert Name of Project*]**

Species	**Habitat**	
	Authorized Level of Habitat Alteration	Actual Level of Habitat Alteration
Indiana bat – Forest Habitat FY[*Insert year*]	[*Insert # of*] acres	[*Insert # of*] acres

The FHWA, KYTC, and/or its contractors must take care when handling dead or injured Indiana bats or any other federally listed species that are found in order to preserve biological material in the best possible state and to protect the handler from exposure to diseases, such as rabies. In conjunction with the preservation of any dead specimens, the FHWA, KYTC, and/or its contractors have the responsibility to ensure that evidence intrinsic to determining the cause of death or injury is not unnecessarily disturbed. The reporting of dead or injured specimens is required in all cases to enable the Service to determine if the level of incidental take authorized by this biological opinion has been reached or exceeded and to make sure that the terms and conditions are appropriate and effective. Upon locating a dead, injured, or sick specimen of any endangered or threatened species, prompt notification must be made to the Service's Division of Law Enforcement at 1875 Century Blvd., Suite 380, Atlanta, Georgia 30345 (Telephone:

404/679-7057). Additional notification must be made to the Service's Kentucky Ecological Services Field Office at 3761 Georgetown Road, Frankfort, Kentucky 40601 (Telephone: 502/695-0468).

The Reasonable and Prudent Measures, with their Terms and Conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. The Service believes that an indeterminate number of Indiana bats will be incidentally taken as a result of the proposed action with incidental take occurring on about 500 acres of wooded, Indiana bat habitat within the project area in KYTC FY06, 600 acres in KYTC FY07, 720 acres in KYTC FY08, 864 acres in KYTC FY09, and 1037 acres in KYTC FY10. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring re-initiation of consultation and review of the Reasonable and Prudent Measures provided. The FHWA must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the Reasonable and Prudent Measures.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to use their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. The following conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help carry out recovery plans, or to develop information.

The Service provides the following Conservation Recommendations to the FHWA:

1. The FHWA should undertake or fund additional research, inventory, and monitoring work that is necessary to better understand the ecology of the Indiana bat. In particular, project areas should be selected and monitored for Indiana bat maternity roosting, foraging, and travel corridor habitat use, which will provide information to compare and evaluate the effects of future transportation activities on Indiana bat habitat.

2. The demolition or removal of manmade structures (e.g. bridges) that harbor bats should occur while bats are hibernating elsewhere. If public safety is threatened and the structure must be removed while bats are present, a bat expert should examine the structure to determine if Indiana bats are present. Consultation with the Service should be initiated if Indiana bats are found.

3. The FHWA should explore ways to assist other agencies and organizations in the protection of Indiana bat summer and winter habitat through land protection, conservation, and management measures.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the conservation recommendations carried out.

REINITIATION NOTICE

This concludes formal consultation on minor road construction projects in Kentucky as defined in Appendix B of the BA and their effects on the Indiana bat, as outlined in the May 8, 2006, FHWA request for formal consultation. As stated in 50 CFR 402.16, re-initiation of formal consultation is required where discretionary FHWA involvement or control over the action has been retained (or is authorized by law) and if: (A) the amount or extent of incidental take is exceeded, (B) new information reveals effects of the FHWA's action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation, (C) the FHWA's action is later modified in a manner that causes an effect to the listed species or critical habitat not considered in this consultation, or (D) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease until re-initiation.

For this biological opinion, the authorized incidental take would be exceeded when the take exceeds 500 acres of Indiana bat summer habitat in KYTC FY 2006, 600 acres in KYTC FY 2007, 720 acres in KYTC FY 2008, 864 acres in KYTC FY 2009, 1,037 acres in KYTC FY 2010, as described in this document, which is the amount of take that has been exempted from the prohibitions of section 9 of the Act by this biological opinion. The aforementioned figures are based upon KYTC's Fiscal Year beginning July 1 through June 30. The total amount of incidental take that is covered for this period is 3,721 acres.

The Service appreciates the cooperation of the FHWA during this consultation. We would like to continue working with you or your staff on this project. For further coordination, please contact Mr. Phil DeGarmo of this office at the address listed above or at (502) 695-0468. This consultation was assigned Project No. FWS 06-0466; please refer to this number in any correspondence concerning this consultation.

Sincerely,

Virgil Lee Andrews, Jr.

Virgil Lee Andrews, Jr.
Field Supervisor

cc: Mr. Anthony Goodman, FHWA, Frankfort, KY
Mr. David Waldner, KYTC, Frankfort, KY
Field Supervisor, FWS, Asheville, NC (Attn: Mr. Bob Currie)
Field Supervisor, FWS, Bloomington, IN (Attn: Mr. Andy King)
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APPENDIX A

Table for Indiana Bat Annual Chronology (from Service 1999b).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Both sexes:												
	________	________	Hibernation	________	________				________	________	Hibernation	________
Females:				Emerge	Pregnant			Swarming				
"						Lactating						
Young:						Born	Flying					
Males:					Emerge			Swarming				
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC