Biological Opinion on the Effects of the Land and Resource Forest Management Plan and other Activities on Threatened and Endangered Species in the Green Mountain National Forest and Incidental Take Statement

CONSULTATION HISTORY

Formal consultation on the Green Mountain National Forest (GMNF) Land and Resource Management Plan (Forest Plan) was initially completed in January 1986. The U.S. Fish and Wildlife Service (Service) issued a biological opinion concluding that the Forest Plan would promote the conservation of the endangered peregrine falcon (*Falco peregrinus*) and that consultation for the endangered Indiana bat (*Myotis sodalis*) was not required since it was not known to occur on the GMNF.

The Vermont Department of Fish and Wildlife began systematically surveying mines and caves for hibernating bats in the late 1980s. In 1992, three hibernating Indiana bats were observed during a winter survey in Dorset/Aeolus Cave on privately-owned land adjacent to the Green Mountain National Forest. Further surveys of Dorset/Aeolus Cave documented two Indiana bats in 1993 and one Indiana bat in 1998. On December 18, 1997, New England Field Office (NEFO) staff organized a meeting of state and federal agencies to discuss Indiana bat recovery in New England. At that meeting, the participants agreed that the Forest Service should consider consulting formally with the Service under Section 7 of the Endangered Species Act (ESA) on the GMNF Forest Plan, if it were determined that Forest Service management might affect the Indiana bat.

In February, 1999, NEFO staff reviewed the first draft of the Biological Assessment (BA) for the Forest Plan and provided comments to the Forest Service on March 11, 1999. NEFO staff also participated, via telephone, in a February 9, 1999 meeting organized by the Vermont Conservation Law Foundation to discuss the potential effects of the GMNF's timber management activities on the Indiana bat. On March 11, 1999, NEFO staff attended a meeting organized by the GMNF to discuss recovery issues relative to the Indiana bat on the GMNF.

NEFO staff met with GMNF and the White Mountain National Forest staff on April 5, 1999 to discuss the potential effects of timber management on the Indiana bat and to continue informal consultation on Forest Service activities. On May 4, 1999, NEFO staff received a second draft BA for the GMNF Forest Plan and provided comments to the Forest Service on June 23, 1999. On June 24, 1999, NEFO staff met with the GMNF and other non-governmental agencies to discuss the Forest Service's decision to consult formally on the Indiana bat. Subsequently, NEFO staff participated in a July 8, 1999 field visit to a number of timber sales to review harvest methods on the GMNF.

During the week of August 3 through August 12, 1999, NEFO staff participated in a training session organized by the GMNF on survey techniques for the Indiana bat. During the week, a number of ongoing timber sales, completed timber sales and future timber sales were surveyed for bats. No Indiana bats were observed.

On September 21, 1999, the U.S. Forest Service requested that the U.S. Fish and Wildlife Service initiate formal consultation on the Forest Plan in an effort to assess potential adverse effects on the Indiana bat as a consequence of management activities on the GMNF.

On December 9, 1999, staff from the NEFO met with GMNF and White Mountain National Forest staff to discuss additional information needs for the biological opinion. On January 7, 2000, staff from the GMNF and the White Mountain National Forest held a follow-up meeting to discuss the draft biological opinion.

BIOLOGICAL OPINION

Description of the Proposed Action

As defined in 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 cumulative effects of reasonably certain future state or private activities within the action area.

The proposed action, as defined in the BA, is the implementation of the GMNF Forest Plan and projects predicated upon it. The proposed action includes ongoing projects as well as future site-specific projects. The Forest Plan is a general programmatic planning document that provides the "framework, through standards and guidelines and management area objectives, for future activities which will help create desired future conditions on the [GMNF]." The Forest Plan activities assessed in this Biological Opinion include timber sales, timber stand improvements, wildlife habitat management, road and trail construction and maintenance, and special uses (e.g., recreation, firewood permits).

In its BA, the GMNF outlined those activities in the Forest Plan that may adversely affect the Indiana bat, and requested concurrence on effects determinations for the peregrine falcon, bald eagle, Eastern cougar, gray wolf and Canada lynx (a proposed species). Because the Service has concurred with the Forest Service that continued implementation of the GMNF Forest Plan is not likely to jeopardize the continued existence of the proposed threatened Canada lynx, and concluded that a no effect determination is warranted for the bald eagle, Eastern cougar and gray wolf, these species will not be considered further in this opinion. Additionally, since the peregrine falcon was delisted on August 25, 1999, the Forest Service's determination of "not likely to adversely affect" is no longer necessary pursuant to Section 7 of the ESA; thus, this species will not be considered further in this opinion. Therefore, this Biological Opinion only addresses adverse effects on the Indiana bat and whether or not continued implementation of the Forest Plan on the GMNF is likely to jeopardize the continued existence of the Indiana bat.

The National Forest Management Act requires that the Forest Plan be revised every 10 to 15 years. Although the Forest Plan is scheduled to be revised by 2002, the date of revision is uncertain due to Congressional action that temporarily delays Forest Plan revisions for the GMNF. For the purposes of this Biological Opinion, the Service will consider the date of project completion to be 2010.

The Forest Plan's goals are segregated into the following categories: 1) resource protection, 2) public use and enjoyment, 3) vegetation management, and 4) landownership adjustment. Within the goals, the Forest Plan identifies a number of objectives that are time-specific with measurable results. The Forest Plan allocates land to specific management areas, each of which has an identified future condition defined by long-term management objectives and associated outputs (measurable results). Additional management direction and guidelines are included in the Forest Plan for 15 specific management areas whose extent and purpose are summarized in Appendix 1.

Land use allocations are made, and outputs are projected, based upon the direction established in the Forest Plan. The Forest Plan establishes multiple-use management area prescriptions (including associated standards and guidelines) that can be amended following monitoring and evaluation. Forest Service personnel review all proposed project-level activities under the National Environmental Policy Act and assess project effects on federally-listed species in compliance with Section 7 of the ESA.

Management of the GMNF under the Forest Plan includes: 1) wildlife habitat management; 2) timber management; 3) insect and disease management; 4) roads management; 5) energy production and minerals management; 6) recreation management; and 7) fire management. Appendix 2 groups and summarizes planned and completed Forest Plan activities (drawn from the BA, page 12). Each of these management activities is described here, and will be evaluated for potential effects on the Indiana bat.

Wildlife Habitat Management

The Forest Plan prescribes timber harvest as the primary method of managing wildlife habitat for designated species. Other wildlife habitat management activities include the creation and maintenance of wildlife openings, apple tree orchard pruning and restoration, shrub planting, the placement of natural structures in streams, and waterfowl nesting habitat enhancement. Within the past decade, an average of 600 acres was managed annually for wildlife habitat, excluding the use of timber harvest.

Timber Management

Approximately 95 percent of the GMNF is forested habitat that is classified into five broad categories: northern hardwoods (83% of the GMNF), softwoods (8%), aspen and paper birch (5%), openings (3%), and oak (1%). Forest age classes on the GMNF range from 0 years to older than 100 years (Table 1). Of the 374,134 acres comprising the GMNF, approximately 141,000 acres (38%) are considered to be commercial forest land, of which 83 percent is saw-timber sized (generally 8 inches dbh and greater) and older than 60 years of age. Timber harvesting through sales is the primary management activity that alters and/or disturbs the greatest acreage of forested habitat on the GMNF. Between 1987 and 1996, the average annual timber harvest was approximately 1,900 acres (BA, page 19) or 8.2 million board feet.

Table 1. Forest age classes[1]

Age Class (years)	Acres	Percent of GMNF
0 -19	18,725	5%
20 - 39	18,725	5%
40 - 59	26,215	7%
60 - 79	71,155	19%
80 - 99	101,115	27%
100+	93,625	25%
uneven age	44,940	12%

Timber management techniques used on the GMNF included even-aged and uneven-aged stand management, reforestation and the cutting of firewood (cutting of dead or down trees). The different treatment and harvest techniques that could be used for specific management areas are described below, as taken from the BA (page 19).

> *Intermediate thinning* reduces the number of trees in stands with greater than 80 percent relative density (approximately 71 percent canopy closure) to approximately 60 percent relative density (approximately 54 percent canopy closure), generally by removing smaller diameter trees. Open canopy conditions persist for 15 to 20 years following the thinning.
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> *Shelterwood treatments* establish seedling regeneration through the application of one or two "preparation or seed cuts" (removing selected trees in order to allow "seed trees" to flourish), followed by the almost complete removal of overstory trees. Upon completion of the treatment, relative density is reduced from 80 percent or greater (71 percent canopy closure) to 30 to 40 percent relative density (less than 30 percent canopy closure).
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> *Delayed-shelterwood treatments* establish seedling regeneration of shade-tolerant species (sugar maple, American beech, red maple) in areas where the second cut of a standard shelterwood treatment (see above) is delayed for 40 to 60 years. The relative density of 80 percent is reduced to 30 to 40 percent canopy closure in the first cut of the shelterwood treatment.

[1] Information taken from Table 2 on page 17 of the BA.

Clear cut treatments remove all trees in the stands. Existing seedlings are the basis for regeneration. Clear cut treatments are used primarily to regenerate "low quality" northern hardwood stands, regenerate aspen stands (in existing aspen stands) or to convert hardwood stands to softwood stands. Between 1987 and 1996, an average of 250 acres was clear cut annually.

Improvement cut treatments modify the age and size class by removing designated trees through commercial harvest.

Individual tree selection removes lower quality trees and salvages trees that would otherwise die (diseased or injured trees) and opens the canopy by reducing the number of trees in stands of greater than 80 percent relative density to approximately 60 percent relative density.

Group selection removes clumps of trees (usually ¼ to ½ acre) with the removal criteria that are similar to those for individual tree selection, although final relative density will be lower and may be as low as 50 percent relative density.

Reforestation techniques may incorporate any of the above treatments. Seedling regeneration generally occurs naturally on the GMNF.

Firewood permits allow the cutting of standing dead or down trees. Approximately 50 to 150 personal use firewood permits (averaging about 2 to 3 cords of wood per permit) are sold each year. The cutting of standing dead or down trees is allowed within 150 feet of most open Forest Service roads.

Forest Plan standards and guidelines were developed to minimize adverse effects to forest wildlife and water quality that may result from timber harvesting. These standards and guidelines include, among other things, criteria for snag[2] and den[3] tree retention, and maintenance of riparian vegetative buffer strips. Timber sale contracts must provide for the retention and protection of wildlife reserve trees, including snag and den trees.

Forest Plan standards and guidelines require that snag and den trees are retained "in sufficient quality, quantity, and distribution to maintain well dispersed, self-sustaining populations of all snag, den, nest and

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[2] The Forest Plan defines snags as dead or partially dead trees at least 6 inches dbh and 20 feet tall. Hard snags have essentially "sound" exterior wood and may be marketable. Soft snags are trees in an advanced state of decay.

[3] The Forest Plan defines den trees as live trees at least 15 inches dbh containing a natural cavity that may be used by wildlife for nesting, brood rearing, hibernating, or shelter.

mast-dependent wildlife indigenous to the Green Mountain National Forest" (Forest Plan, Chapter IV). In order to achieve this goal, the standards and guidelines require that all soft snags must be left unless they pose a safety hazard. In addition, two hard snags, one den tree and one replacement tree must be left per acre (although mast trees may be substituted for hard snags, den trees or replacement trees). If no hard snags are available, two replacement trees must be left. The standards and guidelines require that soft and hard snags and den trees be left within permanent openings and riparian zones. All soft and hard snags and den trees must be left within 300 feet of permanent openings, ponds, lakes, beaver ponds, and wetlands greater than five acres; within riparian zones of all permanent streams; and within 100 feet of beaver ponds less than five acres. If hard snags and den trees are not available in these areas, at least six replacement trees per acre must be left.

