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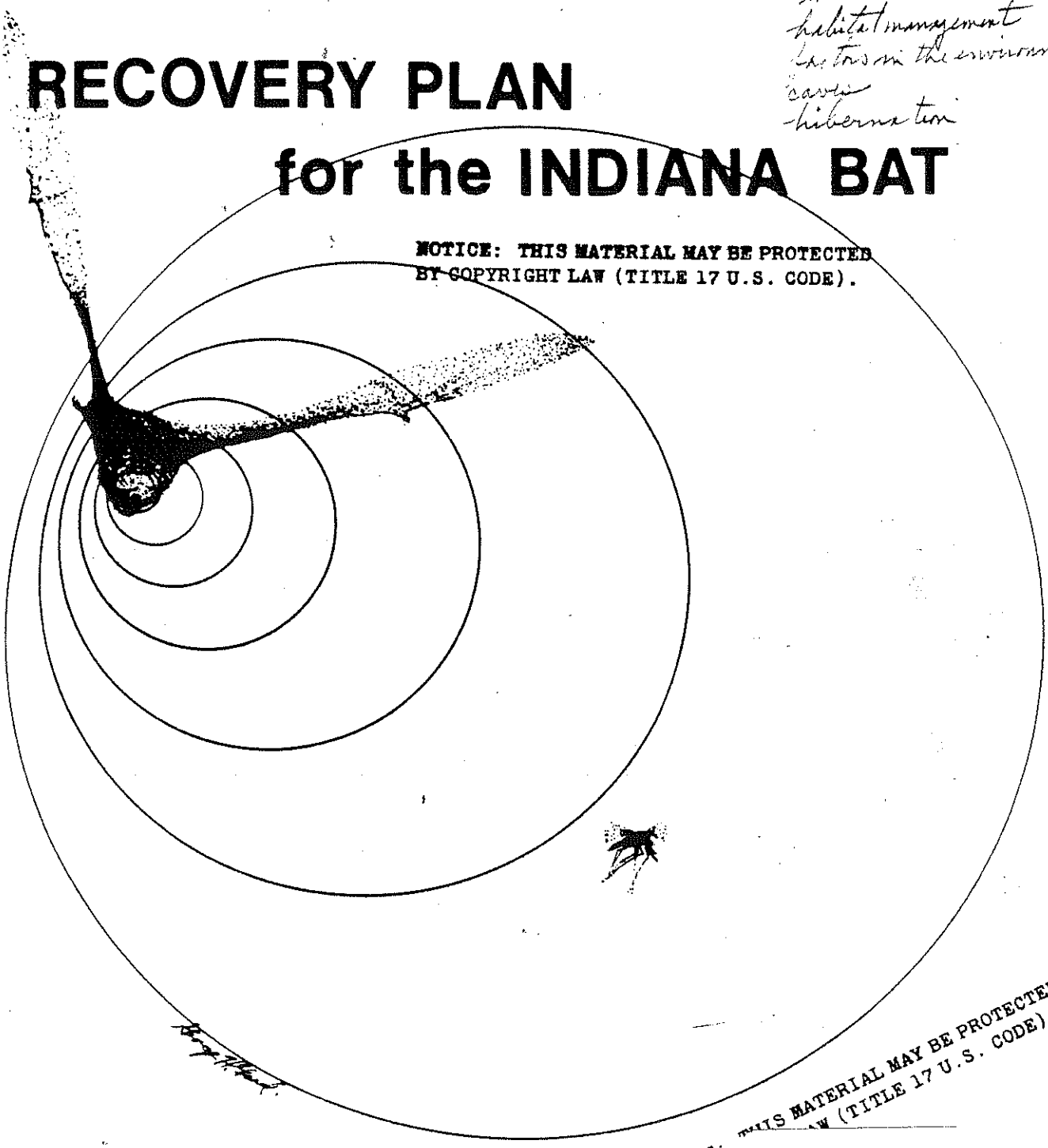
RECOVERY PLAN for the INDIANA BAT



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ADDRESS ONLY THE DIRECTOR,
FISH AND WILDLIFE SERVICE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON, D.C. 20240

RECEIVED
JUN - 3 1976
REGIONAL DIRECTOR
REGION 3
BUREAU OF SPORT FISHERIES AND WILDLIFE

In Reply Refer To:
FWS/OES 310.6

JUN 1 1976

MEMORANDUM

To: Regional Director - Region 3
Associate
From: Director, U.S. Fish and Wildlife Service

Subject: Indiana Bat Recovery Plan

We are approving on an interim basis the Indiana Bat Recovery Plan submitted last August with the stipulation that the plan be revised according to the FY 77 Program Advice. The description of critical habitat in the plan is excepted from this approval and should be deleted in the FY 77 revision. Our memo of July 10, 1975, on the first draft should be reviewed again and fully incorporated in the 1977 revision. We still note the absence of provisions for preserving summer and migration habitats.

From an outside source we received Dr. Humphrey's comments of October 6 on the revised plan. It is unfortunate his input arrived too late for incorporation into this revision. We feel Dr. Humphrey's letter is the most constructive and comprehensive of any received here to date on any plan. It contains additional thoughts on possible critical nature of summer habitats.

Our comments on the plan by page are as follows:

Page 1. As noted in our July 10 comments, a Recovery Team does not have the authority to determine "critical habitat" in context of Section 7 of the Endangered Species Act. The term "critical habitat," if it is to be used in the plan, should be replaced with an analogous term that cannot be confused with the law. We welcome team recommendations on "critical habitat," but cannot "sign off" on such a recommendation in a plan without it being taken by some as a final

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legal decision. A more appropriate introduction would cover a short description of the Indiana Bat, its distribution, life history, habitats, and known and possible limiting factors. We grant the latter was covered.

We recommend code numbers be substituted in place of names for those caves which do not have adequate security. Although it is not practical to keep the names of such caves confidential, we see no point in "advertising" their names through a recovery plan which will receive wide public distribution. This point is pertinent in view of reports of threats to disturb bats in some caves.

Figure 1 referred to on page 1 is not discernible. This figure is useful and should be adequately reproduced.

Pages 3-5. The step-down outline, which should form the basis for all actions to be taken on behalf of the bat, contains items which should be in the implementation chart on page 30 (table 3) rather than step-down. We urge the team to devise a more definitive primary objective. Sufficient information is available on populations, both past and present, and distribution, to come up with a reachable quantitative goal that, in the team's judgment, would qualify the bat to be down-listed if not de-listed. This goal can be changed at a later date if proven impractical.

As pointed out by many reviewers, and in comment 1 of our July 10 memo, no species can survive in the wild without preservation of its habitat. The step-down provides for preservation of winter habitat only. Obviously, the primary objective cannot be met without preservation of habitats used every month of the year. Sections 32 and 34 call for instituting searches and censuses that could lead to more information about summer habitats. Such actions in themselves do not preserve habitat. Preservation of summer habitat should be on an equal level with winter habitat preservation in the step-down. Since actions needed to assure preservation of summer habitat have not been determined, the research needed to identify such actions logically falls under this heading. Thus two major steps could come under summer habitat preservation, (1) research to identify needs and (2) implementation of actions identified by research. We acknowledge this may not be high priority action; but as pointed out on pages 11 and 13 of the plan in Dr. Humphrey's letter, destruction of summer habitat could be a limiting factor and the status and needs of the bat in summer needs to be clarified. The Corps of Engineers sponsored research on the subject mentioned in your responses to reviewers should appear as ongoing in table 3, the Implementation Schedule.

Section 14 of the step-down should be combined with 13 and 2. Sections 1411 through 1417 logically follow 133 in sequence since they all call for restricting entry to specific caves. The step-down should not identify "whos" and "hows" which belong in the Implementation section.

Section 2 should identify the message to be put out in the information and education program.

Sections 34 and 35 are not monitoring. They both relate to needs to identify possible limiting factors.

A more logical step-down could be built around the following:

1. Preserve wintering habitat.

    11. Acquire important caves not already in public ownership.

    12. Maintain habitats of all important caves.

2. Preserve summer and migration habitat.

    21. Determine summer and migration distribution.

    22. Determine summer and migration habitat requirements.

    23. Determine existing and future summer and migration habitat limitations, if any.

    24. Take any actions needed to preserve habitats identified by 23.

3. Protect Indiana Bat against man caused mortality.

    31. Protect hibernating Indiana Bats from disturbance or destruction.

    32. Identify and protect against mortality factors such as pesticides.

4. Disseminate information that will lead to public understanding of Indiana Bat ecology and needs.

5. Monitor Indiana Bat populations for measuring restoration progress.

Under the above major headings could fall all the sub-objectives and actions needed to restore this bat.

Page 8. Several reviewers picked out the erroneous statement heading the 4th paragraph reading, "It is unknown if the summer habits of the Indiana Bat are critical to its life cycle."

Page 9. The subject of swarming is addressed in the 3rd paragraph, and need to protect swarming or migration areas is spoken of also. If swarming areas are essential, as suggested, the item should be covered in the step-down process.

Page 15, Paragraph 4. All Federal agencies are charged with conservation of Endangered species. Besides the Forest Service, we understand the National Park Service and U.S. Army Corps of Engineers administer Indiana Bat habitat.

Page 15, Paragraph 5. DDT has not been "banned" in the U.S.; use is regulated and it was recently used on a large scale for forest insect control. Other organochlorine insecticides such as aldrin, dieldrin, heptachlor and chlordane have been similarly restricted.

Page 29. This table needs a title. It is unclear what the figures represent.

Page 30, (Implementation Schedule). The priority for carrying out actions comes out identical to the consecutive numbers in the step-down, yet many of the actions are not sufficiently specific to enable an agency to carry through without further directions and clarification of objectives from the team. Actions should be further broken down in the step-down and defined in the narrative. For example, should buffer zones be acquired around caves? If so, how much area? What are the standards for population surveys and how and when conducted? What messages should the Information and Education program carry? What seasonal time frames should winter caves be closed to public use?

Is the implementation schedule realistic? Do the States listed as "lead" have prospective funding to carry out the actions assigned to them? We were disappointed their letters did not indicate their ability to carry out the assigned tasks. For example, Kentucky is down for a $75,000 purchase of Coach Cave. Their letter didn't indicate they could make this purchase. This State has not submitted a program or qualifications for funding under Section 6 of the Endangered Species Act, but perhaps you feel they have other funds. The National Park Service is down for several actions, but the only letter in the plan is from Mammoth Cave National Park.

Rather than assume the Service will take over if other agencies don't, as indicated in the note at the bottom of table 3, we would prefer where no sponsor of a proposed action is available, that the table simply state "sponsor needed". The Service is not in position to always fund when others fail to come up with the money. We should keep the door open for cooperative funding.

The plan's basic premise that acquisition and protection of high use wintering caves represents an essential first step meets with our full endorsement. Implementation of the plan as it stands can, therefore, begin, although standards for control of land around caves must follow. The nearly $50,000 proposed for information and Education in FY 77 is a major expenditure which cannot be fully implemented without further delineation and justification. We hope the agencies specified can move toward restricting public entry of caves under their jurisdiction as soon as called for in the plan.

We ask that you rewrite the plan as suggested above, and we will provide a due date for it in the FY 77 Program Advice. The existing plan can be distributed for use on an interim basis if a copy of this memo is attached.

In spite of our criticisms, we commend the team for making a good start. Our thanks to team members for their efforts.

Keith M. Schreiner

Director
U. S. Fish & Wildlife Service
18th and "C" Streets, N. W.
Washington, D. C. 20240

Dear Mr. Greenwalt:

Last January you asked us to prepare a recovery plan for the endangered Indiana bat. We have assembled what we consider a practical plan which, when carried out, will assure recovery of the species.

While the burden of implementation falls on many individuals and agencies, the interest expressed to the team indicates a real concern for the preservation of the species. In considering the rapid decline of the population, it is our hope that implementation of the plan can be initiated in the near future.

As you indicated in your charge to us, we will annually update the plan, making revisions as new information becomes available and as tasks are accomplished. In assuming the coordinating role for the recovery effort on the Indiana bat, we respectfully wait for your concurrence.

Sincerely yours,

Team Members
Indiana Bat Recovery Team

Team Leader;
U.S. Fish and Wildlife Service
Twin Cities

James M. Engel — Fred R. Courtsal — Dr. Robert L. Martin

James R. Messerli — Thomas H. Hooper — Dr. R. E. Mumford

Leslie E. Terry

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INDIANA BAT

RECOVERY PLAN

Introduction

Critical habitat for the Indiana bat is, with present knowledge, defined as those caves and mines utilized by the Indiana bat and essential to the survival of the species throughout its range. At this time, the critical caves and mines are as follows:

- Coach Cave, Edmonson County, Kentucky (private)
- Bat Cave, Shannon County, Missouri (NPS, Ozark Nat. Scenic Riverways)
- Pilot Knob Mine, Iron County, Missouri (Pilot Knob Pellet Co.)
- Cave 021*, Crawford County, Missouri (COE)
- Cave 009*, Franklin County, Missouri (Mo. State Park)
- Cave 029*, Washington County, Missouri (private - Mrs. Scott)
- Cave 017*, Franklin County, Missouri (Mo. State Park)
- Bat Cave, Carter County, Kentucky (Ky. State Park)
- Hellhole Cave, Pendleton County, West Virginia (private - near Nat'l. forest)
- Big Wyandotte Cave, Crawford County, Indiana
- Ray's Cave, Green County, Indiana (private - Mr. Guy Livingston)
- Blackball Mine, LaSalle County, Illinois (Ill. Dept. Conservation)
- White Oak Blowhole Cave, Blount County, Tenn. (NPS - Great Smoky Mt. Nat'l. Park)

The summer habitat, essential to the survival of the species throughout its range, must be delineated and defined. There are indications that riparian habitat is critical for reproduction and foraging.

Approximately 94 percent of the known population hibernates in these thirteen caves and mines; because of the susceptibility of the populations to disturbances by man, it is vital that these sites be protected for the preservation and recovery of the species.

Populations of Myotis sodalis occur in other habitats throughout the range (Figure 1). States, conservation organizations and local governments should be encouraged to take appropriate measures to provide protection to these populations as they are of local significance and preservation of the species would be enhanced.

