U.S. Fish and Wildlife Service

Indiana Bat

(*Myotis sodalis*)

5-Year Review: Summary and Evaluation

Photo by R. Andrew King/USFWS

U.S. Fish and Wildlife Service
Midwest Region – Region 3

Bloomington Ecological Services Field Office
Bloomington, Indiana

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1.0 GENERAL INFORMATION

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1.2 Methodology used to complete the review:

This 5-year Review (Review) was prepared by Andy King , Endangered Species Biologist, U.S. Fish and Wildlife Service (Service), Bloomington Ecological Services Field Office (BFO), in consultation with Service biologists in the Northeast, Southeast, Midwest and Southwest regions (i.e., Service Regions 2, 3, 4 and 5).

The Indiana bat was included in a cursory 5-year review of multiple species in 1991 (56 FR 56882). No new information regarding Indiana bat status was received, nor was a change in status recommended during that review. This current document constitutes the first species-specific 5-year review of the Indiana bat since its listing.

The Service solicited pertinent information from the public through a *Federal Register* notice (71 FR 55212; September 21, 2006) and also reviewed past and recent scientific reports, records, and published literature that had been completed since the November 1991 5-year review (including the species' 1996 and 1999 draft recovery plans). We also relied heavily upon the recently published *Indiana Bat Draft Recovery Plan: First Revision* (2007 Plan) (USFWS 2007) (72 FR 19015, April 16, 2007) to prepare this review. We reviewed each document for new information, beginning with the earliest document not cited in the 1999 draft recovery plan (USFWS 1999).

In large part, the Review was accomplished in conjunction with analyses conducted in support of the 2007 Plan. The 2007 Plan contained updated status and threat data and assessments (with the exception of White-Nose Syndrome (WNS)), up-to-date life history information, and a newly developed set of objective recovery criteria. The 2007 Plan was primarily developed by a team of eleven Service biologists from Regions 3, 4 and 5, two USGS biologists, an Indiana University professor/biometrician, and the 11-member Indiana Bat Recovery Team.

In March 2005, the Service also hosted an Indiana Bat Risk Assessment Workshop (Workshop) at its National Conservation Training Center in West Virginia. The Workshop used a structured decision-making process with input from an expert panel, the Recovery Team, and Service biologists and managers from throughout the species' range and facilitated the development of the 2007

Plan and this Review. Proceedings of the Workshop are hereby incorporated by reference (USFWS 2006).

Prior to its April 2007 publication, the 2007 Plan received substantial internal review and peer review by Recovery Team members and was approved by the Director of the Service and the Office of the Secretary of the Department of the Interior. The 2007 Plan subsequently has been peer reviewed by six independent reviewers. The Service reviewed all comments on the 2007 Plan (197 public comments of which 161 were form letters from different individuals), which were received during a 90-day public review period that ended on 16 July 2007, in addition to the comments received following the 21 September 2006 Federal Register Notice announcing initiation of this Review (395 public comments of which 386 were form letters from different individuals). No new information that has a substantive bearing on the species' classification was received. Because new biennial population data has become available since publication of the 2007 Plan (i.e., primarily collected in Jan. and Feb. 2007), we used this more recent data from across the species' range to assess whether the recovery criteria in the 2007 Plan has been achieved (Appendix A). Data from winter surveys conducted in January and February 2009 were not available for several states and thus were not included in this Review.

The Service acknowledges receipt of some new population data (discussed below in 2.3.1.2) and significant new threats data related to White-Nose Syndrome (see 2.3.2.3) that is relevant to this Review. We have incorporated this new data and reran our analyses using a "revised" 2007 population estimate. Ultimately, our recommendation of maintaining the Indiana bat in its current endangered status remained the same.

1.3 Background

1.3.1 FR Notice Citation announcing initiation of this review:

71 FR 55212 (September 21, 2006) Endangered and Threatened Wildlife and Plants; Initiation of a 5-Year Review of Curtis' Pearlymussel and Indiana Bat.

1.3.2 Listing History

<u>Original Listing</u>
FR notice: 32(48) FR 4001
Date Listed: March 11, 1967
Entity Listed: Indiana Bat – *Myotis sodalis* (the species)
Classification: endangered

1.3.3 Associated rulemakings

<u>Critical Habitat Designated</u>
FR notice: 41(187) FR 41914
Date Listed: September 24, 1976
Entity Listed: 13 hibernacula (winter habitat) including 11 caves and two mines in six states were listed as critical habitat:
Illinois - Blackball Mine (LaSalle Co.); Indiana - Big Wyandotte Cave (Crawford Co.), Ray's Cave (Greene Co.); Kentucky - Bat Cave (Carter Co.), Coach Cave (Edmonson Co.); Missouri - Cave 021 (Crawford Co.), Caves 009 and 017 (Franklin Co.), Pilot Knob Mine (Iron Co.), Bat Cave (Shannon Co.), Cave 029 (Washington Co.); Tennessee - White Oak Blowhole Cave (Blount Co.); and
West Virginia - Hellhole Cave (Pendleton Co.).

1.3.4 Review History

The Indiana bat was included in three five-year reviews: (1) for wildlife classified as endangered or threatened prior to 1975 (44 FR 29566); (2) for species listed before 1976 and in 1979 and 1980 (50 FR 29901); and (3) of all species listed before January 1, 1991 (56 FR 56882). These five-year reviews resulted in no change to the listing classification of 'endangered.'

1.3.5 Species' Recovery Priority Number at start of 5-year review: 8

A Recovery Priority Number of "8" means that a species has a moderate degree of threat and a high recovery potential.

1.3.6 Recovery Plan or Outline

Name of Plan: Indiana Bat (*Myotis sodalis*) Draft Recovery Plan: First Revision
Date Issued: 13 April 2007
Date of Original Recovery Plan: 1983

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) Policy:

2.1.1 Is the species under review a vertebrate? *Yes.*

2.1.2 Is the species under review listed as a DPS? *No***.**

2.1.3 Was the DPS listed prior to 1996? *Not Applicable*.

2.1.4 Is there relevant new information for this species regarding the application of the DPS policy? *No*. Although banding returns and recent population genetics research suggest the Indiana bat population is not panmictic (i.e., some discrete population structuring appears to exist) (USFWS 2007), there currently are no data suggesting that the Service's DPS policy is applicable to or necessary for the current Indiana bat species-level listing.

2.2 Recovery Criteria:

2.2.1 Does the species have an approved recovery plan containing objective, measurable criteria? *No.* Although, the 2007 Plan is a draft and has not yet been finalized and formally "approved" by the Service, it does contain objective and measurable recovery criteria. We expect the 2007 Plan will be finalized and approved within the next 6 months. We respond to the remaining questions regarding recovery criteria with respect to the 2007 Plan.

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat? *Yes.*

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? *No. NOTE:* Although WNS is a new emerging threat that was not identified in the 2007 Plan, the Service still considers the population-based criteria in the 2007 Plan as an appropriate means of assessing its impacts as well as the overall effectiveness of ongoing efforts to mitigate its adverse effects. White-Nose Syndrome will be identified as a new threat and addressed in the forthcoming final recovery plan.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met; citing information.
Appendix A contains a list of the recovery criteria and relevant discussion. Table 1 (below) contains a summary of recovery criteria achievements.

2.3 Updated/New Information and Current Species Status

The Indiana bat originally was listed as an endangered species on 11 March 1967, following establishment of the Endangered Species Preservation Act on 15 October 1966 and is currently listed as endangered under the Endangered Species Act of 1973, as amended. At the time of listing, the bat's rangewide population was estimated at approximately 880,000 bats (Clawson 2002). In 1976, 11 caves and two mines were designated as critical habitat for the Indiana bat and no additions have been made since that time. When the first recovery plan was completed and approved in October 1983, the rangewide population was estimated at about 550,000 (USFWS 1983) with 96% of the bats hibernating in Missouri (50%), Indiana (26%) and Kentucky (20%) and only three maternity colonies had been found. The 1983 Recovery Plan guided recovery efforts through the 1980s and into the mid-1990s. During this period, active conservation measures concentrated on protection of winter habitat and research into the life history of the species, especially summer habitat requirements. By 2001, over 35 caves and mines used as hibernacula had been acquired and protected, many with gates or fences (Currie 2002), by governmental agencies or private conservation organizations. A technical draft of a revised recovery plan for the Indiana bat was completed in October 1996. Reviews of this draft document were received from state and federal agencies and private groups throughout the range of the species, and were incorporated into an agency draft that was completed in March 1999 (1999 Plan) (USFWS 1999). Based on censuses conducted at known Indiana bat hibernacula in 1997, the rangewide Indiana bat population was estimated at 353,000 bats (USFWS 1999). The Service received numerous comments on the 1999 Plan, but it was never finalized. Since the publication of the 1983 approved recovery plan and the 1999 agency draft revised recovery plan, a vast amount of new research and survey data have been generated. Therefore, a new draft revised recovery plan that synthesized and presented all of this new research literature and updated information on the bat's life history, status and threats was prepared by the Service and released for public comment in April 2007 (2007 Plan) (USFWS 2007). When the 2007 Plan was released, the Service had records of extant winter populations at approximately 281 hibernacula in 19 states and 269 maternity colonies in 16 states and the rangewide

Table 1. Summary of progress towards achieving recovery criteria.