With respect to hard snag selection, the standards and guidelines require that the largest diameter hard snags are selected in order to meet the habitat needs of all species. Priority of snag selection might also be established by evidence of wildlife use. Den trees should be 15 inches dbh or greater with a cavity opening that is not prone to collecting water. The standards and guidelines also recommend the retention of clumps of wildlife reserve trees, especially around nest trees, as opposed to scattered individual trees.

Vegetative buffer strips adjacent to riparian areas[4] are also addressed in the Forest Plan standards and guidelines. Filter strips are designed based on the slope and erosion potential of the soil (a table defining the various widths is found on page 4.19 of the Forest Plan). The filter strip separates roads, log landings, construction and other earth-disturbing activities from streams, lakes and other bodies of water. The root mat within the strip must be protected and soil must be left undisturbed. Vegetation within the strip that provides shade to a stream (buffer strip) must be maintained.

Insect and Disease Management

In 1991, the GMNF aerially applied a naturally-occurring bacterium, *Bacillus thuringensis* (B.t.), in an effort to suppress a predicted gypsy moth infestation. No treatments have been conducted since 1991 and none are planned to occur in the near future. Herbicide or insecticide applications are not used on the GMNF for timber management.

Roads Management

Approximately 795 miles of road occur on the GMNF, although GMNF personnel regulate traffic only on 146 miles. The remainder is regulated by the state, towns and local landowners. On average (based on 1987 to 1996 data), the GMNF annually constructs 0.6 mile of road, maintains 111 miles, reconstructs 0.5 mile and restores 1.3 miles of road. In addition, approximately five new parking spaces were created annually during this same time period, although 14 additional parking spaces were created in 1997.

[4]The Forest Plan (page 4.19) considers a riparian area to be the zone between seasonally dry land and surface waters as well as the waterbody itself.

Energy Production and Minerals Management

Currently, there are a few sand and gravel operations on the GMNF, which are generally small "borrows" used by the GMNF and local road agencies. There is no evidence or history of mineral presence on the GMNF that may be of interest for leasing for extraction. No energy production activities, such as hydropower or wind power, are proposed in the near future.

Recreation Management

The GMNF receives more than three million visitors annually and contains seven campgrounds, three alpine ski areas, seven ski touring areas, 448 miles of motorized trails and 514 miles of non-motorized trails. Within this trail system are over 130 miles of the Appalachian and Long Trails (there is some overlap of these trail systems).

There are six federally-designated wilderness areas covering over 59,598 acres (see Appendix 1). Within these areas, no vegetative manipulation may occur other than trail maintenance. Motorized or mechanized vehicles or equipment are not permitted within the wilderness areas.

Fire Management

Prescribed fire is used on the GMNF to create and maintain interior forest openings. Between 1987 and 1996, an average of 260 acres of openings was annually treated with prescribed fire. Burns are conducted primarily in the spring (last two weeks of April or first week of May) and occasionally in the fall (October or November).

Conservation Measures

Conservation measures are activities that the action agency will implement as part of the proposed project to further the recovery of the species under review. Conservation measures should be closely related to the action and should be achievable within the authority of the action agency. The beneficial effects of conservation measures are taken into consideration in the Service's conclusions regarding jeopardy, and in the analysis of incidental take. However, such measures must minimize impacts to listed species within the action area in order to be factored into the Service's analyses.

There are no standards and guidelines designed specifically to protect, maintain, or enhance summer or winter Indiana bat habitat, or to prevent impacts to Indiana bats roosting in trees. However, impacts to Indiana bats resulting from various land management activities (e.g., timber harvesting), may be incidentally minimized through the implementation of standards and guidelines specific to those activities. For example, the take of Indiana bats roosting and foraging on the GMNF would be minimized by the requirement that most tree harvesting activities occur during the winter (harvest time-of-year requirements are based on soil

characteristics of the stand). As a result of this standard and guideline, 75 percent of the timber harvests on the GMNF occur during the Indiana bat's hibernation season (October through April). Forest Plan standards and guidelines for snag and den tree retention and riparian filter strip protection during timber harvesting may also minimize the impacts to migrating or summering Indiana bats. Managing approximately 63 percent of the GMNF for late-successional/old-growth values and riparian values may ensure, through natural processes, ample suitable foraging and roosting habitat for Indiana bats.

Status of the species/critical habitat likely to be affected

Most of the information presented below on Indiana bat habitat requirements, life history, status, and threats is taken from the Service's agency draft recovery plan (U.S. Fish and Wildlife Service 1999a) and the Mark Twain National Forest Biological Opinion (McKenzie 1999).

Species Description

The Indiana bat is a medium-sized, monotypic species of bat (there are no subspecies) of the genus *Myotis,* that occurs in much of the eastern half of the United States. Head and body length range from 1 5/8 - 1 7/8 inches (41 to 49 millimeters) (U.S. Fish and Wildlife Service 1999a). This species is similar in appearance to both the little brown bat *(M. lucifugus*) and the northern long-eared bat *(M. septentrionalis)*. Indiana bats characteristically have a distinctly keeled calcar and their hind feet tend to be small and delicate with fewer, shorter hairs that do not extend beyond the toenails. The ears and wing membranes have a dull appearance and flat coloration that does not contrast with the fur. The fur of the chest and belly is lighter than the flat (not glossy), pinkish-brown fur on the back, but does not contrast as strongly as does that of the little brown or northern long-eared bat. The skull has a small sagittal crest, and the braincase tends to be smaller, lower, and narrower than that of the little brown bat (U.S. Fish and Wildlife Service 1999a). On average, the Indiana bat weighs between 0.2 and 0.3 ounces (6 - 9 grams) (Harvey *et al.*, 1999).

Habitat Requirements

Winter habitat The Indiana bat requires specific roost sites in caves or mines that attain appropriate temperatures for hibernation. In southern parts of the species' range, Indiana bat hibernacula trap large volumes of cold air and the bats tend to hibernate where resulting rock temperatures drop. However, in northern parts of the range, the bats avoid the coldest sites. In both cases, Indiana bats choose roosts with a low risk of freezing. Ideal sites are 50° F (10° C) or colder when the bats arrive in October and November (U.S. Fish and Wildlife Service 1999a). Early studies identified a preferred mid-winter temperature range of 39° to 46° F (4-8° C); however, a recent examination of long-term data suggests that a slightly lower and narrower range of 37° to 43° F (3-6° C) may be ideal for the species (U.S. Fish and Wildlife Service 1999a). Only a small percentage of available caves provides this special thermal requirement.

Stable, low temperatures allow the bats to maintain a low metabolic rate and to conserve fat reserves through the winter (Humphrey 1978, Richter *et al*. 1993). Indiana bats will occasionally use sites other than caves or mines if microclimate conditions are favorable. 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 36E F (4.7E C).

Relative humidity at roost sites during hibernation is usually greater than 74 percent but less than saturation (Humphrey 1978, Kurta and Teramino 1994, U.S. Fish and Wildlife Service 1999a), although relative humidity as low as 54 percent has been observed (U.S. Fish and Wildlife Service 1999a). 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. Indiana bats select roosts within hibernacula that best meet their need 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 (U.S. Fish and Wildlife Service 1999a).

Indiana bats often hibernate with other species of bats, and are occasionally observed clustered with, or adjacent to, other species, including gray bats (*Myotis grisescens*), Virginia big-eared bats (*Plecotus townsendii virginianus*), little brown bats, northern long-eared bats (Kurta and Teramino 1994, Hicks 1999) and small-footed bats (*Myotis leibii*) (Hicks 1999).

Summer habitat A full, well-integrated understanding of the summer needs of this endangered species has yet to be reached. Early researchers considered floodplain and riparian forest to be the primary roosting and foraging summer habitats of the Indiana bat (Humphrey *et al*. 1977), and these forest types unquestionably are important. More recently, Indiana bats have been documented using upland forests for roosting (Clark *et al*. 1987, Callahan *et al*. 1997); and old fields and pastures with scattered trees for foraging (U.S. Fish and Wildlife Service 1999a).

Indiana bats live in highly altered landscapes in the eastern United States and use ephemeral, mostly dead and dying trees for roosting. Anecdotal evidence suggests that the Indiana bat may, in fact, respond positively to some degree of habitat disturbance. In northern Missouri, maternity roosts were found in areas that were heavily disturbed (McKenzie 1999). In some cases, timber management activities that occurred within occupied Indiana bat habitat were reported to have no effect on the bats. For example, Indiana bats continued to forage and roost in an area that had been harvested in Illinois (Gardner *et al*. 1991). The species also has been found roosting in shelterwood cuts in Kentucky (U.S. Fish and Wildlife Service 1999a).

It is possible that Indiana bats in the western portion of their range may have evolved as a savannah species (U.S. Fish and Wildlife Service 1999a). Indiana bats appear to prefer open canopies, forests with an open understory, and fragmented forest landscapes (U.S. Fish and Wildlife Service 1999a). This theory is supported by the analysis of several maternity sites conducted by Romme *et al*. (1995), who found that most Indiana bat roosts were located in areas that had a canopy closure of 60 to 80 percent. Humphrey *et al.* (1977) hypothesized that roost trees were usually located in openings within the forest because they provided the necessary thermoregulatory characteristics.

Within the range of the Indiana bat, its presence within a particular area may be governed by the availability of natural roost structures, primarily standing dead trees with loose bark. 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 (U.S. Fish and Wildlife Service 1999a).

A number of tree species have been reported to be used as roosts by Indiana bats. These include: American beech (*Fagus grandifolia*), ashes (*Fraxinus* spp.), black gum (*Nyssa sylvatica*), black locust (*Robinia pseudo-acacia*), cottonwood (*Populus deltoides*), elms (*Ulmus* spp.), hickories (*Carya* spp.), maples (*Acer* spp.), oaks (*Quercus* spp.), pines (*Pinus* spp.), sassafras (*Sassafras albidum*), sourwood (*Oxydendrum arboreum*), sweet birch (*Betula lenta*), yellow buckeye (*Aesculus octandra*) (Cope *et al*. 1974, Humphrey *et al*. 1977, Gardner *et al*. 1991, Kurta *et al*. 1993, Romme *et al*. 1995, Kiser and Elliott 1996, Kurta1996, Callahan *et al*. 1997), and recently, hemlock (*Tsuga canadensis*) (R. Currie, U.S. Fish and Wildlife Service, Asheville Field Office, pers. comm. 1999). The morphological characteristics of tree bark make certain tree species more suitable as roosts for Indiana bats. Dead, senescent, or severely injured (e.g., lightning-struck) trees that possess bark that springs away from the trunk upon drying will provide niches or crevices for roosting Indiana bats. The persistence of peeling bark varies with the tree species (U.S. Fish and Wildlife Service 1999a). Additionally, the structure of the bark, such as the shaggy bark of some living hickories and large white oaks (*Quercus alba*) also provides roost sites. Therefore, the most important characteristic of trees is not the tree species but rather the bark structure that provides space for bats to roost between the bark and the bole of the tree.

Occasionally, tree cavities or hollow portions of tree boles and limbs provide roost sites for Indiana bats (Gardner *et al*. 1991). Other sites used for roosting include crevices in the tops of lightning-struck trees (Gardner *et al*. 1991), and splits below splintered, broken tree tops (U.S. Fish and Wildlife Service 1999a).