*Number assigned by USFWS, Kansas City, Missouri

In providing protection for critical habitat, regulations must be developed to assure protection of the species after it has been removed from the List of Endangered Species.

Human disturbances to the highly susceptible wintering populations are considered the primary cause of population decline. With control of human access, adverse effects caused by man on the national population can be minimized.

Population levels and habitats should be delineated and monitored annually and this effort should be continued after the species is removed from the Endangered Species List. Universities and other groups should be encouraged to initiate ecological studies of the species, but study proposals should be critically reviewed to assure that they are consistent with recovery efforts. Removal from the Endangered Species List can be expected if the recovery plan is carried out.

RECOVERY PLAN

Primary Objective ... To conserve, as defined by the Endangered Species Act of 1973 (PL 93-205, Section 3, paragraph 2) the Indiana bat, Myotis sodalis; to provide protection and monitor populations for continued conservation of the species after it has been removed from the Endangered Species List.

1. To preserve critical winter habitat, secure primary caves and mines and restrict entry.

   11. Acquire land and restrict entry.

      111. Purchase and restrict entry: Coach Cave, Edmonson County, Kentucky; Lead Agency State of Kentucky.

   12. Acquire control (through easement, land acquisition or lease) and restrict entry.

      121. Pilot Knob Mine, Iron County, Missouri; Lead Agency State of Missouri.

      122. Cave 021*, Crawford County, Missouri; Lead Agency U. S. Fish and Wildlife Service.

      123. Cave 029*, Washington County, Missouri; Lead Agency State of Missouri.

   13. Restrict Entry.

      131. Bat Cave, Shannon County, Missouri; Lead Agency State of Missouri.

      132. Cave 009*, Franklin County, Missouri; Lead Agency State of Missouri.

      133. Bat Cave, Carter County, Kentucky; Lead Agency State of Kentucky.

   14. Encourage States and conservation organizations to acquire control and/or restrict entry of other caves and mineshafts frequented by the Indiana bat.

*Number assigned by USFWS, Kansas City, Missouri

141. Provide assistance to States (technical and financial)

1411. Restrict entry to Cave 017*, Franklin County, Missouri; Lead Agency State of Missouri.

1412. Restrict entry to Hellhole Cave, Pendleton County, West Virginia; Lead Agency State of West Virginia.

1413. Restrict entry to Big Wyandotte Cave, Crawford County, Indiana; Lead Agency State of Indiana.

1414. Restrict entry to Ray's Cave, Greene County, Indiana; Lead Agency State of Indiana.

1415. Restrict entry to Blackball Mine; LaSalle County, Illinois; Lead Agency State of Illinois.

1416. Restrict entry to White Oak Blowhole Cave, Tennessee; Lead Agency State of Tennessee.

1417. Restrict entry to other caves and mines as determined by State Governments.

142. Provide and coordinate information and education programs and technical assistance to private groups and local governments.

15. Assure protection of the caves and habitats after the species is removed from the list.

151. Develop State or Federal conservation regulations.

2. Initiate information and education programs.

21. For general public.

22. For users of caves.

23. For owners of caves.

24. For other individuals necessary to carry out recovery plan (Administrative and political).

25. Develop and initiate information and education programs that will continue after the species is removed from the list.

*Number assigned by USFWS, Kansas City, Missouri

3. Monitor population levels and habitat.

   31. Obtain necessary permits (Federal and State).

   32. Develop and initiate improved census techniques (populations and habitat).

   33. Conduct annual survey in primary caves and mines.

   34. Search for unknown populations and habitats.

   35. Determine effects of pesticides.

      351. Determine effects of pesticides on M. sodalis population levels.

      352. Determine effects of pesticides on closely related species of bats.

NOTE: See Table 3, SCHEDULE FOR IMPLEMENTATION, for estimated costs, responsibilities, implementation dates and completion dates.

Priorities are established by sequence in the step-down plan. Table 3 is the recommended schedule for implementation pending availability of funding.

THE INDIANA BAT, Myotis sodalis

Range and Numbers ... The range of Myotis sodalis includes the mid-western and eastern United States, from the western edge of the Ozark region in Oklahoma to southern Wisconsin and southern Michigan to central Vermont, and as far south as northern Florida (Figure 1). (Allen, 1967; Barbour and Davis, 1969; Davis and Lidicker, 1955; Easterla and Watkins, 1969; Fenton, 1966; Hall and Brenner, 1968; Muir and Polder, 1960; Jennings and Layne, 1957.) Major concentrations are associated with cavernous limestone areas in Missouri and Kentucky, with lesser populations in Illinois and Indiana. Colonies are known from New England, New York, Pennsylvania, Virginia, West Virginia, Arkansas, Ohio, North Carolina, Tennessee, and Alabama. Records from Mississippi, Iowa, Michigan, Wisconsin and Florida have been of individuals rather than of colonies. No large populations have been recorded from the northern or eastern portions of the range. (See Table 1)

In winter, the Indiana bat congregates, sometimes by the thousands, in the relatively few caves and mines which it finds suitable to its needs. Population estimates made from 1956 to 1961 of bats hibernating in certain caves are shown in Table 2 (from Hall, 1962). Two caves in Kentucky (Bat Cave, Carter County and Coach Cave, Edmonson County) and a cave and a mine in Missouri (Bat Cave, Shannon County and Pilot Knob Mine, Iron County) each harbored about 100,000 in winter which accounted for about 90 percent of the known population of the species at that time. The rest occurred in groups numbering from a dozen to a few thousand in several dozen caves and mines scattered throughout its range.

Population estimates of M. sodalis obtained in February, 1971 for four caves in Mammoth Cave National Park, Edmonson County, Kentucky, were: Long's Cave, 8,000 to 10,000; Dixon Cave, 4,000 to 5,000; Colossal Cave, 700 to 750; Bat Cave, 200 to 300 (L. W. McKenzie, in litt., Dec. 27, 1972). Comparison with Table 2 shows that these figures represent increases since 1961 in Long's Cave, Dixon Cave and Bat Cave and decreases in Colossal Cave. McKenzie also stated that, "A fairly sizable population also colonizes Coach Cave, a privately owned cave near the park. Smaller numbers are scattered throughout the Mammoth Cave complex and other private caves."

Recent population census data indicates that the Indiana-Illinois-Kentucky breeding unit of M. sodalis has declined 71.5% in the last 15 years (Humphrey, 1975). Populations were recently found in Missouri (Vogel, 1975), and West Virginia has a population of 1,500 (Hall, 1975). Mumford (1974) reported that the wintering population of M. sodalis in Big Wyandotte Cave (Crawford County, Indiana) has greatly declined during the past twenty years. Populations in Ray's Cave (Greene County, Indiana) have fluctuated, but the numbers present in 1974 are about equal to the recorded high numbers over the years that records are available. Buckner's Cave (Monroe County, Indiana) is holding a rather steady population. Table 1 summarizes population estimates and records trends of the Indiana bat population.