Criterion	Relevant Measure	Current Status	Conclusion
Reclassification Criterion 1	Permanent protection of 80% of all Priority 1 hibernacula in each Recovery Unit.	Ozark-Central (n=7): 57% Midwest (n=12): 50% Appalachia (n=2): 50% Northeast (n=2): 0%	Not Achieved
Reclassification Criterion 2	A minimum overall population estimate equal to the 2005 population estimate of 457,000 bats.	The revised 2007 overall population estimate is 468,000, which exceeds the 457,000 minimum.	Achieved
Reclassification Criterion 3	Predicted continued positive population growth rate at each of the most populous hibernacula in each RU (using a linear regression with 90% confidence interval through 5 most recent population estimates as a means of predicting trend over the next 10-year period).	Noted below are the numbers of hibernacula that currently "pass" this criterion. Ozark-Central: 4 of 6 Midwest: 3 of 4 Appalachia: 1 of 2 Northeast: 2 of 2	Not Achieved
NOTE: The reclassification criteria (above) currently have not been met (i.e., we are not ready to downlist to threatened status). Nonetheless, to see how much progress has been made to-date towards full recovery of the species, we went ahead and also assessed the delisting criteria (below) that would need to be met once the Indiana bat had been reclassified as threatened. To assess the delisting criteria, we again used the most current/complete data set available.			
Delisting Criterion 1	Protection of a minimum of 50% of Priority 2 hibernacula in each Recovery Unit.	Ozark-Central (n=20): 25% Midwest (n=26): 42% Appalachia (n=4): 25% Northeast (n=4): 0%	Not Achieved
Delisting Criterion 2	A minimum overall population estimate equal to the 2005 population estimate of 457,000 bats.	The revised 2007 overall population estimate is 468,000, which exceeds the 457,000 minimum	*Provisionally Achieved**

Table 1.Continued

Criterion	Relevant Measure	Current Status	Conclusion
Delisting Criterion 3	Positive population growth rates at a minimum of 80% of all Priority 1A hibernacula/ complexes as evidenced by a positive slope of a linear regression through the 5 most recent population estimates post-reclassification.	80% (8 out of 10) of P1A hibernacula currently pass. Magazine Mine: Pass Great Scott: Fail Wyandotte Complex: Pass Ray's: Pass Coon & Grotto: Pass Carter Caves Complex:Pass Dixon: Fail White Oak Blowhole:Pass Hellhole: Pass Williams Mines: Pass	*Provisionally Achieved**

population estimate (based on 2005 surveys) stood at approximately 425,000 bats. The most current/2007 Indiana bat rangewide population estimate was 468,184 bats and 50% of these bats hibernated in caves located in Indiana (http://www.fws.gov/midwest/Endangered/mammals/inba/index.html). Bat survey data collected during the winter of 2008-2009 currently are being analyzed and collated and were not sufficiently complete for use in this Review. However, we anticipate that the 2009 rangewide population estimate will be lower than the 2007 estimate because of mortality associated with WNS in the Northeast.

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Since the Indiana bat was listed in 1967 and particularly since the last 5-year review in 1991 (1991 Review), a vast and growing amount of new information on the species biology and life history has been generated. Unfortunately, one of the difficulties in managing the Indiana bat is that most studies and surveys conducted by graduate students, consultants, or government employees are not published. A significant proceedings edited by Kurta and Kennedy (2002) from a 2001 symposium entitled *The Indiana Bat: Biology and Management of an Endangered Species* went a long way toward making much previously unpublished data available and brought 27 new Indiana bat papers into a single volume. Similarly, the 2007 Plan (USFWS 2007) summarized and synthesized both the old and the latest Indiana bat research findings and much unpublished data and currently provides the most complete and thorough summary of the Indiana bat literature (e.g., 382 publications/documents are cited in the 2007 Plan as compared to 58 in the 1999 Plan). These two documents are primary sources of new information on the Indiana bat's biology and life history since the species' listing and the 1991 review and are hereby incorporated by reference. The 2007 Plan is available at http://www.fws.gov/midwest/Endangered/mammals/inba/index.html.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Since the 1991 Review, Indiana bat winter population surveys have continued to be conducted every other winter (biennially) at hibernacula across the species' range. In 2005, the Service's Bloomington Indiana Field Office (BFO) began developing and populating an Indiana bat hibernacula and winter population database. Every known Indiana bat hibernaculum and its associated bat population data from 1930 through the present have been entered into this database. The BFO uses this database to generate the rangewide Indiana bat population estimate every other year (i.e., odd years). Likewise the database is used to generate population graphs, track apparent population trends, and to track identified threats and conservation measures implemented at hibernacula.

Since the Indiana bat's original listing and since standardized winter surveys began in the early 1980's, the Indiana bat's overall population decreased precipitously until an increasing population trend began in 2003 and continued through 2007 (Figure 1). From the time of listing in 1967 through 2003, most of the overall population declines were attributed to declines at high-priority hibernacula in Kentucky and Missouri and to a lesser extent, Indiana. Populations in Missouri hibernacula declined drastically from 1980 through 1997 and have continued to decline at a slower rate from 1997 to present (Elliott 2008, Figure 2).

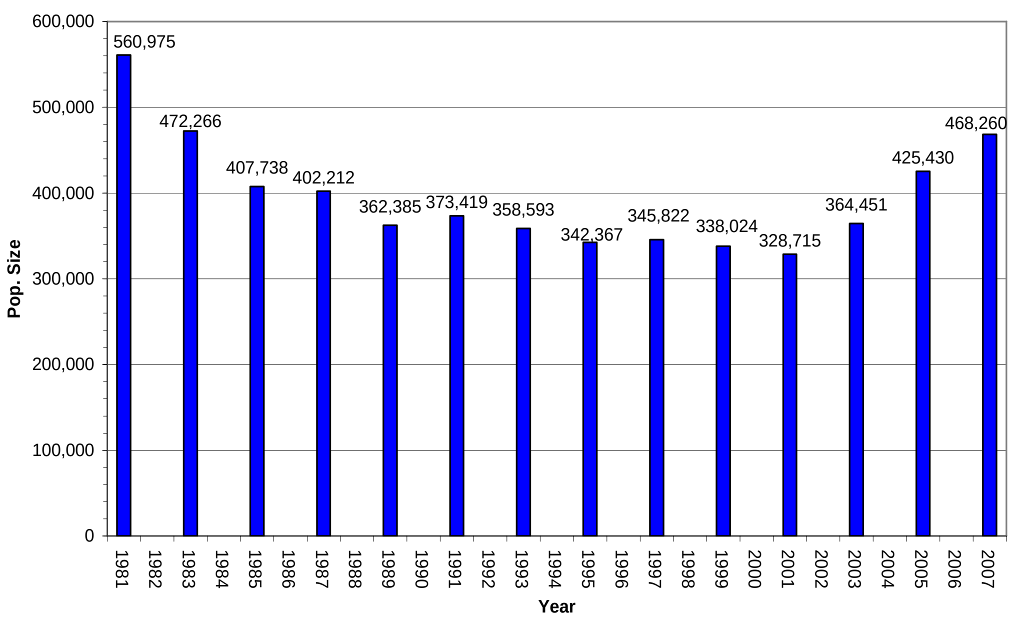

Figure 1. Indiana bat population estimates from 1981 – 2007 (USFWS, unpublished data, 2009)**.**

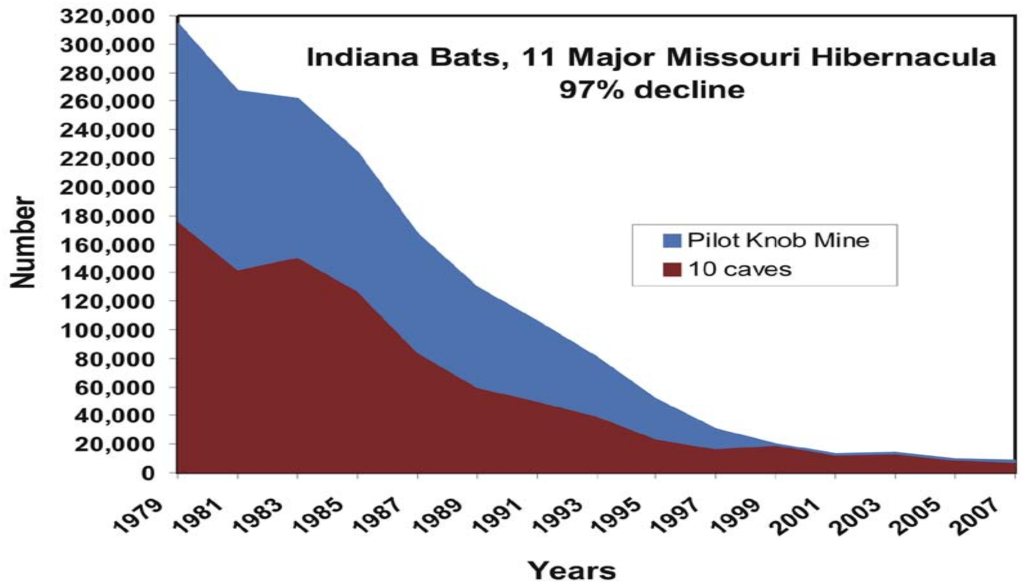

Figure 2. Population trends at 11 major Indiana bat hibernacula in Missouri, 1979-2007. The Pilot Knob data are stacked on the data for 10 caves (from Elliott 2008).

In contrast, the recent 2003-2007 population increase was largely attributed to population growth at hibernacula in Illinois, Indiana, Kentucky, New York, and West Virginia (USFWS, unpublished data, 2009**).** Recent state-by-state and rangewide population estimates are available on the Service's Indiana bat website (http://www.fws.gov/midwest/Endangered/mammals/inba/index.html).

Since publication of the 2007 Plan, the Service received new population data from the 2007 biennial winter surveys from throughout the species' range and some new data collected in winter of 2007-2008 as described below. These new data prompted the Service to revise our original 2007 and earlier rangewide population estimates from those reported in the 2007 Plan (e.g., the 2005 rangewide population estimate of 457,000 bats that was originally reported in the 2007 Plan has been revised to the current estimate of about 425,000 bats). The revised estimates are available on our website above and were used in calculations to assess achievement of recovery criteria for this 5-Year Review (see Appendix A). The revised estimates were prompted by new and/or improved population data at hibernacula in Missouri, Kentucky and New York. The largest change in the revised 2007 estimate involved the State of Missouri. Missouri's 2001 - 2007 estimates had previously assumed 50,550 Indiana bats hibernated within Pilot Knob Mine (PKM, Iron County, MO) based on external fall capture rates at the mine's primary entrance, but a February 2008 internal survey of this mine documented a total population of 1,678 Indiana bats (Elliott and Kennedy 2008). The Service considered this new data to more accurately estimate the total population within the mine and adjusted the 2007 and previous Missouri and rangewide estimates accordingly. Some other, smaller adjustments were made to the original 2007 rangewide population estimate based upon the discovery of new hibernacula in Kentucky and New York in 2008 (i.e., we assumed the same number of Indiana bats that were found at these new sites in 2008 had actually been present in 2007 as well).