Recently, Indiana bats have been found roosting in artificial structures including church steeples (C. Stihler, West Virginia Department of Natural Resources, pers. comm. 1999) and telephone poles (P. McKenzie, U.S. Fish and Wildlife Service Columbia, Missouri Field Office, pers. comm. 1999). Bridges have been used as night roosts in West Virginia (W. Tolin, U.S. Fish and Wildlife Service, West Virginia Field Office, pers. comm. 1999) and Kentucky (J. Kiser, Appalachian Technical Services, pers. comm. 1999).

Indiana bat maternity colonies use multiple roosts in both dead and living trees. Important factors in determining the suitability and use of a roost tree are the tree's exposure to sunlight and location relative to other trees. Cool temperatures can delay the development of fetal and juvenile young (Racey 1982), possibly making selection of maternity roost sites critical to reproductive success. Dead trees with east-southeast and south-southwest exposures may allow solar radiation to effectively warm nursery roosts. Roosts in some species of living trees [e.g., shagbark hickory (*Carya ovata*)], on the other hand, may provide better protection from rain water and other unfavorable environmental conditions. Their greater thermal mass retains more favorable temperatures for roosting bats during cool periods (Humphrey *et al*. 1977).

Most roost trees used by maternity colonies are closely spaced. The spatial extent and configuration of a colony are probably determined by the availability of suitable roosts. The distances between roosts occupied by bats within a single maternity colony are documented to have ranged from just a few yards to several miles. In Missouri, maximum distances between roost trees used by bats from the same maternity colony have ranged from 1.0 to 1.9 miles (McKenzie 1999). Kurta (1996) documented a range of distances between roost trees, generally less than 0.6 mile (<1 km), although one female traveled 3.4 miles (5.8 km) between roost trees.

Indiana bat maternity roosts can be described as "primary" or "alternate" based on the proportion of bats in a colony occupying the roost site, and on the location of the roost site in relation to forest canopy cover (Callahan *et al*. 1997, Kurta *et al.* 1996). Maternity colonies have at least one primary roost (up to three have been identified for a single colony) that may be used by the majority of the bats throughout the summer. Colonies may also have multiple alternate roosts that are used by small numbers of bats intermittently throughout the summer (U.S. Fish and Wildlife Service 1999a). Kurta *et al.* (1996) studied a maternity colony in northern Michigan over a three-year period and noted that roosting bats changed roost trees every 2.9 days and that the number of roosts used by the colony ranged from five 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.* 1991, Kurta *et al.* 1993, Romme *et al.* 1995).

Primary roosts are located in openings or at the edge of forest stands, while alternate roosts can either be in the open or in the interior of forest stands. Primary roosts are not surrounded by closed 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 preferred when temperatures are above normal or during periods of precipitation. The selection of a roost site and its use may differ between northern and southern parts of the species' range. However, analyses have not yet been undertaken and more data are needed to determine whether there are geographical differences.

Primary roost trees that have been studied to date have ranged in size from 12.2 to 29.9 inches dbh (Romme *et al*. 1995). 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) (Romme *et al*. 1995). Trees were significantly larger (12 inches dbh) at sites in northern Missouri where reproductively active Indiana bats were captured than at sites where they were not captured (U.S. Fish and Wildlife Service 1999a).

It is generally not possible to estimate the longevity of an individual tree suitable for roosting by Indiana bats. Bark may slough off completely or the tree may fall. Some tree species may only be habitable for one to two years under "natural conditions" for some tree species (Humphrey *et al*. 1977), while others with good bark retention such as slippery elm, cottonwood, green ash (*Fraxinus pennsylvanica*), and oaks, may provide roosting habitat for four to eight years (Gardner *et al*. 1991, Callahan *et al*. 1997, U.S. Fish and Wildlife Service 1999a).

Humphrey *et al*. (1977) suggested that previously-used summer roosts may be important to the reproductive success of local Indiana bat populations, and that if these roosts are lost or unavailable, adult females may be faced with finding suitable maternity sites at a time when they are already stressed from post-hibernation migration and the increased metabolic energy costs of pregnancy. Bats move from one roost to another within a season, when there are changes in environmental conditions (temperature and precipitation), or when a particular roost becomes unavailable due to being blown down or structurally damaged (Gardner *et al*. 1991, Callahan *et al*. 1997). Thus, the species appears to take advantage of the ephemeral habitat available to it. Nonetheless, it is apparent that a variety of suitable roosts within a colony's occupied summer range should be available to assure the continuance of the colony in that area (Kurta *et al*. 1993, Callahan *et al*. 1997).

Individual Indiana bats are known to occupy distinct home ranges during the summer. Average home range sizes vary from approximately 70 acres for juvenile males to over 525 acres for post-lactating adult females (McKenzie 1999). Roosts occupied by individuals ranged from 0.33 mile to over 1.6 miles from preferred foraging habitat, but are generally within 1.2 miles of water [e.g., stream, lake, pond, natural or manmade water-filled depression (McKenzie 1999)].

Indiana bats exhibit varying degrees of site fidelity to summer colony areas, roosts, and foraging habitat. Humphrey *et al*. (1977), Gardner *et al*.(1991), Callahan *et al*. (1997) documented the use by female Indiana bats of the same roosts from one year to the next. Kurta *et al*. (1996), however, noted that individuals in a maternity colony in northern Michigan "were not highly faithful to a particular tree." In Illinois, male Indiana bats exhibited some site fidelity to summering areas they had occupied during previous years (McKenzie 1999).

Fall and spring roosts Indiana bats use roosts in the spring and fall similar to those selected during the summer, although fall roost trees more often tend to be exposed to sunshine rather than shade (U.S. Fish and Wildlife Service 1999a). 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 (2.4 km) of their hibernaculum. In West Virginia, male Indiana bats roosted within 3.5 miles (5.6 km) of their hibernaculum in trees near ridgetops, and often switched roost trees from day to day (U.S. Fish and Wildlife Service 1999a).

Upon emergence from hibernation in the spring, some males remain within the vicinity of their hibernacula, where they roost and forage in mature forests; movements of 2.5 to 10 miles (4-16 km) have been reported in Kentucky, Missouri, and Virginia (Hobson and Holland 1995; McKenzie 1999). However, other males were reported to leave the area entirely upon emergence in the spring.

Foraging habitat and behavior Indiana bats forage in and around the tree canopy of floodplain, riparian, and upland forests. In riparian areas, Indiana bats primarily forage around and near riparian and floodplain trees [e.g., sycamore (*Platanus occidentalis*), cottonwood, black walnut (*Juglans nigra*), black willow (*Salix nigra*), and oaks], and solitary trees and forest edge on the floodplain (Cope *et al*. 1974, Humphrey *et al*. 1977, Clark *et al*. 1987). Within floodplain forests used by foraging Indiana bats, canopy closures range from 30 to 100 percent (McKenzie 1999). 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 1½ miles (2.5 km) from upland roosts. 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 fence rows, and over farm ponds in pastures (Clark *et al*. 1987).

Indiana bats usually forage and fly from 6 - 100 feet (2 - 30 m) above ground level (Humphrey *et al*. 1977). Most Indiana bats caught in mist nets are captured over streams and other flyways at heights greater than 6 feet (2 m) (Gardner *et al*. 1989).

During the 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 (*M. grisescens*). Some male bats also foraged at the edges of small floodplain pastures, within dense forest, and on hillsides and ridge tops; the maximum reported distance was 1.2 miles (2 km) (LaVal *et al.* 1977). In the fall, male Indiana bats tend to forage in upland and ridgetop forests, but may also forage in valley and riparian forest; movements of 1.8 - 4.2 miles (2.5 - 6.8 km) have been reported in Kentucky (Kiser and Elliott 1996).

Life History

Generally, Indiana bats hibernate from October through April (Hall 1981) or from September through early May in northern areas (U.S. Fish and Wildlife Service 1999a), depending upon local weather conditions (see Figure 1 for a depiction of the annual cycle). They hibernate in large, dense clusters of up to 300 bats per square foot (3,230 bats/m^2) (Clawson *et al*. 1980; Clawson 1987). In New York, data collected over a number of years indicate that Indiana bats demonstrate site fidelity to and possibly within the hibernaculum (A. Hicks, New York Department of Conservation, pers. comm. 1999).

Upon arrival at hibernating 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", although relatively few roost in the caves during the day (Cope and Humphrey 1977). Swarming continues for several weeks 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 (U.S. Fish and Wildlife Service 1999a), although swarming has occurred in caves other than those in which the bats hibernated (Cope and Humphrey 1977).

During swarming, males remain active over a longer period of time at cave entrances than do females, most likely to mate with females as they arrive (McKenzie 1999). After mating, females enter directly into hibernation, followed by the males (Clawson 1987). A majority of bats of both sexes hibernate by the end of November (by mid-October in northern areas) (McKenzie 1999), but hibernacula populations may increase throughout the fall and even into early January (Clawson *et al*. 1980).

Figure 1. Indiana bat annual chronology (from U.S. Fish and Wildlife Service 1999a)

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

Adult females store sperm through the winter and become pregnant via delayed fertilization soon after emergence from hibernation. Young female bats can mate in their first autumn and have offspring the following year, whereas males may not mature until the second year. Limited mating activity occurs in the winter and into late April, as the bats leave hibernation (U.S. Fish and Wildlife Service 1999a).

Females emerge from hibernation ahead of males; males exit over a longer period of time (Clawson 1987). Most wintering populations leave by early May although they may emerge later in the northern portion of their range. Indiana bats (3 percent of the mid-winter count) have been documented roosting in a New York hibernaculum as late as May 29 under fairly average springtime weather conditions (A. Hicks 1999). Some males spend the summer near hibernacula, as has been observed in Missouri and West Virginia (U.S. Fish and Wildlife Service 1999a).

Females have been observed at their summer habitats as early as April 15 in Illinois (Gardner *et al*. 1991). Humphrey *et al*. (1977) determined that Indiana bats first arrived at their maternity roost in early May in Indiana, with substantial numbers arriving by mid-May.

Female Indiana bats have never been documented in Vermont during the summer. However, it may be expected, due to the fact that average springtime temperatures are cooler in Vermont than in the center of the Indiana bat's range, that females would generally arrive later in May. One of the primary factors in determining the arrival of female Indiana bats (as well as males) may be temperature. In general, insectivorous bats will not forage when temperatures fall below 50° F (P. Huber, U.S. Forest Service Huron-Manistee National Forests, *in litt*. 1998). Furthermore, Humphrey *et al*. (1997) believed that cool temperatures might prolong gestation and juvenile growth of Indiana bats. Therefore, it is possible that Indiana bats arriving in late April or early May in Vermont may be unable to forage, and any that do arrive early may reproduce unsuccessfully.

During early spring, a number of roosts (e.g., small cavities) may be used temporarily, until a roost with larger numbers of bats is established. Parturition occurs in late June and early July (Easterla and Watkins 1969; Humphrey *et al*. 1977) and young are able to fly between mid-July and early August (Mumford and Cope 1958, Cope *et al*. 1974, Humphrey *et al*. 1977, Clark *et al*. 1987, Gardner *et al*. 1991, Kurta *et al*. 1996).

Most of the documented maternity colonies contained 100 or fewer adult bats. After grouping into nursery colonies, females give birth to a single young in late June or early July. 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, while other males remain near their hibernacula. Maternity colonies occupy roost sites in forested riparian, floodplain, or upland habitats, and exhibit strong roost site fidelity (Clark *et al* 1987, Gardner *et al.* 1991, Callahan *et al.* 1997, U.S. Fish and Wildlife Service 1999a).