Biology of Myotis sodalis as related to Endangerment

Limited Distribution ... The major winter populations for M. sodalis are found in cavernous limestone areas drained by the Mississippi River and its tributaries and from the eastern United States. Some records are from mine tunnels in limestone areas or close to them. Since the entire winter range is closely associated with major riverways, these rivers may be important in the dispersal, summer habitat, navigation and feeding of M. sodalis (Hall, 1962; Guthrie, 1933). Precisely selected caves are the same each year, though different caves may be utilized by an individual in different years. In Kentucky, a state which contains some of the world's largest caves, M. sodalis was found in only seven caves in Edmonson County (Table 2). These preferred caves (Wilson, Coach, Dixon, Long's, James', Colossal and Bat) are medium-sized with large passageways which do not extend for great distances (Hall, 1962). Mumford (1974) reported that the Indiana bat is known to hibernate or roost in only 19 caves in Indiana. Since the cave areas of Missouri and Kentucky are the primary centers of winter abundance of the species, any localized factors contributing to a decline of the species would be more serious than if the populations were less concentrated.

Hibernating Conditions ... Temperature and relative humidity are important factors in the selection of hibernation sites. In mid-winter, temperature in caves in which M. sodalis hibernates averages 3° to 6° C., with little fluctuation. Relative humidity is high, ranging from 66% to 95% and averaging 87% throughout the year (Barbour and Davis, 1969). These exact conditions, and the concentrations of this species, are found only in a rather narrow zone close to the cave entrance (Hall, 1962).

Any disturbance which would alter the temperature or humidity of this zone is most apt to come from outside the cave; thus, this species would be more vulnerable than those species hibernating deeper in the cave. Then too, bats hibernating near the cave entrance would be the first to suffer from an outside disturbance such as vandalism.

Clustering ... An interesting feature of bat behavior is the habit of clustering. As several of the bat species which cluster are adapted to different temperature zones, several species may occupy the same cave in winter (Hall, 1962). M. sodalis characteristically forms large, tight, compact clusters of as many as 5,000 individuals, although normally there are about 500 to 1,000 bats to a cluster. The bats bunch together so tightly that it is difficult to discern the outline of an individual bat (Fig. 2). The size of a cluster of M. sodalis and its location near the cave entrance is about the same every year. There may be more than one cluster in a cave (Hall, 1962). Dense hibernating clusters of M. sodalis may contain 300 per square foot.

The species aggregates so intensively in winter that a few caves contain a high percentage of the known total individuals of the species. Thus, a local catastrophe would be of great importance to M. sodalis while the same event or pressure would not as seriously effect the species during summer months when it is more randomly distributed. Hall (1962) has noted that "any selective pressure against aggregation could cause, very rapidly, a near or complete extinction of the species". Because of the clustering and aggregation behavior, protection of the primary caves is a major portion of recovery efforts for the species.

Summer Habitat ... It is unknown if the summer habits of the Indiana bat are critical to its life cycle. Mumford (1974 personal communication) states that "once the animals leave the hibernating sites, they evidently scatter widely and possibly do not form large breeding colonies like those of other species of Myotis. The Indiana bat evidently does not breed in caves and it appears likely that houses are not used extensively, or else someone would have found maternity colonies by now. James B. Cope and Stephen Humphrey are working with the only known breeding colony in Indiana. This colony is situated beneath the loose bark of a dead tree and is composed of a small number of females and young. If we assume that this is the typical breeding aggregation, there must be literally thousands of such small colonies scattered about the summer range of the species".

Humphrey (1974) concluded that numerous small, obscure nurseries in trees would make M. sodalis far less vulnerable to catastrophic threats in summer than when congregated in caves in winter. The loss of one, or several, of these breeding colonies would not be detrimental to the species as a whole. The loss of large amounts of summer habitat, however, could be catastrophic (Humphrey, 1975).

Staging ... Myotis sodalis and some other bats gather in numbers at the mouths of certain caves during the fall. The bats have been captured by setting mist nets across these cave entrances at night (Barbour and Davis, 1969). This so-called staging behavior seems to involve mostly animals presumably on migration. Staging takes place from August to October and its significance to the bats is unknown. One theory is that it facilitates fall mating and copulating by bringing together numbers of males and females. Evidently, in most cases, the bats mill about the cave mouth but do not necessarily enter the cave to roost. For example, one may net and band hundreds one night at the cave entrance but the next day an examination of the cave may reveal none of these animals.

We do not know whether staging (called swarming by some authors) takes place at all caves that harbor wintering M. sodalis, but this is the case for two such caves in Indiana. Further investigation might shed more light on the subject. If there are staging areas where M. sodalis gathers in large numbers each fall but where the species does not winter, such areas should be protected.

Associated Species ... Hall (1962) analyzed the habitat selection of M. sodalis and other bat species found in the same caves. Each species has definite environmental requirements for hibernation.

According to Hall (1962), Eptesicus fuscus is fairly common in the same caves as M. sodalis, but generally hibernates in colder areas than M. sodalis, from -2° to 5° C. Unlike M. sodalis, Eptesicus does not form tight clusters and (if hanging) hangs singly on the sidewalls of the cave or jams into cracks or holes. Thus, there is no competition with M. sodalis. Myotis lucifugus has a much wider temperature tolerance than M. sodalis. In caves housing M. sodalis, M. lucifugus has been seen hibernating in areas where the temperature ranges from -1° up to 13° C. Its area of hibernation seems to be controlled more by moisture than temperature and the species is

typically found where the humidity is near 100%. Hall (1962) states that M. lucifugus forms a semi-dense cluster different from M. sodalis. Again, there does not appear to be any competition between M. sodalis and M. lucifugus. Another species commonly found in caves with M. sodalis is Pipistrellus subflavus. This small bat occupies the warmer, deeper parts of the cave where the temperature is 12° to 13° C. (Hall, 1962).

The bat which has ecological requirements which are most similar to those of M. sodalis is Myotis grisescens. M. grisescens may be found in the same caves as M. sodalis and although they cluster somewhat like M. sodalis, active competition for hibernation space may or may not occur, since M. sodalis is more cold tolerant than M. grisescens. Hall (1962) cites an example where M. grisescens, not normally competitive with M. sodalis, could be a disturbing influence. During the winter of 1958 to 1959, there were about 10,000 M. grisescens in a colony of approximately 100,000 to 150,000 M. sodalis, located in Coach Cave, Edmonson County, Kentucky. There was an overlapping area of hibernation space and M. grisescens tended to hang directly on clusters of M. sodalis. The next winter the number of M. grisescens increased to about 50,000. Hall speculated that M. grisescens was taking over Coach Cave as a hibernating site to the possible detriment of M. sodalis. Twente (1955) in his behavioral study of several other species of bats concluded that the distribution of all species (while resting or hibernating) may overlap, but "generally it can be said that the type of habitat selected by each species is different".

Natural Hazards to Bats

Declines in cave bat populations were reported as early as 1952 and have reached serious and alarming proportions (Mohr, 1972; Humphrey, 1975). A survey of 100 of the Nation's leading bat experts (Jones, 1971) indicated that a total of 39 bat species was believed to be declining in part or in all of their ranges. Various natural hazards apparently contribute to the decline of bat populations.

Floods ... Hall (1962) postulated that M. sodalis follows river valleys in its migrations and may be vulnerable in caves subject to flooding. He reported that along the Green River in Mammoth Cave National Park, Kentucky, there is a deposit of an estimated 300,000 skeletons of M. sodalis in a section of Bat Cave, Edmonson County, that apparently had been flooded in 1937, and definitely was in 1957 and 1964.