In addition to the recent revisions made to the 2007 population estimate, a new threat, White-Nose Syndrome (WNS), has emerged in the northeastern United States that has caused mortality of thousands of hibernating Indiana bats and has affected five other bat species over the past several winters. Among the nine states currently known to be affected by WNS (NY, VT, NH, MA, CT, NJ, PA, VA, and WV), New Jersey, New York, Pennsylvania, Vermont, and West Virginia have "affected" Indiana bat hibernacula (USFWS, unpublished data, 2009). In recent years, New York's hibernating populations of Indiana bats had steadily increased and by 2007 they represented 11.3% of the rangewide population. New York's Indiana bat population estimates from the last four surveys periods (for which we have data) were: 2001 – 29,671; 2003 – 32,981; 2005 – 41,727; and 2007 – 52,803 bats (USFWS, unpublished data, 2009). The average increase between surveys during this time range was 21% (every two years). In sharp contrast, surveys conducted at New York's hibernacula during early 2008 (post-WNS) estimated the population at 37,141 Indiana bats (a drop of 15,662 bats), which is a 30% decrease from the previous year's estimate for New York hibernacula. We presume the observed decline in the New York population was a direct result of WNS-related mortality. In fact, the decline probably should be considered a conservative estimate of the mortality associated with WNS because: 1) surveys were conducted prior to the end of hibernation, and it appeared that mortality associated with WNS continued throughout the hibernation period and 2) there is evidence from the Northeast that some WNS-affected bats continued to die throughout the summer. By the end of the 2008-2009 winter, WNS had been documented in all of New York's major Indiana bat hibernacula. From a broader perspective, the loss of 15,662 Indiana bats from WNS in 2008 represented a loss of approximately 3.3% of the revised 2007 rangewide population. We had not received population estimates from winter surveys conducted at New York hibernacula in 2009 at the time of this Review, but the New York bat surveyors had told us that precipitous population declines had continued there as a result of WNS-associated mortality (A. Hicks, New York State Department of Environmental Conservation, pers. comm., 2009).

At the end of the winter of 2008-2009, all of the known WNS-affected hibernacula were in states located within Region 5 (R5) of the Service (i.e., the Northeast Region). In 2007, before widespread WNS mortality of Indiana bats had been documented, hibernacula in R5 states (primarily in NY) contained approximately 70,293 Indiana bats or 15% of the total 2007 rangewide population of 468,164 bats.

Indiana bat demographics are discussed in detail in the 2007 Plan (USFWS 2007, p 37). All Indiana bat demographic groups appear to be equally affected by WNS and no differences in mortality rates have been reported.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

Population structure of the Indiana bat has been investigated using mitochondrial DNA from wing tissue of Indiana bats sampled at 13 hibernacula with the discovery of four separate population groups: Midwest, Appalachia, Northeast 1, and Northeast 2 (USFWS 2007). Knowledge of the spatial organization of genetic variation, gene flow, and any relationships with fragmentation and/or isolation is needed to develop long term conservation and recovery strategies. Trujillo and Amelon (2009) recently developed a set of polymorphic microsatellite (simple sequence repeats—SSR) markers that will be useful in describing the population genetic structure of *Myotis sodalis*.

2.3.1.4 Taxonomic classification or changes in nomenclature: *no change.*

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

In general, the spatial distribution of winter habitat/hibernacula has changed little since the Indiana bat was first listed. However, in at least three known cases, the species has expanded its current winter range beyond its historic winter limits as a result of occupying man-made hibernacula (e.g., mines, tunnels, a dam) in relatively recent times. Some occupied man-made structures are relatively far removed from natural cave areas (e.g., Black Ball Mine in northern Illinois, Lewisburg Limestone Mine in west central Ohio, Tippy Dam near the eastern border of Lake Michigan in Michigan). Of the 33 mines with extant winter populations (i.e., one or more positive records since 1995), some have served as hibernacula for Indiana bats for nearly a century or more (e.g., Pilot Knob Mine in Missouri; Clawson 2002). Others, where mining activities have been abandoned more recently, have only supported significant winter populations within the past decade, such as the Magazine Mine in southern Illinois (Kath 2002). These findings suggest that Indiana bats are capable of expanding their winter distribution by colonizing suitable hibernacula as they become available within and for some distance beyond their traditional winter range. In 2005, approximately 30 percent (136,410 bats) of the rangewide population of Indiana bats hibernated in man-made hibernacula (24 mines, one dam, and one tunnel) and the other 70 percent (320,964 bats) hibernated in natural caves (USFWS, unpublished data, 2006). In addition, it appears in some instances that Indiana bats may redistribute themselves over relatively short periods of time (e.g., several years) as evidenced by swift population declines in some hibernacula that coincided with rapid population increases at others nearby (e.g., Twin Domes and Wyandotte caves in Indiana; USFWS, unpublished data, 2006). Such rapid increases cannot be attributed to reproduction alone, and are due at least in part to immigration.

Relating to the Indiana bats summer habitat, the first Indiana bat maternity colony was not discovered until 1971 (in east-central Indiana, Cope et al. 1974). As of October 2006, we had records of 269 maternity colonies in 16 states that are considered to be locally extant (USFWS 2007). Of the 269 colonies, 54 percent (n=146) had been found (mostly during mist-netting surveys) within the past 10 years (i.e., since 1997). Because maternity colonies are widely dispersed during the summer and difficult to locate, all the combined summer survey efforts have found only a fraction of the maternity colonies presumed to exist based on the rangewide population estimates derived from winter hibernacula surveys. For example, based on the 2007 rangewide population estimate of 468,000 bats, and assuming a 50:50 sex ratio, and an average maternity colony size of 50 to 80 adult females (Whitaker and Brack 2002), then the 269 known maternity colonies may only represent 6 to 9 percent of the 2,925 to 4,680 maternity colonies we would assume exist. Regardless of reasonable disagreements regarding the average colony size, the geographic locations of the majority of Indiana bat maternity colonies remain unknown.

Most capture records of reproductively active female and juvenile Indiana bats (i.e., evidence of a nearby maternity colony) have occurred in glaciated portions of the upper Midwest including southern Iowa, northern Missouri, much of Illinois, most of Indiana, southern Michigan, and western Ohio, and in Kentucky; however, a growing number of maternity records have been documented in New York, New Jersey, and Vermont in recent years as a result of spring emergence studies and mist netting efforts (USFWS, unpublished data, 2006). The more rugged, unglaciated portions of the Midwest (Ozarks/southern Missouri, parts of southern Illinois, and south-central 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 than does the upper Midwest. Additional summer survey efforts and spring emergence studies will be needed in some areas, particularly along the periphery of the range, before final conclusions may be reached regarding the extent of the species' summer range. Likewise, a comprehensive analysis of existing positive and negative summer survey data is warranted.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

An extensive amount of literature pertaining to the Indiana bat's summer and winter habitat has been published since the species was listed and the last review. The two documents discussed in 2.3.1.1 (Kurta and Kennedy 2002, UFWS 2007) provide an excellent overview of what new habitat information is now available and how habitat conditions have changed since the species was listed.

2.3.1.7 Other: *none.*

2.3.2 Five-Factor Analysis

Please refer to the 2007 Plan (USFWS 2007, pp. 71-101) for an in-depth 5-factor threats analysis and a discussion of the species' status including biology and habitat, threats, and management efforts.

The 1967 Federal document that listed the Indiana bat as "threatened with extinction" (32 FR 4001, March 11, 1967) did not address the five factor threats analysis later required by Section 4 of the 1973 ESA. The original recovery plan (USFWS 1983) identified threats or "causes of decline" as:

- natural hazards (i.e., flooding, freezing, mine ceiling collapse),
- human disturbance and vandalism at hibernacula (identified as "the most serious cause of Indiana bat decline"),
- deforestation and stream channelization,
- pesticide poisoning,
- indiscriminate scientific collecting,
- handling and banding of hibernating bats by biologists,
- commercialization of hibernacula,
- exclusion of bats from caves by poorly designed gates,
- man-made changes in hibernacula microclimate (blocking or adding entrances and/or by poorly designed gates), and
- flooding of caves by dams/reservoir developments.

Several of the original threats listed above have largely been addressed and are no longer adversely affecting the species to the degree or extent that they once had (e.g., human disturbance at hibernacula, indiscriminate scientific collecting, banding of hibernating bats, commercialization of hibernacula, and poorly designed cave gates). The 1999 agency draft recovery plan (USFWS 1999) identified all of the causes of decline listed above, but also pointed out that "although several human-related factors have caused declines in the past, they do not appear to account for the declines we are now witnessing." Even now, there remains much uncertainty as to the underlying cause(s) of the longstanding and ongoing population decline in Missouri and a few other areas.

The 2007 Plan (USFWS 2007) identified and expounded upon additional threats including:

- quarrying and mining operations (summer and winter habitat),
- loss/degradation of summer/migration/swarming habitat,
- loss of forest habitat connectivity,
- some silvicultural practices and firewood collection,
- disease and parasites,
- predation,
- competition with other bat species,
- environmental contaminants (not just "pesticides"),
- climate change, and
- collisions with man-made objects (e.g., wind turbines, communication towers, airstrikes with airplanes, and roadkill).

With few exceptions, all of the identified threats are still affecting the species to varying degrees. The most significant rangewide threats to the Indiana bat have traditionally been habitat loss/degradation, forest fragmentation, winter disturbance, and environmental contaminants. In addition to these threats, climate change and White-Nose Syndrome are increasingly being identified as significant threats to the future recovery of the Indiana bat and its congeners.

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range: *See the 2007 Plan for in-depth discussion (USFWS 2007, page 71).*

Destruction and degradation of the bat's winter hibernacula (i.e., caves and mines) and summer habitat (i.e., forests) has been identified as a long-standing and ongoing threat to the species. A distinction should be drawn between habitat conversion for agriculture and conversion for development. Agricultural conversion has been responsible for high rates of forest conversion within the range of the Indiana bat historically; however, some marginal farmlands have been abandoned and allowed to revert back to forest. Since the time of listing as endangered, there has been a net increase in forest land within the range of the Indiana bat, particularly in the Northeast. Currently, the greatest single cause of conversion of forests within the range of the Indiana bat is urbanization and development (USFWS 2007).

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes: *See the 2007 Plan for in-depth discussion (USFWS 2007, page 80).*

Human disturbance of hibernating bats was originally identified as one of the primary threats to the species and still remains a threat at several important hibernacula in the bat's range (USFWS 2007). The primary forms of human disturbance to hibernating bats result from cave commercialization (cave tours and other commercial uses of caves), recreational caving, vandalism, and research-related activities. Disturbance of hibernating Indiana bats seldom results in immediate mortality of bats within the hibernacula, except in cases of vandalism when bats are purposely killed. Impacts of recreational caving on hibernating bats are more difficult to assess and to control compared with commercial uses because commercial caves are generally gated, or have some effective means of controlling access. Many noncommercial Indiana bat hibernacula also have controlled access, but others do not and may be used for recreational caving during the hibernation season. Disturbance of hibernating bats by cavers remains a threat in many hibernacula.