Young Indiana bats are capable of flight within a month of birth. Young born in late June may be flying as early as the first week of July (Clark *et al.* 1987), and most young are flying between mid-to-late July. Indiana bats spend the latter part of the summer accumulating fat reserves for fall migration and hibernation.

Humphrey and Cope (1977) determined that female survivorship in an Indiana population of Indiana bats was 76% for ages one to six years, and 66% for ages six to 10 years; for males, survivorship was 70% for ages one to six years, and 36% for ages six to 10 years. The maximum age for banded individuals was 15 years for females and 14 years for males. Mortality between birth and weaning has been estimated at 8% (Humphrey *et al.* 1977).

Indiana bats feed only on flying insects, both aquatic and/or terrestrial. They are habitat generalists and their selection of prey items reflects the environment in which they forage. Diet varies seasonally and among different ages, sexes, and reproductive-status groups (U.S. Fish and Wildlife Service 1999a). Reproductively active females and juveniles exhibit greater dietary diversity than males and non-reproductively active adult females, perhaps due to higher energy demands. Reproductively active females eat more aquatic insects than do adult males or juveniles (U.S. Fish and Wildlife Service 1999a; McKenzie 1999).

Moths (Lepidoptera) are major prey items identified in several studies (Brack and LaVal 1985, U.S. Fish and Wildlife Service 1999a); however, Kurta and Whitaker (1998) also documented caddisflies (Trichoptera) and flies (Diptera) as major prey items. A third prey group includes flies and midges (Clawson 1987). Other insect prey include bees, wasps, and flying ants (Hymenoptera), beetles (Coleoptera), leafhoppers (Homoptera), treehoppers (Homoptera), stoneflies (Plecoptera), and lacewings (Neuroptera) (Whitaker 1972).

Male Indiana bats summering in or near a hibernacula feed preferentially on moths and beetles. Additionally, caddisflies, flies, mosquitoes, midges, stone flies, leafhoppers, treehoppers, and true bugs are consumed, but in low percentages (U.S. Fish and Wildlife Service 1999a). Brack and LaVal (1985) examined fecal pellets of 140 male Indiana bats and identified 83 percent of the prey items as Lepidoptera and 7 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 man-made ponds and water-filled road ruts in forest uplands are also very important water sources for Indiana bats, especially in parts of their range where natural water sources are limited (U.S. Fish and Wildlife Service 1999a).

Status and distribution The Indiana bat was listed as endangered by the Service pursuant to the Endangered Species Preservation Act on March 11, 1967. The following sites have been designated as critical habitat for the Indiana bat: Bat Cave in Carter County, Kentucky; Coach Cave in Edmonson County, Kentucky; White Oak Blowhole Cave in Blount County, Tennessee; the Blackball Mine in LaSalle County, Illinois; Big Wyandotte Cave, Crawford County, Indiana; Ray's Cave, Greene County, Indiana; Cave 021, Crawford County, Missouri; Cave 009, Franklin County, Missouri; Cave 017, Franklin County, Missouri; Pilot Knob Mine, Iron County, Missouri; Bat Cave, Shannon County, Missouri; Cave 029, Washington County, Missouri; and Hellhole Cave, Pendleton County, West Virginia.

Rangewide trend

Based on censuses taken at hibernacula, the total known Indiana bat population in 1997 was estimated at 353,000 bats. Indiana bat populations were first surveyed in the late 1950s (U.S. Fish and Wildlife Service 1999a). In the decades since then, additional colonies of hibernating Indiana bats were discovered and knowledge of the distribution and status of the species has been expanded. However, the most recent population count demonstrated a 60 percent decline in the range-wide population since regular surveys began in the early 1980s.

Winter range Indiana bats are restricted to suitable hibernacula that are primarily located in karst areas of the east-central U.S. More than 85 percent of the range-wide population occupies nine Priority One hibernacula (hibernation sites with a recorded population >30,000 bats since 1960 when surveys first

started, although two of these currently have extremely low numbers of bats). Indiana, Kentucky, and Missouri each contain three Priority One hibernacula. During the period of 1983 through 1997, populations declined by 38 percent in eight of the nine hibernacula (U.S. Fish and Wildlife Service 1999a).

Priority Two hibernacula (sites with recorded populations >500 but <30,000 bats since 1960) are known from Arkansas, Illinois, New York, Ohio, Tennessee, Virginia, and West Virginia in addition to the Indiana, Kentucky and Missouri. Priority Three hibernacula (sites with recorded populations <500 bats or records of single hibernating individuals) have been reported in most of the above states and Alabama, Connecticut, Florida, Georgia, Iowa, Maryland, Massachusetts, Michigan, Mississippi, New Jersey, North Carolina, Oklahoma, Pennsylvania, South Carolina, Vermont, and Wisconsin.

The wintering status of the Indiana bat in the three states with the largest hibernating populations is reviewed below (U.S. Fish and Wildlife Service 1999a):

Indiana: The known population in Indiana apparently dropped from the earliest known surveys through 1980, but has increased steadily in recent years. Indiana now contains half (182,500) of all Indiana bats in existence.

Kentucky: This state has exhibited the most significant decline in population numbers of Indiana bats, with the loss of an estimated 145,000 bats between 1960 and 1975. Losses at two of the major hibernacula were attributed to microclimate changes due to a poorly designed cave gate at one hibernation site (Humphrey 1978), and the construction of a building over the upper entrance to another (U.S. Fish and Wildlife Service 1999a). Although not as dramatic as earlier losses, many of the major remaining hibernating populations have declined steadily during the past 15 years. Populations in west-central, northeastern, and extreme southeastern Kentucky declined between 1960 and 1975, while populations in east-central and western Kentucky increased.

Missouri: Despite efforts to protect Indiana bats (e.g., the construction of appropriate gates at cave entrances), populations of hibernating Indiana bats in Missouri have declined steadily and drastically since 1980. Colonies of Indiana bats in the two Priority One caves that can be surveyed, as well as colonies of 12 of the 13 Priority Two hibernacula in the state, have declined during this period. Since 1983, the overall Missouri population has shown a cumulative estimated decline of over 250,000 bats, a loss of more than 80 percent of the population. The current total estimated population of Indiana bats in the state is less than 50,000 (U.S. Fish and Wildlife Service 1999a).

Other states: Among the other states with regularly occurring hibernating populations of Indiana bats, recent trends are mixed. Population trends in Alabama, Illinois, Ohio, Tennessee, and Virginia are either not known or poorly documented. Alabama, Illinois, Tennessee, and Virginia do not have sufficient recent survey information for a trend analysis, while the only known hibernaculum in Ohio was only recently discovered in the winter of 1995/1996. The population of Indiana bats is apparently declining in Arkansas. The species may be increasing in Pennsylvania, and West Virginia, but complex cave systems such as those

at Hellhole Cave in West Virginia make surveying Indiana bats difficult, and complicate population trend analysis. The species appears to be steadily increasing in New York (Hicks 1999). During the 1988-1989 winter survey of all known Indiana bat hibernacula, 12,861 Indiana bats were counted; during the 1998-1999 winter survey, approximately 22,000 Indiana bats were recorded (Hicks 1999).

A few Indiana bats have been documented in the winter in Connecticut, Florida, Georgia, Iowa, Maryland, Massachusetts, Michigan, Mississippi, New Jersey, North Carolina, Oklahoma, South Carolina, Vermont, and Wisconsin. However, because most of these records are from hibernacula with less than 10 individuals, no regular hibernacula surveys are conducted in most of these states. Connecticut and Vermont conduct hibernacula surveys on a biennial basis, although the one known winter site in Connecticut was not surveyed in 1999 because access to the site was prohibited.

Summer range Although the number of band returns for the Indiana bat is limited, certain migration patterns may be extrapolated from the little information that does exist. Based on sparse band recovery records, all of which are from the Midwest, it appears that females and some males migrate north in the spring upon emergence from hibernation (Hassell and Harvey 1965, U.S. Fish and Wildlife Service 1999a), although there also is evidence that movements may occur in other directions. Most summer captures of reproductively active Indiana bats (pregnant or lactating females) or juveniles have been made between April 15 and August 15 in areas generally north of the major cave areas.

Summer habitats in the mid-Atlantic states have not been well investigated, although it has been documented that both sexes of Indiana bats occur scattered throughout these regions. Little is known about Indiana bat summer habitat use in the Northeast. While observations based on Indiana bats migrating from mid-western hibernacula indicate a northward direction, bats in northern hibernacula may migrate in other directions. For example, although there is an Indiana bat hibernaculum in Watertown, New York near the Canadian border, Indiana bats have never been observed in neighboring Ontario, Canada although extensive summer surveys for many species of bats have been undertaken (A. Kurta, Eastern Michigan University, pers. comm. 1999).

Most of the maternity records of the Indiana bat originated in the Midwest (southern Iowa, northern Missouri, northern Illinois, northern Indiana, southern Michigan, and western Ohio). The first maternity colony was found in the Midwest and several studies of Indiana bat maternity habitat have also been based in this region. Although woodlands in this glaciated region are mostly fragmented, there is a relatively high density of maternity colonies. Today, small bottomland and upland forested tracts with predominantly oak-hickory forest types and riparian/bottomland forests of elm-ash-cottonwood associations exist in an otherwise agricultural-dominated (non-forested) landscape (U.S. Fish and Wildlife Service 1999a). Unglaciated portions of the Midwest (southern Missouri, southern Illinois, southern Indiana), Kentucky, and most of the eastern and southern portions of the species' range appear to have fewer maternity colonies per unit area of forest. However, such conclusions may be premature, given the lack of search effort in these areas (U.S. Fish and Wildlife Service 1999a).

Male Indiana bats may be found throughout the entire range of the species. Males appear to roost singly or in small groups, except during brief summer visits to hibernacula.

Threats to the Species

Not all of the causes of the Indiana bat population decline have been determined. Although several known human-related factors were responsible for specific declines in the past, they may not be solely responsible for recent declines. Several known and suspected causes of decline are discussed below.
Disturbance and vandalism During the 1960s through the 1980s, human disturbance at hibernacula was a primary cause of the decline of the Indiana bat. Bats enter hibernation with fat reserves sufficient to last only until spring. When a bat is aroused, as much as 68 days of fat supply may be used in a single disturbance (Thomas *et al*. 1990). Humans, including recreational spelunkers and researchers, passing near hibernating Indiana bats can cause arousal (Humphrey 1978, Tuttle 1991, Thomas 1995, Johnson *et al*. 1998). Disturbance depletes the bats' fat reserves which may be exhausted before the bats are able to begin foraging in the spring.

Direct mortality due to human vandalism has also been documented. The worst known case occurred in 1960 when an estimated 10,000 Indiana bats were killed in Carter Cave State Park, Kentucky, by three youths who tore masses of bats from the ceiling and trampled and stoned them to death. Another documented incident was reported from Thornhill Cave, Kentucky, where at least 255 Indiana bats were killed by shotgun blasts in January 1987 (BATS 1987; U.S. Fish and Wildlife Service 1999a).

Improper cave gates and structures Indiana bats were excluded from some hibernacula by the erection of solid gates in the entrances (Humphrey 1978). Exclusion of Indiana bats from caves and changes in air flow were the major causes of Indiana bat declines or loss in Kentucky [an estimated 200,000 bats at three caves (U.S. Fish and Wildlife Service 1999a)]. Other cave gates modified the hibernacula climate to the point that Indiana bats were unable to survive the winter. Changes in air flow caused by the installation of the cave gates elevated temperatures that in turn increased the metabolic rate and caused premature use of fat reserves in Indiana bats residing in the hibernacula (U.S. Fish and Wildlife Service 1999a).