It is not known whether one or several floods caused the death of these bats, but this M. sodalis colony was considerably larger than the largest present colony in the area.

According to Griffin (1953), a flood in Aitkin Cave, Mifflin County, Pennsylvania, in November, 1950, drowned about 90 percent of a population of 5,000 bats, mostly M. lucifugus but including M. sodalis. DeBlase reported that a flash flood swept through Wind Cave, Breckenridge County, Kentucky, and virtually wiped out a wintering population of bats under study for several years. Three months before the flood, the population was counted at 6,545 bats, of which 60 percent were M. sodalis and 40 percent were M. lucifugus. After the flood, 1,600 carcasses were found (DeBlase et al, 1965).

Collapse of Hibernating Site ... A hibernating site of M. sodalis collapsed in the Blackball Mine, LaSalle County, Illinois, when the mine shoring gave way, killing a small colony of M. sodalis always found in the same spot (Hall, 1962).

Disease ... After the disclosure in 1953 that insectivorous bats in the United States could carry rabies virus and transmit it to man, Constantine (1970) reported that rabies virus had been isolated from 24 of 40 species of bats in all 48 states south of Canada. Though M. sodalis has not been found infected, it is probable that any species of mammals can contract rabies.

The incidence of disease as a mortality factor in M. sodalis is not known.

Predation ... There seems to be no North American predator that habitually makes bats its prey. Almost all carnivorous mammals, birds, reptiles, amphibians, and fish occasionally prey on bats, but for the most part are merely opportunistic (Gillette and Kimbrough, 1970). A common natural phenomenon is heavy loss of young which fall to the cave floor and are consumed by a host of predatory vertebrates and invertebrates (Mohr, 1972).

Disturbances by Man

Insectivorous bats are heavy with fat deposits when they enter hibernation and they are able to survive the winter dormancy more successfully if not disturbed. Since even minimal disturbance during

hibernation may arouse bats to an active state and drain their energy supply (Mohr, 1972; Twente, 1955), any unnatural arousal may increase mortality.

Vandalism ... Mohr (1972) reported attacks on bat colonies at Carter Caves State Park, Carter County, Kentucky. In the winter of 1975, hundreds of M. sodalis were killed by being stoned from the low cave ceiling. In December, 1958, vandals discharged fire crackers and homemade bombs in the midst of the clusters. On December 26, 1960, an estimated 10,000 bats were killed when three boys tore great masses of bats from the ceiling and trampled and stoned the helpless animals; thousands fell into the stream which flows through the cavern and were drowned before they could rouse from their torpid state.

The Blackball Mine, LaSalle County, Illinois (mentioned earlier in connection with the collapse of the site) has been visited by many persons, including vandals (Hall, 1962).

Mohr (1972) reported that "during the long period of hibernation there may be many visitors (to caves and mines) - banders, serious spelunkers, curious school boys, and wanton vandals."

Speleologists and Spelunkers ... According to Jones (1971) it is the opinion of virtually every bat expert that the disturbances of bats by speleologists, unaware of the effect their activities have on bats, is damaging. The simple act of entering a hibernating site may arouse hibernating bats and drain their energy supply. Humphrey (1969) pointed out that "since mines and caves provide the only suitable habitat for many North American bats during at least part of the year, spelunkers are concerned that their activities might disrupt cave environment, causing a reduction or extermination of bat populations."

Biologists and Bat Banding ... Jones (1971) has pointed out that biologists carrying out research either with or without handling the animals have caused measurable declines in the numbers of well known cave bat populations. Merely handling hibernating bats may cause them to awaken and use large amounts of their fat reserves which must last them all winter. They also may move to a less suitable hibernating site or venture out into winter weather. Females may fail to reproduce and handling of pregnant bats may cause them to abort.

Banding of bats has been extensive; for example, Hassell and Harvey (1965) reported that 17,000 M. sodalis had previously been banded in Bat Cave (Carter County, Kentucky). In the 1965 study, an additional 1,572 were banded.

Fenton (1966) banded 503 M. sodalis in two caves (Jefferson County, New York).

Mohr (1972) discussed data gathered from 30 banding cooperators who had banded 70,000 bats. He stated that in 1972 there were 70 active banders and possibly 2,000,000 bats had been banded.

Banding of bats may cause wing infection and tooth wear due to band chewing if the wrong type or size of band is used or the band is carelessly fitted. The Department of Interior moratorium on issuance of bat bands was based on mortality apparently engendered by banding activities.

Loss of Habitat and Roosts ... Urbanization and deforestation have contributed to the decline of bat populations (Mohr, 1972). While no specific examples of this can be cited for the decline of M. sodalis, this species may have suffered from these pressures.

Distinct from natural flooding is the destruction of roosts and habitat by dam construction which results in the inundation of a large area. An example of this possibility directly affecting M. sodalis is a proposed dam to be built by the Corps of Engineers on the Meramec River in the east central part of Missouri. If constructed, this proposed dam will totally inundate approximately 45 caves, some of which are occupied by M. sodalis and M. grisescens (Vogel, 1975). Indirect effect caused by dam construction such as weather modification or habitat destruction are unknown but may be deleterious to the bat population.

Commercialism ... There are many commercially operated caves in the United States. Since M. sodalis is found in states that contain some of the largest cave systems in the world, it is not surprising that some of these caves having M. sodalis populations are commercially operated. Examples are the Coach-James' Cave System, Edmonson County, Kentucky; Carroll Cave, Camden County, Missouri; and Marvel Cave, Stone County, Missouri (Mohr, 1972). Despite cooperative attitudes by the present operators, the future of the M. sodalis and M. grisescens colonies in these caves is uncertain (Mohr, 1972).

While bats have been collected for legitimate scientific purposes such as museum and medical studies and surveys, they also have been collected by biological supply houses and individuals for sale to universities, schools, museums, or individuals as preserved specimens and plastic mounts. Sanborn (1951) mentioned that professional collectors visited Blackball Mine, LaSalle County, Illinois.

Pesticide Poisoning ... Persons who have expressed concern over declining bat populations believe that the chlorinated hydrocarbon insecticides have been poisoning bats (Mohr, 1972). Racey and Stebbings (1972) mentioned that a recent study of insecticides in British bats revealed that they were more sensitive to DDT than other mammals, and contained slightly less than the lethal level of insecticide after hibernation. Lukens and Davis (1964) found that the LD100 of DDT was 40 mg/kg of body weight in Eptesicus fucus (big brown bat), and they concluded that, "bats appear to be far more sensitive to DDT than any other mammal yet tested."

The great sensitivity to pesticides combined with the opportunity of the insectivorous bats to pick up a pesticide support the theory that pesticides may have an adverse effect on bat populations. Cockrum (1969) stated that the use of insecticides on farms and forests, notably in the southwestern United States, is thought to have caused large declines in bats. One cause of bat mortality over the past twenty years may have been pesticides. Mohr (1972) states, "The evidence that the survival of a number of species of bats is threatened by organochlorine pesticides is now so clear that organizations of scientists would seem to be obligated to support legal action against further use of these chemicals." As M. sodalis is an insect eater found in forest and farming areas, pesticides can affect these bats. The number of insects is reduced by pesticides and the bats may eat poisoned insects.