Progress has been made in reducing the number of caves in which disturbance threatens hibernating Indiana bats, but the threat has not been eliminated. Biologists throughout the range of the Indiana bat were asked to identify the primary threat at specific hibernacula. “Human disturbance” was identified as the primary threat at 38 percent of Priority 1, 2 and 3 hibernacula combined (USFWS 2007, p. 82).

2.3.2.3 Disease or predation: *See the 2007 Plan for additional discussion of diseases and predation (USFWS 2007, page 87).*

White-Nose Syndrome

Prior to the current WNS epizootic, significant disease outbreaks affecting populations of Indiana bats or other North American bat species were not known. Since the 5-factor threats analysis was conducted during preparation of the 2007 Plan, WNS has emerged as an unprecedented threat to hibernating bat species in North America. The consensus of bat experts at a May 2009 WNS meeting in Austin, Texas was that “White-Nose Syndrome is a devastating disease of hibernating bats that has caused the most precipitous decline of North American wildlife in recorded history.” (http://www.batcon.org/, accessed 8-18-09). The following list highlights some of the emerging information surrounding WNS:

- WNS was first detected in a single, commercial cave (i.e., Howe Caverns) near Albany, New York in February 2006 and has since rapidly spread over the subsequent three winters causing mass mortality of hibernating bats (Blehert et al. 2009).

- To date, over 60 WNS affected sites are known or suspected in nine states including Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Vermont, Virginia and West Virginia (updated information on WNS is being maintained on the Service’s Region 5 WNS webpage at http://www.fws.gov/northeast/white_nose.html). All known affected sites currently are within the Northeast and Appalachian Mountains Recovery Units of the Indiana bat’s range (USFWS 2007). Since its initial discovery in New York in 2006, WNS has spread approximately 500 miles.

- WNS was named for a white, powdery fungus observed on the muzzles, ears and/or wings of most infected bats as they hibernated.

- This previously unknown fungus was recently named *Geomyces destructans* and is considered the causal agent of the cutaneous infection associated with WNS (Gargas et al. 2009). The origin of this cold-loving fungus (does not grow at or above 24ºC) remains unknown (Gargas et al. 2009), but its uniquely curved conidia (i.e., asexual spores) are morphologically similar to those of a *Geomyces* sp. observed growing on noses of some hibernating bat species in several European countries since the 1980's and preliminary DNA analyses indicate that the European fungus may be the same species (D. Blehert, USGS, National Wildlife Health Center, pers. comm., 2009).

- While the pattern of emergence and spread of WNS is suggestive of an emergent infectious disease and *G. destructans* is clearly playing a significant role, the fungus itself has not yet been conclusively shown to be the single causative pathogen. Other potential underlying causes have not yet been completely explored or excluded. The possibility remains that WNS may be caused by synergistic effects of multiple causal influences (e.g., contaminants, altered patterns of fat deposition or utilization, and a potential pathogen).

- Behavioral changes are also characteristic of WNS affliction. Service and state biologists in the WNS-affected areas have observed a general shift of animals from traditional winter roosts to colder areas, or to roosts unusually close to hibernacula entrances. There has also been a general lack of responsiveness by affected bats to human activity during hibernation. Animals have been regularly observed flying across the mid-winter landscape, and, on occasions, carcasses of little brown bats by the hundreds to thousands have been found outside affected hibernacula with more found inside.

- In New York, WNS has killed up to 95 percent or more of bats in affected hibernation caves and mines and no clear evidence of resistance has been observed among survivors (A. Hicks, pers. comm., 2009).

- WNS has infected six bat species including Indiana bat (*Myotis sodalis),* little brown bat (*M. lucifugus*), northern long-eared bat (*M. septentrionalis*), small-footed bat (*M. leibii*), tri-colored bat (formerly Eastern pipestrelle) (*Perimyotis subflavus*), and big brown bat (*Eptesicus fuscus*) (Blehert et al. 2009).

- Hibernating bats with WNS apparently rouse much more frequently (torpor bouts of only 1-3 days) than normal (D. Reeder, Bucknell University, pers. comm., 2009; Reeder 2008). Frequent arousal of bats leads to depletion of stored fat reserves before the end of winter. Therefore, starvation prior to the spring emergence of insects may be the ultimate cause of death of WNS-affected bats.

- Preliminary work has indicated that the transmission of WNS is primarily bat-to-bat, but human-assisted transmission from WNS-affected hibernacula to unaffected hibernacula remains a possibility. Thus, in March 2009, the Service issued a cave advisory recommending that people refrain from entering caves and mines in WNS-affected and adjacent states.

- Researchers have/are screening numerous chemicals for their ability to kill *G. destructans* (and/or a closely related surrogate species) in a laboratory setting. Preliminary field tests of some potentially promising chemicals (i.e., they were effective in the lab) are being planned (H. Barton, Northern Kentucky University, pers. comm., 2009). The potential for causing adverse affects by introducing various natural and/or synthetic fungicidal agents into cave ecosystems is a significant concern in need of further investigation.

- A primary concern for managers is the ability to scientifically predict when and where the fungus will next occur, which at present is highly uncertain. With 15% of the 2007 rangewide population, Indiana bats in Region 5 of the Service (i.e., the Northeast Region) currently are at highest risk for contracting WNS and suffering additional population declines. Given its current rate of spread, WNS is expected to reach Indiana bat hibernacula in Regions 3 (Midwest Region) and 4 (Southeast Region) within the next couple of winters. In 2007, Indiana bat hibernacula in the Midwest and Southeast contained 67.4% and 17.6% of the rangewide population, respectively (UFWS, unpublished data, 2009).

- If current trends of mortality at affected sites and spread to additional sites continue, WNS threatens to drastically reduce the abundance of most species of hibernating bats in major regions of North America in a remarkably short period of time.

- The Service and other state and federal managers/biologists and other researchers and conservation partners have taken many additional actions in response to WNS. A bulleted list summarizing many of these actions can be viewed at the Service's WNS website at http://www.fws.gov/northeast/white_nose.html.

In short, WNS has quickly and significantly raised the degree of threat against the Indiana bat and has lowered the species overall recovery potential (see discussion at 3.2).

2.3.2.4 Inadequacy of existing regulatory mechanisms: *See the 2007 Plan for in-depth discussion (USFWS 2007, page 90).*

Listing of the Indiana bat in 1967 under the Endangered Species Preservation Act brought attention to the dramatic declines in the species' populations and led to regulatory and voluntary measures to alleviate disturbance of hibernating bats (Greenhall 1973). Subsequent listing under the ESA in 1973 led to further protection of hibernacula. The Federal Cave Resources Protection Act of 1988 (18 U.S.C. 4301-4309; 102 Stat. 4546) was passed to "secure, protect, and preserve significant caves on Federal land" and to "foster increased cooperation and exchange of information between governmental authorities and those who utilize caves located on Federal lands for scientific, educational, or recreational purposes." This law provides additional protections for hibernacula located on Federal lands. At the time of listing, summer habitat requirements of the Indiana bat were virtually unknown, so listing had minimal impact on protection of summer habitat. Discovery of the first maternity colony under the bark of a dead tree in Indiana was made in 1971. Since the advent of radiotransmitters small enough to attach to bats in the late 1980s, summer habitat has been extensively studied and increasingly is the subject of consultation under the ESA.

State endangered species laws also afford protection to the Indiana bat; in most states protection is limited to prohibitions against direct take and does not extend to protection of habitat. The Indiana bat is state listed in 18 of 20 states where it currently occurs including Alabama, Arkansas, Connecticut, Illinois, Indiana, Iowa, Kentucky, Ohio, Oklahoma, Maryland, Michigan, Missouri, New Jersey, New York, Pennsylvania, Tennessee, Vermont, and Virginia. The species is also listed in four states where there are no current records (Florida, Georgia, Massachusetts, and South Carolina). State recognition of the need for protection of endangered species, including the Indiana bat, has increased dramatically. When listed under the ESA, the Indiana bat was only listed by two states (Martin 1973). Local laws, particularly ordinances that regulate development in karst areas, also help to protect areas surrounding caves and other karst features from inappropriate development, although local karst protection ordinances are not common within the species' range (Richardson 2003).

Generally, existing regulatory mechanisms are more effective at protecting Indiana bat hibernacula than summer habitat. Hibernacula are discrete and easily identified on the landscape, whereas summer habitat is more diffuse. Even in situations where we know a maternity colony is present, we seldom know the extent of the range of the colony. Further, the conservation value of protecting a hibernaculum is easier to demonstrate and quantify compared with the value of protecting summer habitat. Therefore, application of regulatory mechanisms at hibernacula is more easily justified. Similarly, factors that affect hibernacula directly (e.g., construction of barriers in cave openings) are easier to identify, and thus regulate, compared with activities in the surrounding landscape that less directly affect hibernacula (e.g., land-use practices that lead to siltation in cave entrances).

Ownership of Indiana bat habitat is probably the primary factor that limits effectiveness of existing regulatory mechanisms. Of 74 Priority 1 and 2 hibernacula 14 (19%) are federally owned, 18 (24%) are state owned, 37 (50%) are privately owned, and 5 (7%) have ownership recorded as "other" or it is unknown (USFWS, unpublished data, 2008). ESA protection extends to hibernacula that are privately owned, but recovery options are often limited on private lands. However, it should be noted that most private hibernacula owners are cooperative in efforts to protect Indiana bats.

We suspect that the majority of summer habitat occurs on private land, although this is difficult to document. The location of most Indiana bat maternity colonies is not known; the U.S. Fish and Wildlife Service estimates that the location of approximately 250 maternity colonies has been identified, representing perhaps 5 to 9% of all colonies (USFWS 2007). We cannot assess ownership of summer habitat, as we did for hibernacula. However, in every state within the range of the Indiana bat, the majority of the forest land is privately owned (Smith et al. 2003), particularly in the core maternity range of the species in the Midwest (e.g., percentage of forest land privately owned is 84 percent in Illinois, 83 percent in Indiana, 88 percent in Iowa, 83 percent in Missouri, and 91 percent in Ohio). Krusac and Mighton (2002) and Kurta et al. (2002) noted that opportunities for managing for Indiana bat maternity habitat on public lands are limited and suggested that strategies for engaging private landowners in management are needed. Kurta et al. (2002) provided the example of ownership patterns within the range of one maternity colony they studied in Michigan. Roost trees for the colony were on property controlled by 11 different entities, and if foraging areas were also considered, the number of landowners involved with this one colony increased to over 35. Monitoring and management of maternity colonies on private lands can only be achieved through effective outreach to private landowners. Current regulatory mechanisms, or the manner in which those mechanisms have been implemented, have thus far not been effective in providing for this type of outreach on a broad scale.

