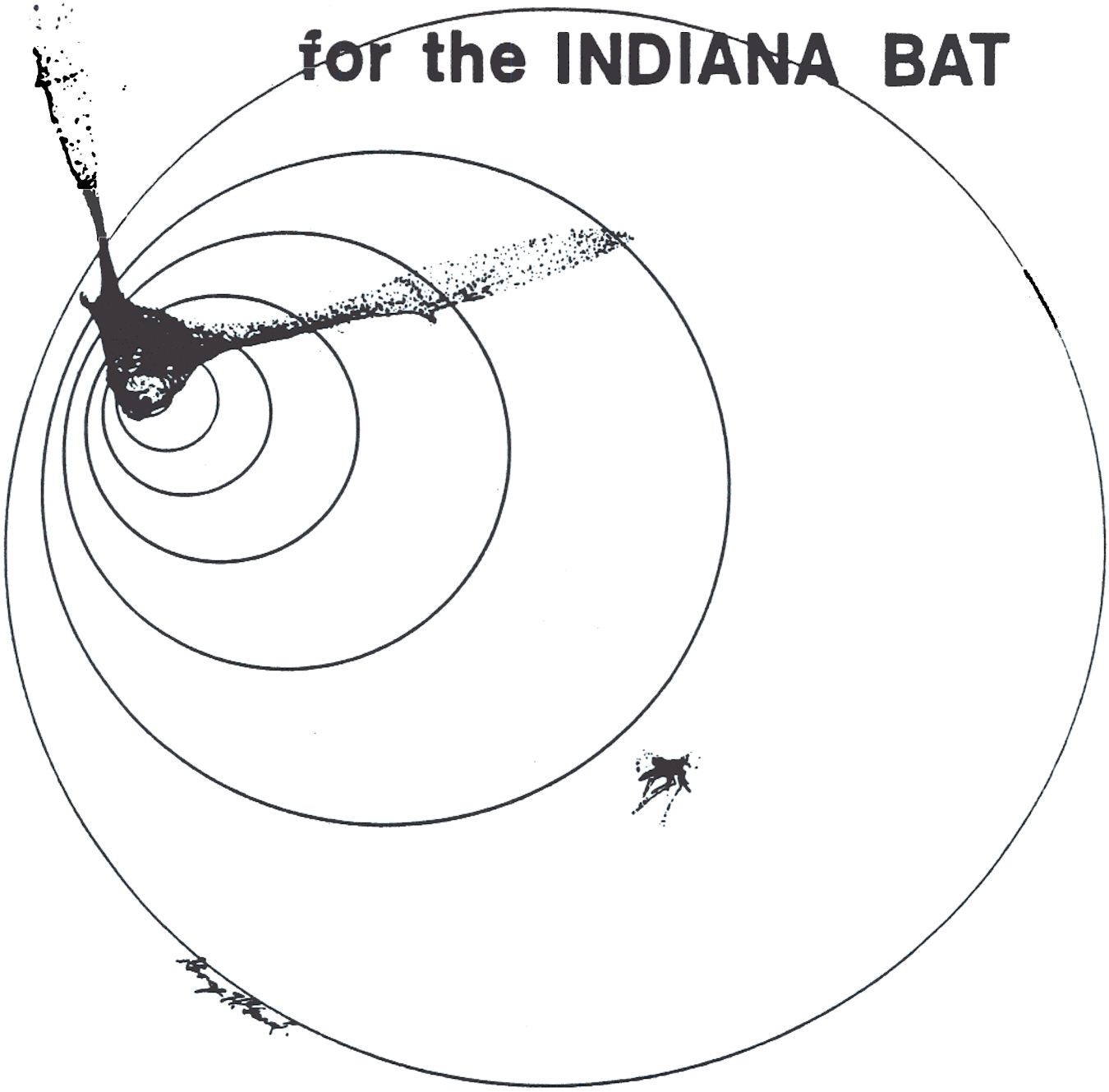
RECOVERY PLAN for the INDIANA BAT



This is the completed Indiana Bat Recovery Plan. It has been approved by the U. S Fish and Wildlife Service. It does not necessarily represent official positions or approvals of cooperating agencies (and it does not necessarily represent the views of all recovery team members/individuals, who played the key role in preparing this plan. This plan is subject to modification as dictated by new findings and changes in species status and completion of tasks described in the plan. Goals and objectives will be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints.