Summary of Status of Potential Hazards

Several factors in the biology of M. sodalis make this species particularly vulnerable. The species hibernates in large, dense clusters in and near the mouths of a relatively few caves in a limited geographic area. Due to these factors, it is particularly subject to human disturbance which, when added to the natural mortality and hazards faced by this and other cave-dwelling species, serves to concentrate the effect of any decimating factor. Little is known of the biology of the species at other times of the year.

Actions Already Taken to Protect the Indiana Bat, Myotis sodalis

United States Government ... All wildlife currently designated on the Endangered Species List are protected. Thus, M. sodalis receives statutory protection under the 1973 Endangered Species Act. The National Park Service (Mammoth Cave National Park, Kentucky) has been actively protecting several winter colonies. Iron gates have been installed at most of the cave entrances, including Long's, Dixon, Colossal, and Bat Caves, which permit bats easy ingress and egress. Frozen Niagara Cave entrance also has a gate with small openings that allow limited bat movement in and out. Dixon Cave has a chain-link fence around the sinkhole. Visitors to caves with bat populations are restricted by the Park Service.

These measures protect approximately 4.7 percent of the known population. If similar measures are taken with the thirteen caves and mines as recommended in the recovery plan, protection will be afforded to 99 percent of the known population.

The Department of the Interior has placed M. sodalis on the "Official List of Endangered Native Fish and Wildlife, as amended May 19, 1972". As of November, 1972, a moratorium was affected on issuing bat bands either to new bat banders or for new banding projects. The current supplies of bat bands will be issued to investigators for use in the completion of ongoing, pertinent projects that do not involve species of bats with greatly reduced populations. The use of bands procured elsewhere is still permissible.

The U. S. Department of Agriculture, Forest Service, is charged with the protection of endangered wildlife on National Forest Service lands. The Service has contracted with several specialists to determine the status of M. sodalis populations on Forest Service lands. A gate has been placed on Big Springs Cave, Monongahela National Forest, Tucker County, West Virginia.

The Environmental Protection Agency banned the general use of DDT in this country effective December 31, 1972. Since that time, two States have been permitted the use for bat control. At present, there are no other chemicals registered for the control of bats.

The U. S. Fish and Wildlife Service, the U. S. Army Corps of Engineers and the Missouri Department of Conservation have initiated a joint effort in cooperation with the University of Missouri to evaluate the habits of the Indiana bat in the Meramec Park Lake and Union Lake project areas.

State Actions ... Martin (1973) summarized the status of bat protection by states, noting that M. sodalis lacked adequate state protection throughout most of its range. States which provide apparent legal protection for M. sodalis currently are: Arkansas, Kentucky, Illinois, Missouri, New York, Tennessee, Vermont, and West Virginia. Enforcement of bat protection laws is not yet evident in those states with such laws, however. Massachusetts and New Hampshire have even been granted permission to use DDT in bat control by the Environmental Protection Agency. State protection has been provided for the following areas which have M. sodalis populations: Bat Cave, Carter County, Kentucky; Old Indian Cave, Jackson County, Florida; Wyandotte Cave, Crawford County, Indiana; and Blackball Mine, LaSalle County, Illinois. Recent incidents at the Blackball Mines indicate the need for greater control of the area by the State of Illinois (the state is developing plans for additional protection).

National Speleological Society ... A 'Bat Conservation Task Force' has been appointed within the NSS responsible for notices and reports in the monthly "NSS News" and the North American Biospeleological Newsletters, in addition to the development of research and conservation programs (Mohr, 1972). Some action to specifically protect bats has already been taken by some Grottos of the NSS. "Disturbances and Bats" (Humphrey, 1969) was written at the request of the Central Oklahoma Grotto and published in its newsletter. It is an analysis of the problem with recommendations. There has been the replacement of some improperly designed cave closures (Mohr, 1972).

Scientific Organizations and Scientists ... The editorial policy established by the American Society of Mammalogists for the Journal of Mammalogy, published by the American Society of Mammalogists, is not to accept manuscripts for publication dealing with endangered mammal species or subspecies unless evidence is presented that the data were developed from specimens obtained legally and with the approval of all appropriate regulatory agencies and that observations were made under circumstances that were not detrimental to the survival of any natural endangered population (Amer. Soc. Mammal., 1973). The National Pest Control Association has indicated its willingness to cooperate with bat biologists and has requested members of the Association to save exterminated bats for donation to museums for identification and study or to health agencies for disease examination. Bat control in areas where M. sodalis occurs should be subject to monitoring, although the species is unlikely to be involved in extermination programs. The publication "Bat Research News" and the International Council for the Protection of Endangered Bats have periodically provided information and announcements concerning bat conservation.

Figure 1. From BATS OF AMERICA
Barbour and Davis,
1969

Distribution of *Myotis sodalis*

Figure 2.

Courtesy
Corps of Engineers

Table 1.

CENSUS DATA - INDIANA BAT

(Maximum Populations Cited for Year)

STATE	YEAR	POPULATION
Arkansas		
Bat Cave, Newton County	1974	1,000[18]
Dinny (Denny) Cave, Madison County	1933	1[20]
	1935	500[20]
Florida		
Old Indian Cave, Jackson County	1955	1[6]
Illinois		
Blackball Mine, LaSalle County	1956	337[17]
	1957	337[3]
	1958	257[3]
	1959	120[3]
	1960	120[3]
	1973	115[17]
Cave Spring Cave, Hardin County	1959	2[3]

2.

STATE		YEAR		POPULATION
Indiana				
Big Wyandotte Crawford County	.....	1953	.....	15,000[10]
		1954	.....	1,000[19]
		1955	.....	544[19]
		1957	.....	2,000[3]
		1961	.....	1,713[19]
		1962	.....	1,000[19]
		1963	.....	2,500[19]
		1964	.....	2,500[19]
		1965	.....	3,200[19]
		1967	.....	1,338[19]
		1968	.....	1,100[19]
		1969	.....	1,400[19]
		1970	.....	1,030[19]
		1971	.....	1,271[19]
		1972	.....	1,724[19]
		1973	.....	1,095[19]
		1974	.....	1,900[10]
Buckners Cave	.....	1952	.....	nearly 550[19]
		1953	.....	350[19]
		1954	.....	800[19]
		1955	.....	295[19]
		1956	.....	2(?)[19]
		1962	.....	160[10]
		1974	.....	300[10]

STATE	YEAR	POPULATION
Indiana (Cont'd.)		
Coons Cave ..... Monroe County	1953	150[10]
	1974	70[10]
Grotto Cave ..... Monroe County	1959	200[3]
	1962	200[10]
	1969	30[10]
	1974	50[10]
Ray's Cave ..... Greene County	1952	2,700[19]
	1953	12[19]
	1954	4[19]
	1955	1,000[19]
	1956	0[19]
	1957	1,500[10]
	1958	2,700[10]
	1960	6[19]
	1961	"Many"[19]
	1962	500[10]
	1963	3,000[10]
	1964	960[10]
	1965	3,269[19]
	1966	3,000[19]
	1967	2,800[19]
	1969	1,200[19]
	1970	1,347[19]

4.