2.3.2.5 Other natural or manmade factors affecting its continued existence: *See the 2007 Plan for in-depth discussion (USFWS 2007, page 91).*

Several natural factors have threatened the existence of local bat populations including flooding and freezing events at winter hibernacula. These natural events typically are not wide-spread, but rather associated with specific flood/freeze-prone sites.

Anthropogenic factors that may affect the continued existence of Indiana bats include numerous environmental contaminants (e.g., organophosphate and carbamate insecticides, oil spills, and PCBs), collisions with man-made objects (e.g., poorly constructed cave gates, vehicles, aircraft, communication towers, and wind turbines) and climate change.

Potential impacts of climate change on temperatures within Indiana bat hibernacula were reviewed by V. Meretsky (USFWS 2007). Climate change may be implicated in the disparity of population trends in southern versus northern hibernating populations of Indiana bats (Clawson 2002), but Meretsky noted that confounding factors are clearly involved. Humphries et al. (2002) used climate change models to predict a northern expansion of the hibernation range of the little brown bat; such modeling would likely result in predictions of range shifts for Indiana bats as well. Potential impacts of climate change on hibernacula can be compounded by mismatched phenology in food chains (e.g., changes in insect availability relative to peak energy demands of bats) (V. Meretsky, pers. comm., 2006). Changes in maternity roost temperatures may also result from climate change, and such changes may have negative or positive effects on development of Indiana bats, depending on the location of the maternity colony. The effects of climate change on Indiana bat populations are uncertain and deserve further consideration.

2.4 Synthesis

Despite impressive gains in the Indiana bat’s rangewide population between 2001 and 2007, the majority of its population-based, and protection-based recovery criteria have not yet been achieved. In addition, WNS poses a significant new threat to the species’ status and may quickly reverse recent population gains. At this time, only one of the three reclassification criteria, Criterion 2, has been met (Table 1, see Appendix A for details). Reclassification Criteria 1 and 3 have not been met. Therefore, identified threats have not yet been sufficiently reduced and stable population growth at the most important hibernacula has not been sustained for long enough for reclassification to threatened status to occur.

Although Delisting Criteria 2 and 3 requirements are currently being met, additional recovery efforts, such as protection of additional Priority 2 hibernacula (i.e., Delisting Criterion 1), would be needed before delisting could be considered after the bat had been reclassified to ‘threatened’ status.

Based on the Service's Review, the Indiana bat still meets the definition of 'endangered' and the required reclassification criteria have not all been met. We reached this conclusion by using the most current population data from 2007 and 2008 (USFWS 2008) in conjunction with the recovery criteria set forth in the 2007 Plan (USFWS 2007, see Appendix A).

3.0 RESULTS

3.1 Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
____ *Extinction*
____ *Recovery*
____ *Original data for classification in error*
__X_ **No change is needed**

3.2 New Recovery Priority Number: 5

The Recovery Priority Number has been changed from "8" to "5" following the guidelines in Federal Register notice 48(184) FR 43098-43105 (September 21, 1983). Table 3 from these guidelines, the Recovery Priority Table, is below.

Recovery Priority Table				
Degree of Threat	**Recovery Potential**	**Taxonomy**	**Priority**	**Conflict**
High	High	Monotypic genus	1	1C 1
	High	Species	2	2C 2
	High	Subspecies/population	3	3C 3
	Low	Monotypic genus	4	4C 4
	Low	**Species**	**5**	5C **5**
	Low	Subspecies/population	6	6C 6
Moderate	High	Monotypic genus	7	7C 7
	High	Species	8	8C 8
	High	Subspecies/population	9	9C 9
	Low	Monotypic genus	10	10C 10
	Low	Species	11	11C 11
	Low	Subspecies/population	12	12C 12
Low	High	Monotypic genus	13	13C 13
	High	Species	14	14C 14
	High	Subspecies/population	15	15C 15
	Low	Monotypic genus	16	16C 16
	Low	Species	17	17C 17
	Low	Subspecies/population	18	18C 18

Brief Rationale: The ongoing WNS epizootic has changed the "degree of threat" to the Indiana bat from "moderate" to "high." The high category means "extinction is almost certain in the immediate future because of a rapid population decline or habitat destruction" whereas the moderate category means "the species will not face extinction if recovery is temporarily held off although there is continual population decline or threat to its habitat". Prior to emergence of the WNS threat, the Service considered the Indiana bat to have a "high" recovery potential (i.e., biological/ecological limiting factors and threats were well understood and intensive management was not needed and/or recovery techniques had a high probability of success). The Service now considers the Indiana bat to have a “low” recovery potential, because WNS is poorly understood and we currently have very limited ability to alleviate this threat. Preliminary/experimental management techniques/efforts will likely be intensive with an uncertain probability of success. At this time, the Service is not aware of any significant “conflict” with construction or development projects that have resulted in a negative biological opinion or would otherwise warrant adding a “c” designation to the Indiana bat’s recovery priority number. The level of conflict may change (increase or decrease) as a result of WNS-related population reductions, and will be reassessed on at least an annual basis (e.g., during the annual recovery data call). Therefore, according to Table 3 in 48(184) FR 43098-43105 (above), a species having a “high” degree of threat, a “low” recovery potential and no conflict should be assigned a recovery priority number of “5.” The recovery priority number can be changed at any time and changes will be considered as our understanding of WNS and its management improves.

3.3 Listing and Reclassification Priority Number:
Not applicable.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Within the next year (and prior to the next 5-year review), the Service plans to approve and finalize a revision to the Indiana Bat Recovery Plan. The revised plan will certainly need to address the newly emerging threat of WNS at whatever level is possible given the knowledge base at that time. Although WNS was not identified/addressed as a threat in the 2007 Plan, the population-based recovery criteria in the 2007 Plan are likely to remain as one of the most effective means of assessing the WNS-related mortality and recovery from WNS in the future. While we have a successful means of monitoring WNS in Indiana bat hibernacula, additional actions are necessary to help minimize the impacts of WNS on Indiana bats if possible. Additional research to understand the causes and potential spread of WNS should be initiated immediately. Research of potential management actions aimed at minimizing the potential spread of WNS must continue to be supported and effective actions implemented and adapted as we learn more about the cause(s) of WNS-related mortalities. As we understand more about the cause(s) and vectors of WNS, management actions to help minimize mortalities should be investigated and implemented (i.e., an adaptive management approach will be taken). Public education/outreach efforts about WNS must also continue.

It is also apparent from this Review that additional attention should be placed on securing permanent/long-term protection of both Priority 1 and Priority 2 hibernacula. Several Priority 1 hibernacula would satisfy Reclassification Criterion 1 if their cave/mine entrances were gated or if appropriate buffer zones were delineated and protected.

We also recommend that the Service pursue some of the highest priority recovery actions identified within the 2007 Plan that would improve our understanding of the Indiana bat's population status and progress towards recovery. In particular, actions 2.4.1, 3.1.2 - 3.1.6, and 3.2.2.1 should ideally be completed prior to the next 5-year review (USFWS 2007). These specific actions involve estimating population biology parameters and demographics such as juvenile and adult survivorship, reproductive success, and developing population models for the Indiana bat. We recommend a population viability analysis be conducted that would model the population impacts of discrete catastrophes and/or variable WNS mortality scenarios across the species' range. The Service is currently planning such a population analysis to be conducted in 2009-2010.

Finally, it is apparent from conducting this Review that the Service will need to continue to improve and maintain a significant, ongoing level of coordination with bat surveyors, the caving community, and other conservation and research partners in order to maintain the Service's hibernacula and population databases and in order to successfully coordinate and implement the recovery actions outlined in the 2007 Plan across the species' wide range.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of the INDIANA BAT (*Myotis sodalis*)

Current Classification: **Endangered**

Recommendation resulting from the 5-Year Review:

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
__X__ **No change is needed**

Appropriate Recovery Priority Number: __5__

Review Conducted By: Andy King, Bloomington, Indiana, ES Field Office

FIELD OFFICE APPROVAL:
Lead Field Supervisor, Fish and Wildlife Service

Approve ____________________ Date 9/3/09
Scott Pruitt, Bloomington, Indiana, ES Field Office

REGIONAL OFFICE APPROVAL:
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Cooperating Assistant Regional Director, Ecological Services, Fish and Wildlife Service

Signature Nancy J Gloman Date 9/10/09
Southwest Region

Cooperating Assistant Regional Director, Ecological Services, Fish and Wildlife Service

Signature Franklin J Arnold III Date 9/28/09
Southeast Region

Cooperating Regional Director, Fish and Wildlife Service

Signature Acting James G. Geiger Date 9/29/09
Northeast Region

APPENDIX A:

Status of Recovery Criteria from the Indiana Bat Draft Recovery Plan: First Revision (USFWS 2007)

(as of December 2008)

The criteria are presented in quotations (and blue text) below and their supporting text from the Plan (USFWS 2007) is shown in italics. Current status of each criterion is summarized in text boxes.

Reclassification Criteria (RC):

"Reclassification Criterion 1: Permanent protection at 80 percent of all Priority 1 hibernacula in each Recovery Unit, with a minimum of one Priority 1 hibernaculum protected in each unit. (In the Northeast and Appalachian Mountain Recovery Units, 80 percent protection would translate to 100 percent protection because these units have one and two Priority 1 hibernacula, respectively.)"

Greater than 80 percent of the Indiana bat population hibernates in the Priority 1 hibernacula. Thus, by achieving this criterion, a significant proportion (but not necessarily 80%) of the Indiana bat rangewide population will be protected from disturbance in its winter habitat and from anthropogenic changes to the thermal regime of the hibernacula. Protection of hibernacula includes conserving a buffer zone around each hibernacula and restoration of hibernacula if necessary.

Protection of hibernacula was and remains a primary focus of the recovery plan for this species (U.S. Fish and Wildlife Service 1983). To be considered protected, the hibernacula can be publicly or privately owned, but there must be a long-term voluntary landowner agreement, such as a stewardship plan, conservation easement, habitat management plan, or memorandum of agreement that protects the hibernacula in perpetuity. Protection of hibernacula includes assuring minimal disturbance to the bats during the season of hibernation (e.g., only authorized surveys or other conservation-related activities). While it is advisable to avoid disturbance between mid-August and mid-May, entry to hibernacula should be prohibited between September 1 to April 30 in most of the species' range, and September 1 to May 31 in the northern portion of the range (Connecticut, Massachusetts, Michigan, New York, and Vermont).