Conversely, an Indiana bat population may be restored if an improper gate is replaced with one of appropriate design, or if air flow is restored. In Wyandotte Cave, Indiana, dramatic population increases followed gate replacement and restoration of traditional air flow (Richter *et al*. 1993). Improved air flow facilitated by the enlargement of an upper level entrance was apparently responsible for a three-fold increase in Indiana bat numbers in a cave in Indiana (U.S. Fish and Wildlife Service 1999a). The recovery of hibernating populations to historic levels, however, has not been as successful elsewhere. At Hundred Dome Cave, Kentucky, predicted population gains were never realized, even though air flow obstructions have been removed and gates suitable for the species were installed (U.S. Fish and Wildlife Service 1999a).

Natural hazards Indiana bats in their hibernacula are subject to natural hazards such as ceiling collapse and flooding, and temperature changes.

In a number of documented cases, Indiana bats drowned when their hibernacula were flooded (DeBlase *et al*. 1965; U.S. Fish and Wildlife Service 1999a). In early March 1997, a severe flood occurred in Bat Cave at Carter Caves State Park, Kentucky. Water reached the ceiling in portions of the hibernation section of the cave and drowned an estimated 3,000 Indiana bats (U.S. Fish and Wildlife Service 1999a). Severe flood conditions in January 1996 apparently resulted in the loss of approximately 450 hibernating Indiana bats (64 percent of the censussed population in 1994) in a cave in New York. During a survey the following January, investigators found carcasses of bats wedged in the ceiling crevices of the flood-prone sections of the cave (Hicks 1999).

Since Indiana bats hibernate in cool portions of caves that tend to be near entrances, or where cold air is trapped, some bats may freeze to death during severe winters (Humphrey 1978, Richter *et al.* 1993). Indiana bats apparently froze to death in Bat Cave (Shannon County, Missouri) in the 1950s (U.S. Fish and Wildlife Service 1999a), as well as in the mid-1980s (U.S. Fish and Wildlife Service 1999a).

Conversely, should temperatures rise within a hibernaculum, Indiana bats may be forced to abandon the site or may suffer mortality if the temperature increases during hibernation. At Missouri's Great Scott Cave, average mid-winter temperatures appear to have risen 8º F from the mid-1980s through the present, compared to temperatures in the 1970s and early 1980s. A major population loss was observed at this site between the mid-1980s and 1998. Preliminary analysis of fall and winter temperature data suggests that a similar trend has occurred in ambient temperature outside the cave, and thus appears to have played a role in these population losses (McKenzie 1999). [Currently, Bat Conservation International is conducting a study of temperature and humidity of 13 Indiana bat hibernacula (J. Kennedy, Bat Conservation International, pers. comm. 1999).]

Indiana bats are vulnerable to the effects of severe weather when roosting under exfoliating bark during summer. For example, a maternity colony was displaced when strong winds and hail during a thunderstorm stripped the bark from their cottonwood roost and the bats were forced to move to another roost (U.S. Fish and Wildlife Service 1999a).

Microclimate effects Changes in the microclimates of caves and mines may have contributed more to the decline in population levels of the Indiana bat than previously thought. Entrances and internal passages essential to air flow may become larger, smaller, or close with concomitant increases or decreases in air flow (U.S. Fish and Wildlife Service 1999a). Blockage of entry points, even those too small to be recognized, can be extremely important in hibernacula that require chimney-effect air flow to function. As suggested by Richter *et al*. (1993), changes in air flow can elevate temperatures which can cause an increase in metabolic rate and a premature exhaustion of fat reserves. Modifications that obstruct air flow or bat movement could adversely affect the species (U.S. Fish and Wildlife Service 1999a).

Recent analysis of mid-winter temperature records obtained during hibernacula surveys, especially of Priority One caves, suggests that unacceptable deviations in roost temperatures may account for some of the overall population decline (U.S. Fish and Wildlife Service 1999a). The relatively little data available suggest that when populations roost mostly at temperatures below 35° F or above 47° F (2° C and 8° C), they usually decline, and when roosting between 37° F and 45° F (3° C and 7.2° C), they tend to grow.

Land use practices The Indiana bat's maternity range has changed dramatically since pre-European settlement times (U.S. Fish and Wildlife Service 1999a). Most of the forest in the upper Midwest has been fragmented, fire has been suppressed, and native prairies have been converted to agricultural crops or to pasture and hay meadows for livestock. Native species have been replaced with exotics in large portions of the maternity range, and plant communities have become less diverse. Additionally, numerous chemicals, in particular pesticides, are regularly applied to the agricultural lands. Changes in the landscape and use of chemicals may have reduced the availability and abundance of the bats' insect forage base (McKenzie 1999).

In the eastern U.S., the area of land covered by forest has been increasing in recent years. Whether or not this is beneficial to the Indiana bat is unknown. The age, composition, and size class distribution of woodlands will have a bearing on their suitability as roosting and foraging habitat for the species outside the winter hibernation season. An understanding of the factor(s) responsible for the continued decline of the species is needed before it can be accurately determined whether the loss of roosting habitat is limiting regional or range-wide populations of the species (U.S. Fish and Wildlife Service 1999a).

Chemical contamination Pesticides have been implicated in the decline of a number of insectivorous bats in North America (Reidinger 1976; Clark *et al*. 1978; Geluso *et al*. 1976; U.S. Fish and Wildlife Service 1999a). The effects of pesticides on Indiana bats have yet to be studied. However, depressed levels of acetylcholinesterase were observed on two sympatric bat species in Missouri, the little brown bat and the northern long-eared bat, suggesting that bats there may have been exposed to sublethal levels of organophosphate and/or carbamate insecticides applied to agricultural crops (McKenzie 1999). Analysis of tissue and guano samples of five species of bats at a site in Missouri indicated that bats had been exposed to p,p'-DDE, heptachlor epoxide, and dieldrin (U.S. Fish and Wildlife Service 1999a).

Other Other documented sources of decline include indiscriminate collecting, handling and banding of hibernating bats by biologists, and flooding of caves due to rising waters in reservoirs (Humphrey 1978).

Environmental Baseline

Status of the Species in Vermont, New York and New Hampshire

Surveys of hibernating bats in Vermont caves and mines date back to the early 1930s (Trombulak and Parren *in litt*. 1998). Between 1934 and 1946, Indiana bats were documented in low numbers (<100) in the Ely Copper Mine and Plymouth Caves, and in higher numbers (<270) in Dorset/Aeolus Cave and Nickwacket Cave. However, by 1994, Indiana bats had disappeared from the Ely Copper Mine, Plymouth Caves and Nickwacket Cave, and were found in very low numbers in Dorset/Aeolus Cave (one to eight bats). Only one Indiana bat was found in the most recent survey (1998) of Dorset/Aeolus Cave.

Systematic surveys of eight New York caves and mines that are known hibernacula for Indiana bats began in 1982. Since then, there has been a consistent, gradual increase in the wintering population of Indiana bats in New York, occurring primarily in five of the eight hibernacula. In 1999, the year of the last survey, 21,875 Indiana bats were counted in all eight hibernacula, of which 14,731 Indiana bats were counted in the five eastern hibernacula nearest the New England states (Table 2).

Bat hibernacula have been infrequently surveyed in New Hampshire throughout the past decade. To date, there are no records of Indiana bats hibernating in New Hampshire. In July, 1992, one Indiana bat was documented on the White Mountain National Forest (Krusic *et al.*, 1996). Although there have been surveys for summer woodland bats elsewhere in New England, to date, no additional Indiana bats have been caught.

Status of the species within the action area

Since 1993, one Indiana bat has been periodically documented from Dorset/Aeolus Cave, a hibernaculum located on private property surrounded by lands managed by the GMNF. Although there are no records of summer presence of Indiana bats on the GMNF, its status cannot be conclusively determined since there have been insufficient surveys.

Effects of the action

Beneficial effects

Selected removal of trees, as well as prescribed fires, during a time when Indiana bats are not present, may provide some beneficial effects to the species by opening closed forest canopies and creating optimal foraging and roosting habitat. Prescribed fires may also decrease dense understory vegetation that can inhibit movements to foraging habitats and roosting sites.

Table 2. Hibernacula Survey Results in New York, 1997 and 1999

Location: Site Name (County)	Year Surveyed	*Myotis sodalis*
Barton Hill Mine (Essex)*	1997	4,096
	1999	4,842
Bennet Hill-Hitchcock Mine (Essex)*	1997	5
	1999	17
Glen Park Commercial Cave (Jefferson)	1997	2
	1999	0
Glen Park Caves (Jefferson)	1997	2,535
	1999	3,129
Hailes Cave (Albany)*	1997	246
	1999	345
Jamesville Quarry Cave (Onondaga)	1997	3,035
	1999	4,015
Main Graphite Mine (Warren)*	1997	113
	1999	112
Walter Williams Preserve (Ulster)*	1997	8,537
	1999	9,415
Total	1997	18,588
	1999	21,875

*Hibernacula in eastern New York located in counties near the New England states.

Direct Effects

Direct adverse effects on Indiana bats would occur in the GMNF from forest-wide management activities that result in the removal of trees being used by the bats. These actions include timber management, wildlife habitat management, roads management, recreational management and fire management. During the non-hibernation season (mid-May through August[5]), the primary potential direct effect to Indiana bats on the GMNF would result from the removal of roost trees occupied by: 1) a maternity colony (if such colonies indeed exist on the GMNF; no maternity colonies have been documented in New England to date); 2) summering males; 3) transitory bats during spring and fall migration; or 4) males and females during the fall swarming period near[6] the Dorset/Aeolus Cave hibernaculum. Additional adverse effects would occur from prescribed fires if bats are present in roost trees in or adjacent to a burn.

Tree Removal The felling of trees during a time when Indiana bats may be present in the GMNF (non-hibernation period) may result in direct mortality or injury to individual roosting bats or small groups of roosting bats if undetected roost trees are included in the management area (i.e., summer harvests, road maintenance, etc.). Other direct adverse effects would result if tree harvesting activities cause bats in a roosting or maternity colony to abandon a traditionally-used site if the activities occur within or adjacent to the roosting habitat. Direct effects resulting from the abandonment of a traditional roost site during the spring or summer include additional stress and energy demands on pregnant females and abandonment of occupied roosts by lactating females that may result in lower survival of young.

Fire Management Prescribed fires conducted during the summer when Indiana bats might be present would result in direct mortality, particularly if non-flying young bats occur in roost trees within a burn unit. Smoke inhalation might also cause the abandonment of a roost site. The GMNF currently burns between 280 and 325 acres annually during the late spring and fall when bats are migrating. Prescribed burning does not occur during the summer. No prescribed burns have occurred within the vicinity of the only known hibernaculum in Vermont (Dorset/Aeolus Cave). The GMNF's practice of not conducting prescribed burns during the summer will minimize potential direct adverse effects to the species.

[5] The non-hibernation season in Vermont should be considered to extend from mid-May through the end of August except near hibernacula where fall swarming may occur through September and into October.

[6] Within an approximate five-mile radius and determined by the extent and location of the proposed tree removal activity.

Indirect effects

Indirect effects are defined as those that are caused by the proposed actions and are later in time, but still reasonably certain to occur (50 CFR 402.2). Indirect effects to the Indiana bat could be related to: 1) a reduction in available roost trees; 2) a reduction in the forage base due to the loss of foraging habitat; and 3) a loss of the prey base due to water quality degradation of streams and rivers within the riparian corridors where Indiana bats forage.The potential for these indirect effects to occur as a result of Forest Plan implementation on the GMNF is analyzed below.