STATE		YEAR		POPULATION
Indiana (Cont'd.)				
Ray's Cave	.....	1971	.....	40[19]
Greene County		1972	.....	2,765[19]
		1973	.....	1,500[19]
		1974	.....	2,500[10]
		1975	.....	2,000[19]
Kentucky				
Bat Cave	.....	1957	.....	100,000[3]
Carter County		1962	.....	100,000[9]
		1965	.....	90,000(?)[12]
		1975	.....	40,000[4]
Edmonson County:				
Bat Cave	.....	1960	.....	6[3]
		1975	.....	68[4]
Coach Cave	.....	1958	.....	100,000[3]
		1959	.....	100,000[3]
		1960	.....	100,000[3]
		1975	.....	4,500[4]
Colossal Cave	.....	1957	.....	1,000[3]
		1958	.....	1,000[3]
		1959	.....	2,000[3]
		1960	.....	2,000[3]
		1962	.....	6,000[4]
		1967	.....	2,000[4]
		1975	.....	14[4]

5.

STATE	YEAR	POPULATION
Kentucky (Cont'd)		
Edmonson County:		
Dixon Cave	1957	2,500[3]
	1958	2,500[3]
	1959	2,500[3]
	1960	2,500[3]
	1975	3,600[4]
James Cave	1959	100[3]
Long's Cave	1957	1,200[3]
	1958	3,000[3]
	1959	2,000[3]
	1960	1,500[3]
	1975	7,600[4]
Wilson Cave	1958	550[3]
Wind Cave ..... Breckenridge County	1964	3,650[11]
Stillhouse Cave	1968	120[22]
	1974	1,000[22]
Cave Hollow Cave	1968	75[22]
Ash Cave	1968	60[22]
Missouri		
Cave 001	1975	8[1]
Cave 005	1975	3[1]
Copperhollow Sinkhole ..... Franklin County (009)	1975	23,300[1-4]
Cave 013	1975	100[1]

STATE	YEAR	POPULATION
Missouri (Cont'd.)		
Cave 015	1975	6[1]
Cave 017	1975	3,200[1-4]
Cave 020	1975	1[1]
Onyx Cave (021) Crawford County	1955	600[20]
	1962	80[20]
	1964	50,000[2]
	1975	14,300[1]
Cave 022	1975	100[1]
Scott Cave (029) Washington County	1975	82,000[1-4]
Bat Cave Crawford County	1957	800[20]
	1962	300[20]
Bat Cave Shannon County	1959	100,000[3]
	1962	51,000[20]
	1975	48,400[1-4]
Carroll Cave Camden County	1956	600[20]
	1962	300[20]
Coffin Cave Laclede County	1962	250[20]
Mary Lawson Cave Laclede County	1957	250[20]
	1962	200[20]
Pilot Knob Mine Iron County	1959	100,000[3]
	1962	80,000+[20]
	1975	*800[1-4]

*Major colony may not have been located[1-4]

STATE		YEAR		POPULATION
Missouri (Cont'd)				
Powder Mill Cave Shannon County	.....	1962	.....	150[20]
Sink Cave Franklin County	.....	1957	.....	1,000[20]
		1962	.....	200[20]
Boone County:				
Hunter's Cave	.....	1931	.....	2[14]
Rocheport Cave	.....	1931	.....	1,200+[14]
Pulaski County:				
Bruce Cave	.....	1955	.....	500[20]
		1962	.....	50[20]
Inca (Moxey) Cave	.....	1954	.....	2,000[20]
		1962	.....	200[20]
Piquet Cave	.....	1954	.....	600[20]
		1959	.....	100[3]
		1962	.....	30[20]
Ryden Cave	.....	1962	.....	3,000[20]
Tunnel Cave	.....	1954	.....	4,000[20]
		1959	.....	200[3]
		1962	.....	300[20]
New York				
(East) Jefferson County	.....	1955	.....	32[7]
(West) Jefferson County	.....	1955	.....	1,000[7]

STATE	YEAR	POPULATION
Pennsylvania		
Aitkin Cave ..... Mifflin County	1964	12[5]
Old Cement Mine Tunnel ..... Blair County	1966	1,000[13]
Tennessee		
Little Mammoth Cave ..... Campbell County	1962	4,000[4]
	1975	1,250[4]
White Oak Blowhole Cave	1975	6,050[4]
Wolf River Cave ..... Fentress County	1967	200[21]
Virginia		
Star Chapel Cave ..... Bath County	1960	600[13]
	1961(?)	
	1974	30[13]
West Virginia		
Monroe County:		
Greenville Saltpeter Cave	1952	1,000[16]
	1963	0[16]
Patten Cave	1963	8[16]
Pendleton County:		
Hellhole Cave	1964	500[16]
	1974	1,500[13]
Minor Rexrode Cave	1952	Several Hundred[16]
Trout Cave	1952	1,000[16]
	1972	0[16]

STATE	YEAR	POPULATION
West Virginia (Cont'd.)		
Pocahontas County:		
Cass Cave	1974	4[13]
Martha's Cave	1953	151[13]
	1974	80[13]
Tucker County:		
Big Springs Cave (Blowing)	1952	150[16]
	1971	150[16]
	1972	150[13]
	1974	150[13]
Cave Hollow Cave	1965	150[16]
	1971	0[16]
	1974	23[13]
Wisconsin		
Aitkins Diggings ..... Grant County	1954	1[15]

1. Vogel, T. 1975

2. LaVal, R. K. 1973

3. Hall, J. S. 1960

4. Humphrey, S. 1975

5. Hall, J. S. and F. J. Brenner. 1968

6. Jennings, W. L. and J. N. Layne. 1957

7. Fenton, M. B. 1966

9. Hassell, M. D. 1963

10. Mumford, R. E. 1974

11. DeBlase, A. F., S. Humphrey and K. S. Drury. 1965

12. Hardin, J. W. and M. D. Hassell. 1970

13. Hall, J. S. 1975

14. Guthrie, M. J. 1933

15. Davis, W. H. and W. Z. Lidicker. 1955

16. Hall, J. S. 1972

17. White, John. 1974

18. Harvey, M. J. 1975

19. Mumford, R. E. 1975

20. Myers, R. F. 1964

21. State of Tennessee. 1975

22. U. S. Dept. of Agriculture, Forest Service. 1975

Table 2 DURING FIVE WINTERS OF STUDY From Hall, J. S., 1962

Cave	1956-57	1957-58	1958-59	1959-60	1960-61
Northern Illinois					
1. Blackball Mine, La Salle County	337	257	120	120	--
Southern Illinois					
2. Cave Spring Cave, Hardin County	--	0	2	--	--
South-Central Indiana					
3. Ray's Cave, Greene County	--	--	100	500	--
4. Coon's Cave, Monroe County	--	9	0	--	--
5. Grotto Cave, Monroe County	--	--	200	--	--
6. Wyandotte Cave, Crawford County	2,000	--	--	--	--
Eastern Kentucky					
7. Bat Cave, Carter County	100,000	--	--	--	--
Central Kentucky					
8. Wilson Cave, Edmonson County	--	550	--	--	--
9. Coach Cave, Edmonson County	--	100,000	100,000	100,000	100,000
10. Dixon Cave, Edmonson County	2,500	2,500	2,500	2,500	--
11. Long's Cave, Edmonson County	1,200	3,000	2,000	1,500	1,500
12. Colossal Cave, Edmonson County	1,000	1,000	2,000	2,000	3,000
13. James' Cave, Edmonson County	--	--	100	--	100
14. Bat Cave, Edmonson County	--	--	--	6	14
South-Central Missouri					
15. Tunnel Cave, Pulaski County	--	--	200	--	--
16. Onyx Cave, Pulaski County	--	--	100	--	--
17. Piquet Cave, Pulaski County	--	--	100	--	--
18. Bat Cave, Shannon County	--	--	100,000	--	--
19. Pilot Knob Mine, Iron County	--	--	100,000	--	--

LITERATURE CITED

Allen, Glover M. 1967. Bats. Dover Pub., Inc., New York, N. Y.