The protection of hibernacula also involves conserving a buffer zone around each hibernaculum to prevent adverse impacts to the physical structure or microclimate. In general, conservation of buffer zones ensures the elimination of the negative effects of disturbances such as land clearing or development. Specific management plans for each P1 hibernaculum will be developed (see Recovery Action 1.1.1.2.2 and 1.1.1.2.3) that include recommendations on size and management actions for a buffer zone.

Status of Reclassification Criterion 1 (as of December 2008): NOT ACHIEVED.
Currently, none of the four Recovery Units has successfully achieved adequate protection of 80% or more of their respective Priority 1 hibernacula (see Table 1 for details). This criterion directly addresses threats at the most important hibernacula and ensures that they be addressed throughout the range by the per Recovery Unit requirement (i.e., redundancy).

Table 1. Status of Priority 1 hibernacula in regards to Reclassification Criterion 1.

Recovery Unit & Priority 1 Hibernacula Names	Ownership	Has Long-term/ Permanent Protection Been Secured?	Is Wintertime Human Disturbance Physically Controlled?	Is Human Disturbance of Hibernating Bats still a Threat in this Hibernaculum?	Are Surface Buffer Zones Being Conserved/ Protected?	Pass / Fail (80% of hibernacula must pass for an RU to pass)
Ozark-Central (n= 7)						**FAIL** **(57% pass)**
Magazine Mine, IL	Private	Yes	Yes (gate)	No	Yes	Pass
Pilot Knob Mine, MO	Federal	Yes	No (hole in fence)	Unknown	Yes	Fail
Great Scott, MO	State	Yes	Yes (gate)	No	Yes	Pass
Onyx, MO	State	Yes	Yes (gate)	No	Yes	Pass
Copper Hollow Sink, MO	State	Yes	No	Yes	No	Fail
Brooks, MO	Federal	Yes	No	Yes	No	Fail
Ryden, MO	State	Yes	Yes (gate)	No	Yes	Pass
Midwest (n=12)						**FAIL** **(50% pass)**
Batwing, IN	State	Yes	Yes (gate)	No	Yes	Pass
Wyandotte, IN	State	Yes	Yes (gates)	No	Yes	Pass
Ray's, IN	Private	No	No	Yes	No	Fail
Jug Hole, IN	Private	No	No	Yes	No	Fail
Twin Domes, IN	State	Yes	Yes (fence)	Unknown	Yes	Pass
Coon, IN	Private	No	No	No	No	Fail
Grotto, IN	Private	No	Yes (fence)	No	No	Fail
Bat, KY	State	Yes	Yes	No	Yes	Pass
Dixon, KY	Federal	Yes	Yes	No	Yes	Pass
Coach, KY	Private	No	Yes (gates)	No	Unknown	Fail
Long, KY	Federal	Yes	Yes (gate)	No	Yes	Pass
Line Fork, KY	State	Yes	No	Yes	Unknown	Fail
Appalachian Mtns. (n=2)						**FAIL** **(50% pass)**
White Oak Blowhole, TN	Federal	Yes	Yes (gate)	No	Yes	Pass
Hellhole, WV	Private	No	Yes (fence)	Unknown	Yes	Fail
Northeast (n=2)						**FAIL** **(0% pass)**
Walter Williams Preserve Mine, NY	State	Yes	No	Yes	No	Fail
Williams Hotel Mine, NY	Private	Unknown	No	Yes	No	Fail

"Reclassification Criterion 2: A minimum overall population estimate equal to the 2005 population estimate of 457,000."

Because of lack of information on the species' demographic parameters, it is not possible to calculate a minimum viable population number for this species or to justify biologically an overall numerical population goal. Furthermore, a low population number was not one of the reasons that the bat was originally listed as endangered; the species was listed because of vulnerability to human and environmental disturbance and subsequent large-scale declines (Barbour and Davis 1969; Mohr 1972; Greenhall 1973; L. Pruitt, pers. comm., 2006). Species experts consider the 2005 population estimate of 457,000 to be an adequate number for recovery as long as the threats to the species have been alleviated (e.g., RC 1), the population growth rate has been positive (e.g., RC 3), and there is a rangewide distribution that incorporates the need for redundancy, resiliency, and representation (i.e., achieved via recovery unit-based criteria).

Pilot Knob Mine (PKM) is a P1A hibernaculum in Missouri that can no longer be safely entered to conduct a traditional winter bat survey. Therefore, Clawson (2002) relied on capture rates of Indiana bats at the mine entrance in 2001 and rates from previous years to estimate the mine's bat population at 50,550 bats. Subsequently, this estimate has been used for Pilot Knob Mine in the 2003 and 2005 rangewide population estimates. Although we are currently unable to determine an accuracy level for the population estimates of Indiana bats hibernating within Pilot Knob Mine, we intend to include this mine's estimate as part of the 2005 rangewide population estimate used in Reclassification Criterion 2 and future rangewide population estimates. However, if improved survey techniques or future field tests (see Recovery Action 1.3.7) reveal that the 50,500 estimate for Pilot Knob Mine contained a large amount of error, then we will adjust this mine's previous estimates accordingly through time and reassess whether an adjustment is needed to the numerical goal of this criterion. [NOTE: This paragraph will be updated in the final recovery plan to reflect new and improved population data for PKM].

At the present time, hibernaculum counts comprise the only data that can be used as a basis for reclassification and delisting of the Indiana bat. Given the progress that has been made to date in securing hibernacula and in analyzing information needs for the species, and given the recent apparent upward trends in species numbers, reclassification on the basis of hibernaculum data represents an acknowledgement of progress made towards recovery.

Status of Reclassification Criterion 2 (as of December 2008): ACHIEVED.
In January and February 2007 (and again in Jan. – Feb. 2008), significant new Indiana bat population data was obtained during biennial winter surveys of hibernacula across the species' range. The Service's Bloomington Field Office coordinated with all bat surveyors, collated the new data, and calculated a 2007 population estimate, which was recently revised (Table 2; USFWS 2008). The revised 2007 population estimate is approximately 468,000 Indiana bats, which represents a 10 % increase above the revised 2005 estimate of 425,000 bats. Because the revised 2007 estimate is > 457,000 bats, the numerical requirement of Reclassification Criterion 2 has been achieved.

Reclassification Criterion 2 simply sets a bare minimum rangewide population estimate that must be met before the Service would consider the species eligible to reclassify to "threatened" status. The rangewide population estimate for the Indiana bat is generated every two years, and represents the Service's single most important and straightforward means of indirectly assessing how well all threats to the species are being reduced or mitigated on an overall basis.

Table 2. Revised 2007 rangewide population estimate for the Indiana bat (USFWS 2008).

USFWS Region	State	2001	2003	2005	2007	% Change from 2005	% of 2007 Total
Region 2	**Oklahoma**	**0**	**5**	**2**	**0**	**-100.0%**	**0.0%**
Region 3	Indiana	173,111	183,337	206,610	238,009	15.2%	50.8%
	Missouri	18,999	17,722	16,102	15,895	-1.3%	3.4%
	Illinois	21,677	43,646	55,166	54,095	-1.9%	11.6%
	Ohio	9,817	9,831	9,769	7,629	-21.9%	1.6%
	Michigan	20	20	20	20	0.0%	0.0%
	Total	**223,508**	**254,556**	**287,667**	**315,648**	**9.7%**	**67.4%**
Region 4	Kentucky	51,053	49,544	65,611	71,250	8.6%	15.2%
	Tennessee	9,564	9,802	12,074	8,906	-26.2%	1.9%
	Arkansas	2,475	2,228	2,067	1,829	-11.5%	0.4%
	Alabama	173	265	296	258	-12.8%	0.1%
	Total	**63,265**	**61,839**	**80,048**	**82,243**	**2.7%**	**17.6%**
Region 5	New York	29,671	32,981	41,727	52,803	26.5%	11.3%
	Pennsylvania	702	931	835	1,038	24.3%	0.2%
	West Virginia	9,714	11,444	13,417	14,745	9.9%	3.1%
	Virginia	969	1,158	769	723	-6.0%	0.2%
	New Jersey	335	644	652	659	1.1%	0.1%
	Vermont	246	472	313	325	3.8%	0.1%
	Total	**41,637**	**47,630**	**57,713**	**70,293**	**21.8%**	**15.0%**
Rangewide Total:		**328,526**	**364,030**	**425,430**	**468,184**		**100.0%**

2-yr. Net Increase of:	**35,620**	**61,400**	**42,754**
% Increase of:	10.8%	16.9%	**10.0%**

"Reclassification Criterion 3: Documentation using statistically reliable information that indicates important hibernacula within each Recovery Unit, on average, have positive annual population growth rates and minimal risk of population declines over the next 10-year period. Using population estimates from the most recent 10 years (i.e., five sequential biennial surveys), linear regression lines will be calculated for each of the most populous hibernacula and/or hibernaculum complexes (P1s and largest P2s) that collectively account for 80% or more of their respective Recovery Units' estimated total number of bats. Each hibernaculum's regression line and 90% confidence interval will be projected through the most recent five data points and extended into the next 10-year period as a means of estimating future potential population levels. For reclassification, the slope of each hibernaculum's regression line must be positive or neutral and the lower bound of the 90% confidence interval must not fall below the minimum threshold set at 90% of the hibernaculum's 2005 population estimate by the end of the predicted 10-year period (see Figure 15)."

In other words, a 90% confidence interval for the regression extended forward 10 years will need to sit above 90% of a given hibernaculum's 2005 population estimate.