Adverse effects on Indiana bat roosting habitat in the GMNF are expected to be insignificant due to the large amount of available roosting habitat within the GMNF that will not be affected at any given time. There are approximately 4.7 million potentially suitable roost trees on the GMNF (BE, page 4, based on the GMNF estimate of 18 potentially suitable roost trees/acre). Sixty-three percent of the GMNF is not managed for timber harvest. Only 1.1 percent of the GMNF is planned for harvest in any given year. Moreover, habitat alteration as a result of timber management activities may only be temporal; that is, as management activities create less desirable or unsuitable roosting habitat, other areas that were previously altered are evolving (or have evolved) into suitable or even optimal habitat. Therefore, the vast majority of suitable roost trees on the GMNF will be available for Indiana bats during any given year.

Forest Plan standards and guidelines require the retention of large old trees (snags and wildlife trees) and the protection of riparian corridors. These standards and guidelines further reduce adverse effects on roosting habitat by requiring the retention of a portion of the suitable roost trees for a given management activity.

GMNF personnel reviewed pre- and post-harvest timber stands at a site-specific level to determine whether or not adequate numbers of live and dead trees remained to maintain suitable versus optimal roosting habitat (as described by Romme *et. al*. 1995) (Grove *in litt*. 1999). The analysis described site conditions after the stands were harvested and determined that optimal habitat conditions were found more than 45 percent of the time and that sufficient potentially suitable roost trees remained (Table 3). Canopy closures were either slightly below (in shelterwood regeneration cuts) or at optimal levels for foraging or roosting habitat. It appears, based on the GMNF analysis, that Forest Plan standards and guidelines requiring that den trees and snags be maintained are being followed and that optimal roosting and foraging habitat is available in many stands even after a timber harvest has been completed.

In view of the fact that a large percent of the GMNF is permanently available to the Indiana bat for roosting habitat, that only a small portion of the GMNF is actually harvested annually, and that there is a large amount of optimal roosting habitat available after tree harvest has occurred, the Service concludes that the reduction in roosting habitat as a result of GMNF management activities is insignificant and therefore not likely to adversely affect the Indiana bat.

Table 3. Post-Harvest Maternity Habitat Conditions[7]

Harvest Type	# of Units Sampled	Trees in Residual Stand (#/acre)	Ave. dbh of Residual Stand (inches)	Suitable[8] Roost Trees in Residual Stand	Ave. dbh of Suitable Roost Trees (inches)	Optimal Habitat Criteria (per acre)	
						# trees > 9 in dbh	# trees > 20 in dbh
Shelterwood (regeneration cut)	1	23	19"	11	20"	16	3
Thinning	2	72	16"	9	18"		
Individual Tree Selection	4	54	15"	9	17"		

Forest management activities that either temporarily or permanently reduce forest canopy closure to less than 30 percent (i.e., certain types of timber harvest, new road construction or the creation of wildlife openings) could potentially reduce the availability and/or suitability of those areas as Indiana bat foraging habitat. However, minor reductions in available foraging habitat in some areas would be offset by the creation of suitable Indiana bat foraging habitat by other forest management activities. For example, the opening of the forest canopy in certain situations [i.e., a mature forest where the canopy closure is greater than the 60 to 80 percent recommended by Romme *et al*. (1995)] might be expected to increase habitat diversity and therefore insect abundance.

It should be noted that the Indiana bat is considered to be a foraging generalist and will take advantage of prey found in numerous types of forest conditions. An abundance of insect prey is likely to be available throughout the GMNF at most times of the year when Indiana bats might be present. Research also indicates that this species forages over a wide range of habitats, including riparian corridors, upland areas, shelterwood cuts, and other disturbed areas (U.S. Fish and Wildlife Service 1999a).

The abundance of aquatic insect prey is not expected to be significantly reduced by management activities within riparian corridors. The Forest Plan standards and guidelines require the implementation of actions that minimize soil erosion and maintain good water quality, reducing the potential for adverse impacts on the aquatic insect community.

[7]Information provided by Clayton Grove, GMNF, in a memorandum dated December 14, 1999.

[8]Based on Romme's (1995) Habitat Suitability Model.

Cumulative Effects

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the Endangered Species Act.

Future federal, state, local or private actions that are reasonably certain to occur within the action area, i.e., the GMNF, will either be carried out by, or will require a permit from, the Forest Service. These actions will therefore require a Section 7 consultation. The Service is not aware of any future state, local or private actions that could occur within the action area that would not be subject to a Section 7 review. Therefore, cumulative effects, as defined in the ESA, are not expected to occur within the action area and will not be addressed further in this Opinion.

Cumulative impact of incidental take anticipated by the Service in previously-issued Biological Opinions

In reaching a decision on whether the continued implementation of activities outlined in the Forest Plan for the GMNF is likely to jeopardize the continued existence of the Indiana bat, the Service considered previous biological opinions involving this species. Within the past three years, the Fish and Wildlife Service has issued final, non-jeopardy biological opinions for the following National Forests: Cherokee, Daniel Boone, George Washington/Jefferson, Ozark/St. Francis, Allegheny, Ouchita and Mark Twain. All opinions concluded that incidental take was directly correlated with the number of acres of roosting habitat being altered.

The implementation of the Forest Plans for the seven previously-issued biological opinions would potentially affect approximately 4,009 Indiana bats, or 1.1 percent of the entire population. However, only the Mark Twain National Forest Biological Opinion provided an incidental take statement that included a number of Indiana bats that might be taken as a result of implementation of a forest plan (25 bats or one maternity colony annually).

MacKenzie (1999) analyzed the impact of forest activities on roosting and foraging habitat for five biological opinions issued prior to the Mark Twain Biological Opinion and determined that there would be an abundance of roosting and foraging habitat after implementation of the respective Forest Plans. Based on the analyses of the impacts of habitat alteration from implementation of Forest Plans for the Allegheny (U.S. Fish and Wildlife Service 1999b) and Mark Twain National Forests, it is still evident that there will be an abundance of available habitat for Indiana bats in both National Forests.

Additional conservation measures provided by the Forest Service as well as reasonable and prudent measures provided by the Service to minimize the impact of the annual allowable take for each National Forest are summarized below.

Cherokee National Forest: The annual incidental take of 1,300 acres identified in the Service's February 1997 Biological Opinion constitutes approximately 0.25 percent of the total area of the Cherokee National Forest (CNF) that is suitable for timber harvest. Based on calculations provided by J. MacGregor (U. S. Forest Service), an estimated 200 Indiana bats may be distributed throughout the Forest (McKenzie 1999).

The potential for incidental taking of Indiana bats and loss of suitable habitat was significantly reduced by measures outlined in the CNF's September 3, 1996 Biological Assessment, as well as by terms and conditions provided by the Fish and Wildlife Service in its Biological Opinion. Measures provided in the Biological Assessment included the retention of: 1) approximately 40-60 trees per acre in a size class equal to or greater than 9 inches dbh (for the primary harvest treatment); 2) at least 20 percent of harvestable timber 61 years or older within each compartment scheduled for management; and 3) at least two snags, preferably large-diameter hardwood snags, in harvested areas. In addition, 12,664 acres previously considered for harvest were designated as old growth.

The primary term and condition associated with the reasonable and prudent measures outlined in the Service's Biological Opinion ensures additional roosting habitat on the CNF by the retention of 20 to 40 Class 1 or Class 2 trees (as identified by Romme *et al.* 1995) per acre of two-aged shelterwood treatments.

Daniel Boone National Forest: The annual incidental take of 4,500 acres provided in the Service's Biological Opinion issued on April 4, 1997, constitutes approximately 0.75 percent of the total area of the Daniel Boone National Forest (DBNF) that is suitable for timber production. Based on calculations provided by J. MacGregor (U.S. Forest Service), an estimated 1,600 Indiana bats may occur on the DBNF (MacKenzie 1999).

Measures that would significantly reduce impacts to Indiana bats and their habitat were provided in the Forest Service's October 6, 1996 Biological Assessment for the DBNF and the Fish and Wildlife Service's Biological Opinion. Measures incorporated in the Biological Assessment included: 1) the retention of all dead and dying suitable Class 1 or Class 2 trees (after Romme *et al.* 1995) of 16 inches dbh or greater; 2) the retention of all shagbark and shellbark hickory, and all hollow or cull trees of other species where possible; 3) the retention of at least 16 Class 1 and/or Class 2 trees with a dbh greater than 9 inches; 4) allowance of no more than 40 acres per square mile per decade of regeneration harvest within a one-mile radius of each significant cave or hibernaculum; and 5) the retention of residual trees with a basal area of 50 square feet in strips or clumps.

Terms and conditions associated with reasonable and prudent measures in the Service's Opinion included: 1) the retention of at least three natural or created snags with a dbh greater than 9 inches in each harvest area; 2) the retention of appropriate numbers of live trees within a 25-foot radius of one-third of all large snags with a dbh greater than 12 inches; 3) the retention of clumps of trees in the harvest area along with irregular strips of trees extending into the harvest area; 4) the retention of all shagbark and shellbark

hickories; and 5) the retention of all additional reserve trees that have developed exfoliating bark as the result of natural or man-made damage.

George Washington and Jefferson National Forests: The annual incidental take of 4,500 acres provided in the Service's Opinion issued on September 16, 1997, constitutes approximately 0.3 percent of the total area of the George Washington/Jefferson National Forests (GWJNFs) that is suitable for timber production. McKenzie (1999) estimated that 300 Indiana bats may be using the GWJNFs during the spring-fall period.

The GWJNFs developed an Indiana Bat Recovery Strategy (John Wolflin, USFWS, Annapolis, MD, *in litt*., September 16, 1997) and agreed to implement the following: 1) a no disturbance primary buffer of at least 0.5 mile placed around each Indiana bat hibernaculum; 2) a limited disturbance buffer of at least 1.5 miles placed around each Indiana bat hibernaculum; within this buffer either a) a minimum of 20 trees per acre in the 10-16 inches dbh class and 15 trees per acre with a dbh of 20 inches or greater must be retained, or b) 60 percent of the area must be maintained in an age class of 70 years or older, and 40 percent of oaks, hickories, and yellow poplar (*Liriodendron tulipifera*) must be maintained in an age class of 80 years of age or older; 3) a 0.25-mile no disturbance buffer placed around all known roost trees; 4) the retention of all shagbark hickory and snags; 5) 40 percent of oaks, hickories, and yellow poplar will be maintained in an age class of 80 years or older forest-wide; and 6) a minimum of 60 percent of the acreage of all forest types combined on the GWJNFs will be maintained over 70 years of age.

Terms and conditions associated with reasonable and prudent measures in the Service's Opinion above and beyond those agreed to by the GWJNFs included: 1) the retention of at least six snags or cavity trees per acre with a dbh of 9 inches or greater for all timber activities; and 2) the retention of all shagbark hickories throughout the GWJNFs.

Ozark-St. Francis National Forest: The annual incidental take of 19,000 acres provided in the Service's Opinion issued on June 25, 1998, constitutes approximately 8.7 percent of the total area of the Ozark-St. Francis National Forest (OSFNF) that is suitable for timber production. An estimated 1000 Indiana bats may be distributed throughout the OSFNF (McKenzie 1999).

The potential for loss of suitable habitat and incidental taking of Indiana bats would be reduced through implementation of measures outlined in the OSFNF Forest Plan and the Forest Service's Biological Assessment dated October 28, 1997. These measures include: 1) the retention of at least two dead snags greater than 12 inches dbh (when possible) per acre in all harvested areas; 2) the retention of all standing dead trees with exfoliating or defoliating bark and den trees within riparian corridors; and 3) the designation of approximately 147,364 acres as old growth (~13 percent).