Acknowledgements should read as follows:

The Indiana Bat Recovery Plan, dated October 14, 1983, prepared by the U. S. Fish and Wildlife Service in cooperation with the Indiana Bat Recovery Team:

John T. Brady, Leader (1980-Present)
Indiana Bat Recovery Team
U. S. Army Corps of Engineers
210 Tucker Boulevard North
St. Louis, Missouri 63101

Richard K. LaVal, Leader (1979-1980)
Apt. 10165
San Jose', Costa Rica
(Formerly with the Missouri Department of Conservation)

Thomas H. Kunz, Member
Indiana Bat Recovery Team
Department of Biology
Boston University
2 Cummington Street
Boston, Massachusetts 02215

Merlin D. Tuttle, Member
Indiana Bat Recovery Team
Vertebrate Division, Curator of Mammals
Milwaukee Public Museum
800 West Wells Street
Milwaukee, Wisconsin 53233

Donald E. Wilson, Member
Indiana Bat Recovery Team
National Fish & Wildlife Laboratory
National Museum of Natural History
Washington, D.C. 20560

Richard L. Clawson, Member
Indiana Bat Recovery Team
Missouri Department of Conservation
Fish and Wildlife Research Center
1110 College Avenue
Columbia, MO 65201

Additional copies may be obtained from:

Fish and Wildlife Reference Service
1776 E. Jefferson Street
4th Floor
Rockville, Maryland 20852
800-582-3421

Approved: F. Eugene Hester
Deputy Director, U.S. Fish and Wildlife Service

Date: 10-14-83

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PART I

Description

The Indiana bat (*Myotis sodalis*) is a medium-sized member of the genus with a forearm length of 35 to 41 mm. The head and body length ranges from 41 to 49 mm. This species closely resembles the little brown bat (*Myotis lucifugus*), but differs in having a keeled calcar. The hind feet of the Indiana bat tend to be smaller and more delicate and hairs on the hind feet tend to be shorter The skull has a small sagittal crest, and the braincase tends to be smaller, lower, and narrower than that of the little brown bat. Appendix V provides a comparison of characteristics useful in identifying Indiana bats from other potentially confusing *Myotis*.

Distribution

The Indiana bat is a monotypic species that occupies much of the eastern half of the United States (Figure 1). Large hibernating populations are found in Indiana, Missouri, and Kentucky; however, populations and individual records have been reported from Alabama, Arkansas, Connecticut, Florida, Georgia, Illinois, Iowa, Maryland, Massachusetts, Michigan, Mississippi, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin. Some records from areas on the margins of the range may represent occasional wanderers rather than viable populations.

Life History

The Indiana bat is known primarily from the caves in which it hibernates. Approximately 85% of the entire known population winters in only seven hibernacula, with almost half limited to two. Summer nursery colonies have been found beneath loose bark of trees, containing 100 bats or less per colony.

Most Indiana bats migrate seasonally between winter and summer roosts. Movement has been recorded between hibernacula in central Kentucky and summer areas in Indiana, Kentucky, Ohio, and Michigan (Barbour and Davis, 1969), as well as between hibernacula in southern Missouri and summer areas in northern Missouri and southern Iowa (Myers, 1964; LaVal and LaVal, 1980; Bowles, 1980). On arrival at hibernating caves, swarming occurs. Swarming is described as "...a phenomenon in which large numbers of bats fly in and out of cave entrances from dusk to dawn, while relatively few roost in the caves during the day" (Cope and Humphrey, 1977). Swarming may continue for several weeks. Fat supplies are replenished prior to hibernation. In Missouri, Indiana bats tended to hibernate in the same cave in which they swarmed, although elsewhere (i.e., Indiana) swarming has occurred in caves other than where they hibernated (LaVal et al., 1977b). Males tend to