American Society of Mammalogists. 1973. Editorial policy on endangered species. Jour. Mammalogy 54:312.

Barbour, R. W. and W. H. Davis. 1969. Bats of America. Univ. Press, Kentucky, Lexington, 286 pp.

Bureau of Sport Fisheries and Wildlife. 1968. Rare and endangered species of the United States. Resource Publ. No. 34.

Bureau of Sport Fisheries and Wildlife. 1973. Threatened wildlife of the United States. Resource Publ. No. 114 (Revised No. 34), 289 pp.

Cockrum, E. L. 1969. Insecticides and Arizona bat populations. Jour. Arizona Acad. Sci., 5:198.

Constantine, D. G. 1970. Bats in relation to the health, welfare and economy in man. In Biology of Bats, vol. II, pp. 319-449, Ed. W. A. Wimsatt, Academic Press, New York, 477 pp.

Davis, W. H. and H. B. Hitchcock. 1965. Biology and migration of the bat Myotis lucifugus in New England. Jour. Mammalogy 46:296-313.

Davis, W. H. and W. Z. Lidicker. 1955. M. sodalis in Wisconsin. Jour. Mammalogy 36:567.

DeBlase, A. F., Humphrey, S. R., and K. S. Drury. 1965. Cave flooding and mortality in bats in Wind Cave, Kentucky. Jour. Mammalogy 46:96.

Environmental Protection Agency. 1972. EPA Order banning general use of DDT in the U. S. A. as of Dec. 31, 1972. Order and Opinion of Administrator. EPA, Washington, D. C. 20460

Easterla, David A. and L. C. Watkins. 1969. Pregnant M. sodalis in northwestern Missouri. Jour. Mammalogy, Vol. 50 #2.

Fenton, M. B. 1966. M. sodalis in caves near Watertown, N. Y. Jour. Mammalogy 47:526.

Geological Survey. 1970. The National Atlas of the United States of America. U. S. Department of the Interior, Washington, D. C. 20240.

Gillette, D. D. and J. D. Kimbrough. 1970. Chiropteran mortality pp. 262-283 in About Bats. Ed. B. H. Slaughter and D. W. Walton. Southern Methodist Univ. Press, Dallas, Texas 339 pp.

Greenhall, A. M. 1973. Indiana bat, a cave-dweller in trouble. Nat. Parks and Cons. Magazine; the Environ. Journal, pp. 14-17.

Griffin, D. G. 1953. Deluge underground. Bull. Natl. Speleol. Soc. 15:34-37.

Guthrie, Mary J. 1933. Notes on the seasonal movement and habits of some cave bats. Jour. Mammalogy 14:1-19.

Hall, J. S. 1960. A life history and taxonomic study of the Indiana bat, Myotis sodalis. Univ. Ill. Ph.D. Thesis, 129 pp.

Hall, J. S. 1962. A life history and taxonomic study of the Indiana bat, Myotis sodalis. Reading Pub. Mus. and Art Gallery Sci. Publs. 12:3-68.

Hall, J. S. 1972. The status of M. sodalis, the Indiana bat in West Virginia. West Virginia Dept. of Nat. Res. Aug. 24, 1972. Special Bulletin.

Hall, J. S. and F. J. Brenner. 1968. Summer netting of bats at a cave in Pennsylvania. Jour. Mammalogy. Vol. 49, p. 779.

Hall, J. S. 1975. Personal communication.

Hardin, James W. and M. D. Hassell. 1970. Observation on waking periods and movements of M. sodalis during hibernation. Jour. Mammalogy. Vol. 51 #4, p. 829.

Harvey, M. J. 1975. Personal communication.

Hassell, Marion D. and Michael J. Harvey. 1965. Differential homing in Myotis sodalis. Amer. Midland Naturalist. Vol. 74:501-503.

Hassell, Marion D. 1963. A study of homing in the Indiana bat. Trans. Ken. Acad. Sci. Vol. 24, No. 1/2. P.1.

Humphrey, S. 1969. Disturbances and bats. Oklahoma Underground 2:42-44.

Humphrey, S. R., J. B. Cope, A. R. Richter and P. P. Humphrey. 1974. Summer ecology of the endangered Indiana bat. Fifth No. American Symposium on Bat Research. Texas Tech. Univ.

Humphrey, S. 1975. Personal communication.

Jennings, W. L. and J. N. Layne. 1957. M. sodalis in Florida. Jour. Mammalogy. 38:259.

Jones, D. 1971. The status of populations of bats in the United States. Second Ann. Symp. of Bat Research, Albuquerque, New Mexico. (unpublished)

LaVal, Richard K. 1973. Personal Communication, Jan. 18.

Lukens, Mark M. and Wayne H. Davis. 1964. Bats: sensitivity to DDT. Science, Vol. 146, #3646. Nov.

Mohr, C. E. 1972. The status of threatened species of cave-dwelling bats. Bull. Natl. Speleol. Soc., 34:33-37.

Martin, R. L. 1973. The current status of bat protection in the United States of America. Period. Biol. 75:153-54.

Muir, Ted J. and E. Polder. 1960. Notes on hibernating bats in Dubuque County caves. Iowa Acad. Sci. 67:602-606.

Mumford, R. E. and J. B. Cope. 1964. Distribution and status of the Chiroptera of Indiana. The Amer. Mid. Naturalist. 72(2) p. 473.

Mumford, R. E. 1974. The status of the Indiana bat and the eastern wood rat on the Wayne-Hoosier National Forest, Indiana. Dept. Forestry and Cons. Purdue University (Special Study).

Mumford, R. E. 1975. Personal communication.

Myers, Richard F. 1964. Ecology of three species of Myotine bats in the Ozark Plateau. Univ. Missouri. Ph.D. Thesis.

Paradiso, John L. and A. M. Greenhall. 1967. Longevity Records for American bats. Amer. Mid. Naturalist. 78(1) p. 251.

Racey, P. A. and R. E. Stebbings. 1972. Bats in Britain - a status report. Oryx 11:319-327.

Sanborn, C. C. 1951. Colonies of Illinois bats invaded by business. Bull. Chicago Nat. Hist. Mus. 22:4-5.

Twente, J. W., Jr. 1955. Some aspects of habitat selection and other behavior of cave-dwelling bats. Ecology 36:706-732.

Vogel, Todd. 1975. Personal communication and in litt., 12/5/74 and 1/16/75.

White, John. 1974. Preservation values of the commonwealth Edison Land including Pecumsaugan Creek and Blackball Mine in LaSalle County, Illinois. Ill. Nat. Preserves Commission. Feb. 11.