A non-discretionary measure described in the terms and conditions requires the retention of at least six snags or cavity trees of #9 inches dbh (Class 1 or Class 2 trees as identified in Romme *et al*. 1995) per acre for all timber activities.

Ouchita National Forest: The annual incidental take of 43,000 acres provided in the Service's Biological Opinion issued on April 26, 1999, constitutes approximately 4.8 percent of the total area of the Ouchita National Forest (ONF) that is suitable for timber production. Nine Indiana bats have been documented on the ONF.

The potential for loss of suitable habitat and incidental taking of Indiana bats would be reduced through implementation of measures outlined in the ONF Forest Plan: 1) the retention of large den trees (≥18 inches dbh); 2) the retention of at least two snags per acre with a minimum of 12 inches dbh; and 3) the retention of mature growth hardwood habitat (≥100 years old) and mature pine habitat (≥80 years old) or the development of such habitat within each project area at a rate of 5 percent. The non-discretionary measures described in the terms and conditions of the Service's Biological Opinion will ensure the availability of additional suitable roost trees above and beyond those measures provided by the ONF. These measures include: 1) a no-disturbance buffer with a radius of 0.5 mile around each occupied Indiana bat hibernaculum, and 2) a secondary buffer consisting of a radius of 1.5 miles around each occupied Indiana bat hibernaculum where limited management activities will occur.

Allegheny National Forest: The annual incidental take, as measured indirectly by acreage, ranges from 7,456 to 14,287 acres and constitutes approximately 1.6 to 3.0 percent of the total forested area (476,735 acres) on the Allegheny National Forest (ANF). Approximately 400 bats are found in Pennsylvania hibernacula. The Service's Biological Opinion, dated June 1, 1999, assumed that the potentially-affected population consisted of 400 bats found in the nearest hibernaculum.

The potential for loss of suitable habitat and incidental taking of Indiana bats was determined to be significantly reduced through the implementation of Forest Plan standards and guidelines and the terms and conditions provided in the Service's Biological Opinion. Forest Plan standards and guidelines require that an average of five to 10 snags, and three to six den trees, per acre be left in areas subject to timber harvesting. Non-discretionary measures described in the terms and conditions include the retention of: 1) all shagbark and shellbark hickories (live, dead, and dying), in partial and final harvest cutting units; 2) all snags in both partial and final harvests in green units; 3) at least 8-15 live trees ≥9 inches dbh per acre in final harvest units, and at least 16 live trees ≥9 inches dbh per acre in partial harvest units; 4) five to 10 snags ≥9 inches dbh per acre for both partial and final harvests in salvage units and clearcuts, and at least 16 live trees ≥9 inches dbh per acre and three live trees ≥20 inches dbh per acre in partial harvest units; 5) at least 8-15 live trees ≥9 inches dbh per acre, and one live tree ≥20 inches dbh per acre in final harvest units and clearcuts. Other terms and conditions addressed the reduction of canopy closure to maintain foraging habitat, protection of suitable roost trees by providing living residual trees, and provision of future suitable roost trees.

Mark Twain National Forest: The annual incidental take of 38,375 acres provided in the Service's June 23, 1999 Biological Opinion constitutes approximately 2.89% of the total forested area of the Mark Twain National Forest (MTNF). The Service anticipated no more than 500 Indiana bats would be potentially adversely affected by the implementation of the Forest Plan. Furthermore, the Service anticipated that

approximately 25 Indiana bats or one maternity colony could potentially be taken during management activities resulting from the accidental removal or disturbance of unknown, occupied roost trees.

The potential for incidental taking of Indiana bats was considered to be significantly reduced through the implementation of Forest Plan standard and guidelines, as well as the terms and conditions associated with the reasonable and prudent measures described in the Biological Opinion for the MTNF. Terms and conditions outlined in the MTNF Biological Opinion include: 1) the retention of "leave" trees around large snags, large live trees and den trees; 2) the retention of at least 25 basal area of residual trees within clearcuts and seed tree harvests and a minimum of 15 basal area of reserve trees; 3) the maintenance of a minimum of 23 suitable roost trees per acre on forested acreage keeping dead trees $20 inches dbh and live trees $26 inches dbh whenever possible.

In view of the above, the Service concludes that potential adverse impacts to the species have been sufficiently minimized to prevent a significant, cumulative reduction in population numbers of the Indiana bat from incidental take allowed under these seven consultations.

Biological Opinion Conclusion

After reviewing the current status of the Indiana bat; the environmental baseline for the action area; the effects of forest management and other activities on the GMNF (both direct and indirect); and previously-issued Service biological opinions that allow various levels of incidental take, it is the Service's biological opinion that implementation of the Green Mountain National Forest Land and Resource Management Plan, as proposed in the Biological Assessment, is not likely to jeopardize the continued existence of the Indiana bat. Although critical habitat has been designated for 13 Indiana bat hibernacula, this proposed action does not affect those areas, nor is destruction or adverse modification of critical habitat anticipated. The non-jeopardy conclusion for the proposed action is based on the following discussion.

The potential Indiana bat population in the action area (the GMNF) that might be affected is insignificant. Any adverse effects on this small portion of the rangewide population would not be likely to jeopardize the continued existence of the species. In order to estimate the number of Indiana bats that might potentially be affected by GMNF management activities, the Service assumed that all Indiana bats hibernating in caves and mines in New York near to the GMNF (ranging within 25 to 80 miles of the western border of the GMNF) migrate north and east. In the 1999 winter survey, approximately 14,731 Indiana bats were counted in Barton Hill Mine, Bennet Hill-Hitchcock Mine, Hailes Cave, Main Graphite Mine and Walter Williams Preserve in Essex, Warren, Albany and Ulster Counties, New York.

Furthermore, the Service could assume that the 14,731 bats are equally distributed throughout the suitable, available habitat in the GMNF (this excludes alpine/krumholz habitat), constituting approximately 374,134 acres. If uniformly distributed over the available habitat in the GMNF, there would be one Indiana bat for each 25 acres of suitable forested habitat[9]. However, since timber harvest is not allowed for 63 percent of the GMNF, only 138,430 acres are available for harvest or other tree removal activities. Therefore, approximately 5,537 Indiana bats[10] (1.6 percent of the species' population) may be present in the acreage that could potentially have some harvest or tree removal activities. Of these 5,537 bats, only a very small portion could be subject to take during the non-hibernation season, since only 300 acres (estimated) are harvested at that time.

However, there is no rational, scientific basis for assuming that all Indiana bats in the five nearest hibernacula would summer only on the GMNF. Similarly, it could be assumed that the GMNF Indiana bat population consists of the single individual found in the hibernaculum (Dorset/Aeolus Cave) adjacent to the GMNF. Alternatively, it could be assumed that there is some portion of the wintering New York population that migrates to the GMNF. Since some male Indiana bats do not migrate far from their hibernacula (see Life History section), it is more likely that the actual population on the GMNF is more than one individual and less than the 14,731 bats found in the five nearest hibernacula.

INCIDENTAL TAKE STATEMENT

Section 9 of the Endangered Species Act and federal regulations pursuant to Section 4(d) of the Act prohibit the take 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 to attempt to engage in any such conduct. Harm is defined by the Service as an act that actually kills or injures wildlife, and is further defined as significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including 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 which 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 Sections 7(b)(4) and 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be a prohibited taking under the Act, provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

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[9]To determine the number of acres over which an individual bat might be found, the number of available habitat acres is divided by the total number of wintering bats found in nearby hibernacula (i.e., 374,134 ÷14,731) to get approximately 25 acres/bat.

[10]To arrive at 5,537 bats, the number of acres over which management activities occur is divided by 25 bat/acre (i.e., 138,430 ÷ 25).

The measures described below are non-discretionary, and must be undertaken by the Forest Service so that they become binding conditions of any grant, permit or contract issued to any applicant, as appropriate, for the exemption in Section 7(o)(2) to apply. The Forest Service has a continuing duty to regulate the activities covered by this Incidental Take Statement. If the Forest Service 1) fails to assume and implement the terms and conditions; or 2) fails to require applicants to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to permits, contracts and/or grant documents, the protective coverage of Section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Forest Service 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 Incidental Take Anticipated

Although, to the best of our knowledge, no Indiana bat maternity colony or individually roosting Indiana bats have been incidentally taken on the GMNF during tree removal or other habitat modifying activities conducted to date, incidental take of this species is anticipated due to the loss of active roost trees. Furthermore, the Service concludes that if roosting individuals (or a maternity colony) are present in an area proposed for timber harvest or other disturbance, even if the roost tree were not removed, the resulting disturbance would result in incidental take of Indiana bats through harm or harassment.

The Service anticipates that it will be difficult to quantify and detect the incidental take of Indiana bats resulting from forest management activities (e.g., timber management, recreational management, wildlife management, or fire management) or other actions implemented on the GMNF, due to the bat's small body size, nocturnal behavior, formation of small, widely dispersed colonies (i.e., 50 or fewer to 100 individuals) under loose bark or in cavities of trees, and unknown areal extent and density of roosting populations within the GMNF. Any incidental take of Indiana bats is expected to occur only during the non-hibernation months (mid-May through August except near occupied hibernacula where fall swarming might occur through early October) when the bats are present on the GMNF and will be in the form of killing, harming, or harassing. Tree removal for harvest or in preparation for other management activities during the non-hibernation season may result in mortality (i.e., take) of individual roosting Indiana bats (or of females and their young if in a maternity colony[11]) if a tree that is removed contains roosting bats (or a maternity colony). If the bats using an occupied roost tree are not killed during the removal, the roosting individuals (or colony) would be forced to find an alternative tree, potentially expending a significant amount of energy that would result in harm or harassment of the individual.

[11]To date there have been no Indiana bat maternity colonies documented in New England nor evidence of Indiana bat reproduction (i.e., capture of juvenile bats or post-lactating females).

Monitoring to determine take of individual bats within an expansive area of forested habitat would be a complex and difficult task. Unless every individual tree that is considered to be a suitable roosting tree is inspected by a knowledgeable biologist before timber harvest begins, it would be impossible to know if roosting Indiana bats (or possibly a maternity colony) are present in an area proposed for harvest. It would also be impossible to evaluate the amount of incidental take of Indiana bats unless a post-harvest inspection is immediately made of every tree that has been cut or disturbed. Moreover, inspecting individual trees is not considered to be a useful survey method and is not recommended by the Service as a means to determine incidental take. Until better pre- and post-harvest monitoring methods for Indiana bats are developed, the level of take of this species can only realistically be anticipated by the areal extent of suitable roosting habitat affected.

Depending upon the circumstances, the loss of a single roost tree might adversely affect Indiana bats, but not result in take[12], since these circumstances may be similar to naturally occurring events. The Service believes that there is a low probability that the removal or disturbance of a roost tree will result in injury or death of an Indiana bat utilizing a roost tree. There are an estimated 4.7 million potentially suitable roost trees that may be available to Indiana bats on the GMNF. However, less than 0.1 percent of suitable roost trees (~ 5,400[13]) will be removed annually during the non-hibernation period when the bats may be present, while less than one percent of all potentially suitable roost trees will be removed over the duration of the consultation period of ten years. Furthermore, the size of the harvested timber stands is small enough (ranging from 5-acre patch cuts to 35-acre regeneration cuts) that distances to alternate roost trees will be short and generally should not result in injury to Indiana bats. Nevertheless, over the duration of the consultation period, it is still possible that a take may occur.