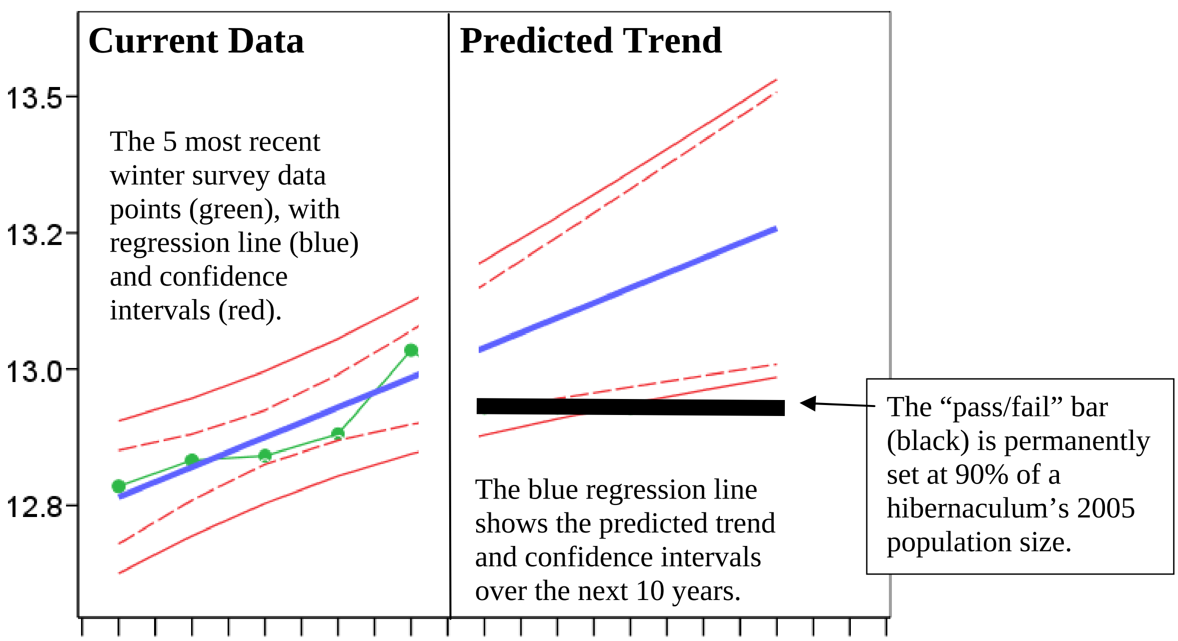

Figure 15. *Example regression (blue line) and confidence intervals (red; 90% - broken lines, 95% solid lines) using a 10-year data set that would "pass" Reclassification Criterion 3. Note: The Y axis is population size in natural logarithms so that constant growth becomes a straight line, instead of an exponential curve. The X axis is the year. The left side shows the 10-year data set that generates the regression line and confidence intervals. The right side is the continuation of the regression line and confidence intervals 10 years into the future, and compares the predicted trend (blue line) to the "pass/fail" bar, which is permanently set at 90% of a hibernaculum's 2005 population size.*

The data in Figure 15 would pass Reclassification Criterion 3 because the 90% confidence interval around the projected regression line rises above the bar by the end of the 10-year period. Therefore, we have a relatively high level of confidence that this example hibernaculum would continue to maintain a positive population growth rate and would not drop below the pass/fail bar over the next 10 years.

Meeting Reclassification Criterion 3 requires a positive population growth rate within each RU and allows only a small statistical possibility of a future population decline to a size that is at or below the 2005 population level. Criterion 3 complements Criterion 2, which requires the population to be larger (i.e., to be estimated to be larger) than the 2005 population estimate. Criterion 3 is a conservative extension of this requirement because it also requires that each hibernaculum's predicted estimate of population size 10 years after downlisting be so far above its 2005 population estimate that a 90% confidence limit on the predicted estimate must also be greater than 90% of each hibernaculum's 2005 population estimate.

The 80% requirement within Reclassification Criterion 3 allows some P1 hibernacula or hibernaculum complexes in the Midwest RU to have less strong trends. In the Northeast and Appalachian Mountain RUs, which have few P1 hibernacula, the 80% requirement will require that all of their Priority 1 hibernacula meet the trend requirement, because even one hibernaculum with a lower trend will drop the proportion in the region below the 80% mark. For the Ozark-Central RU to meet this criterion with a reasonable confidence level, the estimated number of bats hibernating in Pilot Knob Mine will need to be confirmed as previously discussed. Because Pilot Knob Mine is assumed to account for the majority of hibernating bats in the Ozark-Central RU, an inability to accurately estimate numbers there could be an obstacle to future downlisting. Again, we propose that Pilot Knob Mine's estimated population remain in future regional and rangewide population estimates and count towards meeting the recovery criteria unless improved survey techniques and/or field tests for improved accuracy indicate otherwise.

In 2005, approximately 80% of each RUs bats overwintered in a combined total of 12 hibernacula and hibernaculum complexes that would each need to pass Reclassification Criterion 3. The current list of hibernacula needing to pass this criterion includes:

- *Ozark-Central RU – Pilot Knob Mine (MO), Magazine Mine (IL), and Great Scott Cave (MO)*
- *Midwest – Wyandotte Complex (IN; includes Bat Wing, Jug Hole, Twin Domes, and Wyandotte caves), Ray's Cave (IN), Coon-Grotto Complex (IN) and Bat Cave (Carter Co., KY)*
- *Appalachian Mountain – Hellhole Cave (WV) and White Oak Blowhole Cave (TN)*
- *Northeast – Ulster County Complex (NY; includes Walter Williams Preserve Mine and Williams Hotel Mine), Barton Hill Mine (NY), and Jamesville Quarry Cave (NY).* [NOTE: this list of hibernacula will be updated in the final recovery plan].

Based on the five most recent winter survey data points (1997, 1999, 2001, 2003, and 2005), five out of these 12 hibernacula/complexes currently would pass this criterion and several others are likely to pass it over the next one or two survey periods, provided that their population numbers continue to increase.

As mentioned above, Reclassification Criterion 3 allows a small possibility of modest population decline over the predicted 10-year period. As Schwartz et al. (2006) point out in their discussion of grizzly bear recovery, once populations reach carrying capacity they are relatively stable (i.e., slope of regression lines ≈ 0), and out of necessity have confidence intervals about their trend lines that are fully 50% in negative numbers. The only way for a population to continue to fulfill Criterion 3 is either for it to continue to grow indefinitely, or for confidence intervals around its trend line to be quite small. It is possible or likely that neither of these requirements will be achievable continuously for all necessary hibernacula. Therefore, if rangewide recovery of the bat is prolonged and some hibernacula had fully met Criterion 3 at some point during their "recovery phase" and then subsequently stabilized near their 2005 population level, then the Service may still consider those populations as having passed this criterion.

Status of Reclassification Criterion 3 (as of December 2008): **NOT ACHIEVED.**
In January and February 2007, new Indiana bat population data was obtained during the biennial winter surveys of hibernacula across the species' range. The Service's Bloomington Field Office coordinated with all bat surveyors, collated the new data, and analyzed it to determine whether Reclassification Criterion 3 had been achieved. We statistically analyzed population data from 1999-2007 (i.e., the 5 most recent population estimates) from a total of 14 of the most populous hibernacula/hibernacula complexes within the four Recovery Units (USFWS 2008: Table 3). Based on the resulting linear regressions and 90% confidence intervals, ten out of the 14 hibernacula (71%) "passed" Reclassification Criterion 3 and four failed (Table 3).

Table 3. The five most recent Indiana bat population estimates for the most populous hibernacula within each Recovery Unit that were used to assess whether or not Reclassification Criterion 3 had been met. To pass this criterion the projected Y-intercept of the lower bound of the 90% confidence interval must be greater than the "pass-fail" bar.

Recovery Unit	State	Most Populous Hibernacula in Each RU	1999	2001	2003	2005	2007	2007 Total Pop. Est. for Each RU	% of the 2007 RU Total Pop. that the Most Populous Hib. Represent	The "Pass/ Fail Bar" (90% of 2005 pop. est.)	Projected Y-Intercept of Lower bound of 90% CI (year 2017)	Pass or Fail?
1	IL	Magazine Mine	9,074	14,679	35,375	35,375	43,509			30,150	67,572	PASS
	MO	Great Scott	9,100	8,250	7,775	6,450	5,100			5,805	1,905	FAIL
	IL	Mine 30	1,000	1,500	2,065	3,700	2,981			3,330	5,540	PASS
	IL	Blackball Mine	1,455	1,562	1,648	1,804	2,513			1,624	2,491	PASS
	MO	Powder Mill	1,660	1,800	2,175	2,150	2,050			1,935	1,930	FAIL
	MO	Hamilton	1	116	530	1,000	1,900	71,819	80.8%	900	2,745	PASS
2	IN	Ray's	62,464	48,219	50,941	54,325	77,686			48,893	30,733	FAIL
	IN	Wyandotte Complex	108,654	108,410	106,712	127,993	126,448			115,194	116,724	PASS
	KY	Carter Caves Complex	25,575	26,225	23,850	35,588	43,906			32,029	34,166	PASS
	IN	Coon/Grotto Complex	10,702	11,814	21,013	19,145	26,906	320,383	85.8%	17,231	37,519	PASS
3	WV	Hellhole**	8,548	8,566	10,288	11,890	12,858			10,701	11,322	PASS
	TN	White Oak Blowhole	3,084	4,548	5,564	7,861	5,481	22,195	82.6%	7,075	4,707	FAIL
4	NY	Ulster Co. Complex	13,191	17,169	21,356	26,832	37,331			24,149	105,256	PASS
	NY	Barton Hill Mine	4,842	5,329	4,940	6,818	9,393	53,787	86.9%	6,136	8,274	PASS

<u>NOTE</u>: The reclassification criteria currently have **<u>not</u>** been met (i.e., we are not ready to downlist to threatened status). Nonetheless, to see how much progress has been made to-date towards full recovery of the species, we went ahead and also assessed the delisting criteria that would need to be met once the Indiana bat had been reclassified as threatened. To assess the delisting criteria, we again used the most current data available.

Delisting Criteria

We do not currently know what "normal" fluctuations in population size might be for the various RUs, and such fluctuations may well vary among RUs. Thus, writing strict requirements for delisting is inappropriate at this time. In addition, as discussed earlier, delisting requirements based exclusively on hibernaculum survey data are also inappropriate. Given that trend information, even high-quality trend information, becomes less, rather than more positive as a species reaches carrying capacity, multiple lines of evidence are the best insurance against overly optimistic delisting decisions. We provide here an initial delisting requirement, and add adaptive requirements for continuously improving the delisting requirement as data become available.

The Indiana bat will be considered for delisting when the Reclassification Criteria have been met, and the following additional criteria have been achieved.

"Delisting Criterion 1: Protection of a minimum of 50 percent of Priority 2 hibernacula in each Recovery Unit."

Greater than 14 percent of the Indiana bat population hibernates in the Priority 2 hibernacula. By achieving this criterion, a significant proportion (but not necessarily 14%) of Indiana bats rangewide will be protected from disturbance in winter habitat and from anthropogenic changes to the thermal regime of hibernacula. Protection of hibernacula includes conserving a buffer zone around each hibernacula and restoration of hibernacula if necessary.