The lack of records and information on the distribution and movements of Indiana bats on the GMNF makes it extremely difficult to accurately estimate the number of Indiana bats likely to be present and incidentally taken through the continued implementation of the Forest Plan. Since this probable incidental take cannot be determined due to a lack of information on the non-hibernating activities of Indiana bats in the Northeast, quantification of incidental take at this time, without additional site-specific information, is not possible.

The Forest Plan addresses annual management activities for approximately 4,000 acres, although less than one-third of the prescribed level of harvest occurs or is expected to occur annually in the future (C. Grove, U.S. Forest Service, Green Mountain National Forest, pers. comm. 2000). This Incidental Take Statement anticipates the taking of a presently unquantifiable number of Indiana bats from activities (e.g., tree removal associated with timber harvest; road and trail construction and maintenance; recreational facility

[12]The adverse effect must result in significant impairment of behavioral patterns (harm) or create the likelihood of injury to such an extent as to significantly disrupt normal behavior (harass).

[13]300 acres x 18 trees/acre if <u>all</u> roost trees were removed.

maintenance) occurring only during the non-hibernation season (mid-May through August except near occupied hibernacula where the season would extend into October). During this period, approximately 300 acres (25 percent of the actual annual harvest of 1,200 acres) of suitable Indiana bat habitat are affected by management activities that might result in direct take of Indiana bats. The GMNF has stated that this level of timber harvest will be maintained indefinitely (C. Grove, pers. comm. 2000). Therefore, the incidental take statement is based on forest management occurring on a maximum of 300 acres.

Since the level of incidental take of Indiana bats cannot be adequately determined, incidental take will be anticipated by the loss of roost trees occupied by Indiana bats that are contained within the 300 acres annually harvested during the non-hibernation season. However, implementation of the terms and conditions associated with the reasonable and prudent measures provided below by the Service will reduce the impact of the potential for incidental take on site-specific projects. Operations on the GMNF that would increase the number of acres harvested or otherwise affected by tree removal during the non-hibernation season would be considered to affect this determination and would require reinitiation of formal consultation.

Effect of the Take

The Service has determined that the level of anticipated take is not likely to result in jeopardy to the Indiana bat.

Reasonable and Prudent Measures

The Service believes the following reasonable and prudent measures are necessary and appropriate to further minimize impacts of incidental take of Indiana bats on the GMNF:

1. Proposed management activities shall be planned, evaluated, and implemented consistent with measures developed to protect the Indiana bat and reduce adverse impacts from the removal of potentially occupied roost trees and prescribed burns.

2. The Forest Service shall monitor the status of Indiana bats on lands managed by the GMNF during the non-hibernating season.

3. The Forest Service shall monitor timber sales and other activities on the GMNF to determine whether Forest Plan standards and guidelines, and the terms and conditions of this Biological Opinion are being implemented.

Terms and Conditions

In order to be exempt from the prohibitions of Section 9 of the Act, the Forest Service must comply with the following terms and conditions, which implement the reasonable and prudent measures described above

and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary. The terms and conditions associated with the reasonable and prudent measures articulated in this Biological Opinion will minimize the level of the incidental take identified for the Indiana bat on both a programmatic and site-specific scale; accordingly, the following protective measures are applicable, where appropriate, to individual ongoing projects and projects yet to be identified.

In order to reduce possible adverse impacts to Indiana bats that would result from the removal of potentially occupied roost trees during the non-hibernation period (May 15 to August 30, except in the vicinity[14] of active hibernacula where the period is extended through October), the Forest Service shall do the following:

Applicable throughout the year:

1. Retain all shagbark hickory trees on the GMNF.

2. Protect all known roost trees on the GMNF until such time as they no longer serve as roost trees (e.g., loss of exfoliating bark or cavities, blown down or decayed). In the event that it becomes absolutely necessary to remove a known Indiana bat roost tree, the Service shall be consulted and such a removal will be scheduled during the hibernation season. Trees identified as immediate threats to public safety may be removed at any time following consultation with the Service.

3. Determine an area of influence for any occupied Indiana bat hibernaculum that is on or adjacent to lands managed by the GMNF. The area of influence will be an approximate five-mile radius centered on the hibernaculum unless it is determined, based on best science available, that a larger radius is necessary.

4. In cooperation with the Service and the Vermont Department of Fish and Wildlife, develop a management strategy within two years of issuance of this Biological Opinion that will minimize impacts on Indiana bats occurring on lands managed by the GMNF within the area of influence for all occupied Indiana bat hibernacula on or adjacent to the GMNF.

Applicable during the non-hibernation season:

5. Design skid trails to avoid the need to fell suitable roost trees (as identified by Romme *et al*. 1995).

[14]Within an approximate five-mile radius from the hibernaculum or based on the extent and location of the project.

6. Protect 1/3 of all large diameter (≥12 inches dbh) post-harvest snags by retaining live residual trees adjacent to these snags. Such reserve trees shall be located in groups and along intermittent drainages to provide foraging corridors into harvested areas, and where available, shall be Class 1 or Class 2 trees (as identified by Romme *et al*. 1995), or other trees exhibiting or likely to develop characteristics preferred by Indiana bats (e.g., exfoliating bark).

In order to minimize the potential effects of smoke on occupied Indiana bat hibernacula or roosting bats during fall swarming, the following is necessary:

1. Consider occupied Indiana bat hibernacula as smoke-sensitive areas when planning for prescribed burns to be conducted from October to May 1. If hibernacula are in the vicinity of the area proposed for burning, wind direction, speed, mixing height, and transport winds will be considered to minimize drifting in or near occupied hibernacula.

2. Prior to the employment of any prescribed fire, provide the Service's New England Field Office with the opportunity to review burn plans that could potentially affect Indiana bats.

The Forest Service must initiate efforts to determine the use of the GMNF by Indiana bats during the non-hibernation season. Information obtained through the implementation of the following terms and conditions will help the Service to assess the efficacy of the standards and guidelines and the terms and conditions in protecting the Indiana bat on the GMNF. The Forest Service shall implement the following terms and conditions to address underlying assumptions about the Indiana bat's presence and use of the GMNF.

1. Determine and monitor the extent of Indiana bat use on the GMNF to ascertain: a) their presence or absence, b) their habitat use and movements during the non-hibernation season, c) the location of any potential maternity colonies, and d) the major foraging areas used by male Indiana bats near occupied hibernacula during the non-hibernation season. Comparative evaluations of the effectiveness of mist net surveys and Anabat detectors are strongly encouraged. If any Indiana bats (male or female) are netted, the Service recommends tracking them using radio-telemetry to identify and characterize roost trees and foraging habitat. These habitat parameters will be used to develop management strategies for the protection, maintenance, and promotion of Indiana bat habitat. A plan delineating the monitoring protocol should be developed in cooperation with the U.S. Fish and Wildlife Service and the Vermont Department of Fish and Wildlife and shall be completed within two years of the issuance of this Biological Opinion.

2. If monitoring activities result in the discovery of maternity sites on the GMNF, roost trees used by a maternity colony will be protected by establishing a zone centered on the maternity roost site. The actual area will be determined by a combination of topography, known roost tree locations, proximity of permanent water and a site-specific evaluation of the habitat characteristics associated

with the colony. Protective measures shall be established by developing a management strategy, in cooperation with the U.S. Fish and Wildlife Service and the Vermont Department of Fish and Wildlife, immediately upon discovery.

3. Habitat use at all sites where Indiana bats are documented on the GMNF should be characterized and quantified at both the local and landscape levels.

Individual projects must adhere to the reasonable and prudent measures provided in this Opinion. In order to ensure compliance with the terms and conditions, as well as determine the level of incidental take on a project level, the following are necessary:

1. The Forest Service will provide the U.S. Fish and Wildlife Service with compliance reports indicating the project-specific conditions and an effects analysis for all projects that may affect the Indiana bat.

2. If the Forest Service determines that activities on a project level are likely to adversely affect the Indiana bat, further consultation will be necessary.

3. Formal consultation must be reinitiated if an individual project, or if the annual projected total of all proposed projects, will result in exceeding the total of 300 acres annually affected by tree removal or disturbance during the non-hibernation season. However, site-specific projects proposed for the non-hibernation season may be surveyed for Indiana bats according to U. S. Fish and Wildlife Service protocols. If Indiana bats are not detected, it will be assumed that bats may be present in such low numbers that the project is not likely to adversely affect the Indiana bat. In this case, the project will not be included in the annual allowable treatment of 300 acres.

4. The number of acres of trees harvested during the non-hibernation season must be monitored on an annual basis. This information shall be provided to the U. S. Fish and Wildlife Service's New England Field Office no later than April 1 following the previous year's activities.

5. The U. S. Fish and Wildlife Service will review site-specific projects, as appropriate, to ensure that there is strict adherence to the terms and conditions associated with the reasonable and prudent measures outlined in this Opinion.

6. Care must be taken in handling dead specimens of listed species that are found in the project area to preserve biological material in the best possible condition. In conjunction with the preservation of any dead specimens, the finder has the responsibility to ensure that evidence intrinsic to determining the cause of death of the specimen is not unnecessarily disturbed. The finding of dead specimens does not imply enforcement proceedings pursuant to the ESA. The reporting of dead specimens is required to enable the U. S. Fish and Wildlife Service to determine if take is reached or exceeded and to ensure that the terms and conditions are appropriate and effective. Upon

locating a dead, injured, or sick specimen of an endangered or threatened species, prompt notification must be made to the U. S. Fish and Wildlife Service's Essex Junction Division of Law Enforcement, 11 Lincoln Street, Room 105, P.O. Box 649, Essex Junction, Vermont 05453 (telephone: 802- 879-1859), or the Region 5 Division of Law Enforcement, 300 Westgate Center Drive, Hadley, Massachusetts 01035-9589 (telephone: 413-253-8343).

Conservation Recommendations

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

The U. S. Fish and Wildlife Service recommends that the GMNF implement the following conservation measures for the benefit of the Indiana bat:

1. In cooperation with the U. S. Fish and Wildlife Service and the Vermont Department of Fish and Wildlife, develop a plan to assess the number of suitable roost trees and the amount of preferred foraging habitat available to the species. Monitoring efforts should be centered within five miles of all known occupied Indiana bat hibernacula, within 3/4 mile of any Indiana bat maternity colony or roost tree used by a male Indiana bat and at selected sites (pre- and post-harvest).

2. Provide training for appropriate GMNF employees on bats (including the Indiana bat) occurring on the GMNF. Training should include bat identification, biology, habitat requirements, and sampling techniques (including instructions on applicability and effectiveness of using mist net surveys vs. Anabat detectors to accurately determine the presence of various bat species). The proper training of GMNF biologists on bat identification and reliable methods for counting roosting bats will enable the Forest Service to monitor the status of this species.

3. Develop an outreach program specifically directed towards northeastern woodland bat species and their conservation needs. The program might include the development of a slide show, interactive display, and presentations or activities suitable for all ages of the public.

The U. S. Fish and Wildlife Service requests notification of the implementation of any conservation recommendations, so that the Service may better monitor actions minimizing or avoiding adverse effects, or benefitting listed species or their habitats.

REINITIATION NOTICE

This concludes formal consultation on the actions outlined in the Forest Service's September 21, 1999 initiation request. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law), and if: 1) the amount or extent of incidental take is exceeded; 2) new information reveals consequences of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; 3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion; or 4) a new species is listed or critical habitat 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 pending reinitiation.

Sincerely yours,

Michael J. Bartlett
Supervisor
New England Field Office

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