See Reclassification Criterion 1 for further detail and justification.

<u>Status of Delisting Criterion 1 (as of December 2008)</u>: **NOT ACHIEVED.**
Currently, none of the four Recovery Units (RU) has successfully achieved adequate protection of 50% or more of its respective Priority 2 (P2) hibernacula (see Table 4 for details). Protection has been secured at 25% of P2 hibernacula in the Ozark Central RU (n=20), 42% in the Midwest RU (n=26), 25% in the Appalachian Mountains RU (n=4), and 0% in the Northeast RU (n=4).

Table 4. Status of Priority 2 hibernacula (n=54) in regards to meeting Delisting Criterion 1.

RU / State	Hibernaculum Name	Current Ownership	Has Long-term/ Permanent Protection Been Secured?	Is Unauthorized Wintertime Human Disturbance Physically Controlled?	Is Human Disturbance of Hibernating Bats still a Threat?	Are Surface Buffer Zones Being Conserved/ Protected?	Pass / Fail
Ozark-Central (n= 20): **25% currently pass**							
AR	Horsethief	Private	Unknown	No	Yes	No	FAIL
AR	Cave Mountain	Federal	Yes	Yes (fence)	Yes	Unknown	FAIL
AR	Edgeman	Private	Yes	Yes (gate)	No	Yes	PASS
AR	Horseshoe	Federal	Yes	Unknown	Yes	Unknown	FAIL
IL	Unimin - Mine 30	Private	Yes	No	Unknown	Yes	Uncertain
IL	Griffith	Private	Unknown	Unknown	Yes	Unknown	FAIL
IL	Gutherie	Private	Unknown	Unknown	Yes	Unknown	FAIL
IL	Toothless	Private	Unknown	Yes (gate)	No	Unknown	Uncertain
IL	Blackball Mine	State	Yes	Yes (gate)	Yes	Unknown	FAIL
IL	Ellis	Private	Unknown	Unknown	No	Unknown	Uncertain
MO	Chimney Rock	Private	Unknown	Unknown	Yes	No	FAIL
MO	Bear	State	Yes	Yes (gate)	No	No	FAIL
MO	Great Spirit	State	Yes	Yes (gate)	No	Yes	PASS
MO	Tunnel	Private	Unknown	Unknown	Yes	No	FAIL
MO	Cookstove	Private	Unknown	Yes (gate)	No	No	Uncertain
MO	Martin # 1	Private	Unknown	Yes (gate)	No	No	Uncertain
MO	Mose Prater	Federal	Yes	Yes (gate)	No	Yes	PASS
MO	Powder Mill	State	Yes	Yes (gate)	No	Yes	PASS
MO	Hamilton	State	Yes	Yes (gate)	No	No	FAIL
MO	Scotia Hollow	Private	Yes	Yes (gate)	No	Yes	PASS
Midwest (n=26): **42% currently pass**							
IN	Parker's Pit	Private	No	No	Yes	No	FAIL
IN	Wallier	Private	No	No	Yes	No	FAIL
IN	Endless	Private	Yes	No	Yes	Yes	FAIL
KY	B&O	Private	Unknown	Unknown	Yes	Unknown	FAIL
KY	Norton Valley	Private	Unknown	Unknown	Yes	Unknown	FAIL
KY	Thornhill	Private	Unknown	Yes (gate)	No	Unknown	Uncertain
KY	Laurel	State	Yes	Unknown	Yes	Yes	FAIL
KY	Saltpeter	State	Yes	Yes (gate)	No	Yes	PASS
KY	Colossal	Federal	Yes	Yes (gate)	No	Yes	PASS
KY	Jesse James	Private	Unknown	Yes (gate)	Yes	No	FAIL
KY	Morton	Private	Unknown	Unknown	Unknown	Unknown	Uncertain
KY	Wind	Private	Unknown	Unknown	Yes	Unknown	FAIL
KY	Cave Hollow	Federal	Yes	Yes (gate)	No	Yes	PASS
KY	Stillhouse	Federal	Yes	Yes (gate)	No	Yes	PASS
KY	Green	Private	Unknown	Unknown	Yes		FAIL
KY	Little Amos	Federal	Yes	No	No	Yes	PASS
KY	Smokehole	Private	Unknown	Unknown	Yes		FAIL
KY	Waterfall	Federal	Yes	Yes (gate)	No	Yes	PASS

Table 4. Continued.

Midwest: continued							
OH	Lewisburg Limestone Mine	Private	No	Yes (gates)	Yes	No	FAIL
TN	New Mammoth	Private	No	No	Yes	Yes	FAIL
TN	Wolf River	Private	Yes	Yes (gate)	Unknown	Yes	PASS
TN	Pearson	Private	Unknown	Yes (gate)	No	Yes	PASS
TN	Nickajack	Federal	Yes	Yes (gate)	No	Yes	PASS
TN	Bellamy	Private	Yes	Yes (fence)	No	Yes	PASS
TN	Hubbards	Private	Yes	Yes (gate)	No	Yes	PASS
VA	Cumberland Gap Saltpeter	Federal	Yes	Unknown	Yes	No	FAIL
Appalachian Mountains (n=4): **25% currently pass**							
PA	Hartman Mine	State	Yes	Yes (gate)	No	Yes	PASS
PA	Penns	Private	No	Yes (gate)	Yes	No	FAIL
VA	Rocky Hollow	Unknown	Unknown	Yes (gate)	No	No	FAIL
WV	Trout	Private	Yes	Yes (gate)	Yes	No	FAIL
Northeast (n=4): **0% currently pass**							
NY	Barton Hill Mine	Private	Unknown	Yes (fence)	Yes	No	FAIL
NY	Glen Park	Private	No	No	Yes	No	FAIL
NY	Jamesville Quarry Cave	Private	Unknown	No	Yes	No	FAIL
NY	Williams Lake Mine	Private	Unknown	No	Yes	No	FAIL

"Delisting Criterion 2: A minimum overall population estimate equal to the 2005 population estimate of 457,000."

See Reclassification Criterion 2 for justification.

Status of Delisting Criterion 2 (as of December 2008): **ACHIEVED.**
In January and February 2007, significant new Indiana bat population data was obtained during biennial winter surveys of hibernacula across the species' range. The Service's Bloomington Field Office coordinated with all bat surveyors, collated the new data, and calculated a new 2007 population estimate (USFWS2008) (Table 2). The current rangewide population estimate is approximately 468,000 Indiana bats, which is a 10% increase above the 2005 estimate of 425,000 bats and thus Delisting Criterion 2 is currently being met.

NOTE: For Reclassification Criterion 3 (RC3) and Delisting Criterion 3 (DC3) to be successfully met, the overall population minimum established in RC2 and DC2 will have to, by default, increase or stabilize well above 457,000 bats. In the Final Plan, the Service plans to modify this criterion to require that the overall population estimate must be equal to or greater than the population estimate at the time of reclassification, which will be by statistical necessity much greater than 457,000 bats.

"Delisting Criterion 3: Documentation using statistically reliable information that shows a positive population growth rate over an additional five sequential survey periods (i.e., 10 years). The protocol will attempt to include methods for estimating variances in counts, ideally allowing partitioning of variance into components based on population growth processes and on sampling variance. Each Priority 1A hibernaculum will be analyzed independently for trends in growth, with the exception of hibernacula that act as a composite unit (e.g., Wyandotte, Twin Domes, Batwing) or "complex", in which case all hibernacula within the composite unit will be analyzed collectively. Documented increases at 80% of P1A hibernacula are needed for reclassification. An increase will be measured using linear regression through the data points; a slope greater than 0 will be considered an increase.

If improvement in the precision of hibernacula sampling techniques falls short of that desired, we will attempt to determine the population growth rate based on concordance of estimates from two data sets developed independently. The second data set, proposed to be developed from implementation of the recovery actions related to population demographic research, will result in a demographically based life-history model for population growth rate. The model will be derived from reproduction data and survival rate estimates based on individual animal capture-recapture histories in the field."

See Reclassification Criterion 3 for further detail and justification.

Status of Delisting Criterion 3 (as of December 2008): **ACHIEVED.**
We analyzed population data from 1999-2007 (i.e., the 5 most recent population estimates) for each of the Priority 1A hibernacula and P1A hibernacula complexes (n=10) (USFWS 2008) (Table 5). Based on the resulting linear regressions, eight out of the ten hibernacula or 80% have positive slopes. Therefore, the requirement for Delisting Criterion 3 has been met.

Based on recently revised population data (USFWS 2008), Pilot Knob Mine no longer meets the definition of a P1A hibernaculum and therefore was excluded from this criterion. Bat populations within Great Scott and Dixon caves have declined and thus they had negative slopes and "failed" to pass this criterion. Furthermore, we have yet to achieve the desired level of accuracy in our hibernacula sampling techniques that would allow us to reliably estimate confidence intervals around each of our population data points. Likewise, the Service has not yet developed a second, independent data set that could be used with a demographically based life-history model for population growth rate as stated in the criterion. Development of these data sets/demographic models has been identified as a recovery action within the recovery plan.

Table 5. Indiana bat population estimates for Priority 1A hibernacula/complexes (n=10) that were used to assess whether or not Delisting Criterion 3 had been met. For this criterion to be acheived, 80% of the linear regressions through each P1A hibernaculum's data must have a positive slope (i.e., slope > 0).

Recovery Unit	State	County	Hibernaculum Name	1999	2001	2003	2005	2007	Is Slope >0?	Pass or Fail?
1	IL	Alexander	Magazine Mine	9074	14679	26325	33500	32,379	Yes	PASS
	MO	Washington	Great Scott	9,100	8,250	7,775	6,450	5,100	No	FAIL
2	IN	Crawford	Wyandotte Complex	108,654	108,410	106,712	127,993	126,447	Yes	PASS
	IN	Greene	Ray's	62,464	48,219	50,941	54325	77,686	Yes	PASS
	IN	Monroe	Coon & Grotto Complex	6,341	6,395	10,675	9270	14,099	Yes	PASS
	KY	Carter	Carter Caves Complex	25,575	26,225	23,850	35,588	43,906	Yes	PASS
	KY	Edmonson	Dixon	5575	3670	3600	3100	2,563	No	FAIL
3	TN	Blount	White Oak Blowhole	3,084	4,548	5,564	7861	5,481	Yes	PASS
	WV	Pendleton	Hellhole	8548	8566	10,288	11,890	12,858	Yes	PASS
4	NY	Ulster	Williams Mines Complex	13,191	17,169	21,356	26,832	37,331	Yes	PASS