KNOWN & SUSPECTED RANGE OF THE INDIANA BAT
PRIORITY #1 HIBERNACULA

FIGURE 1

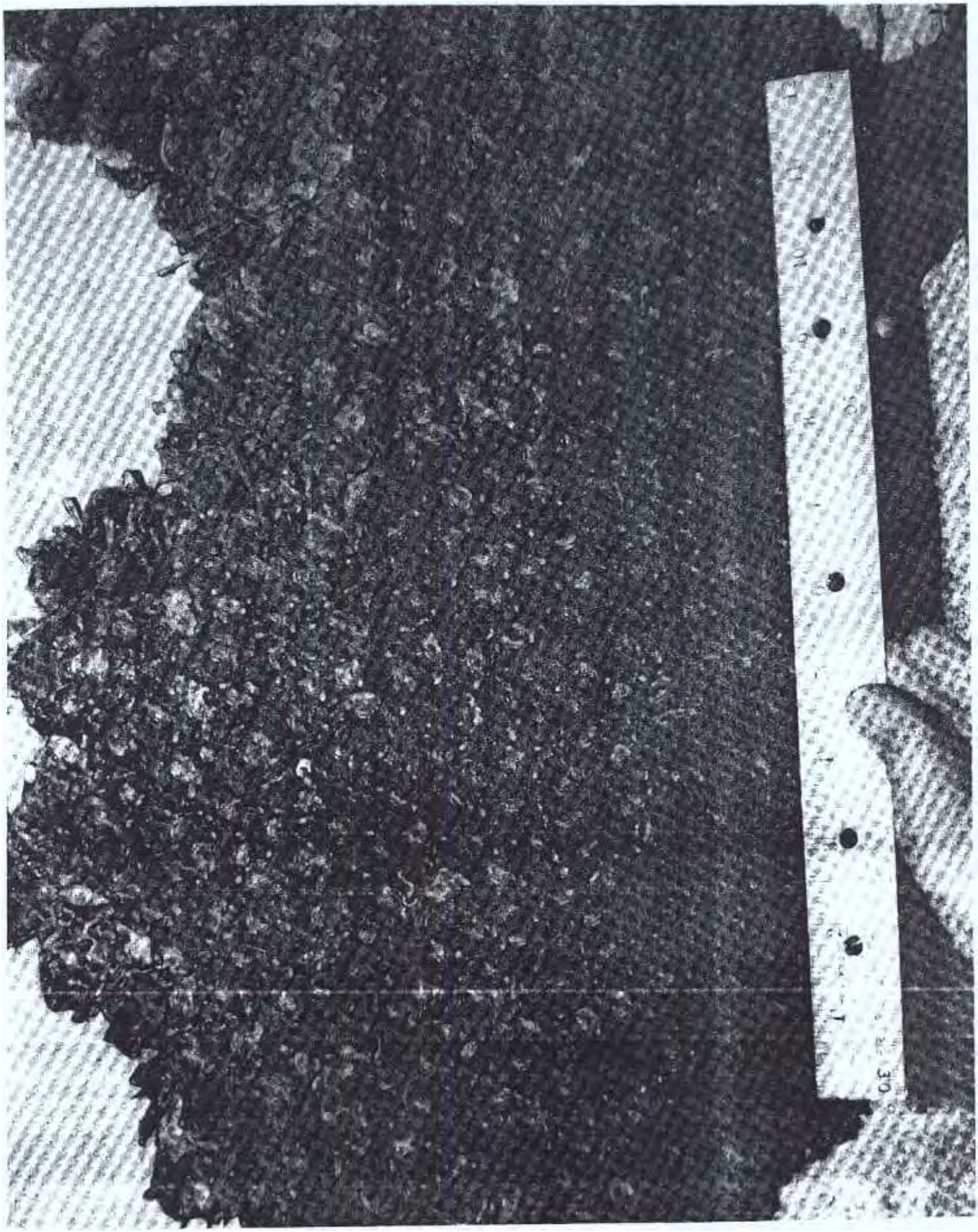

FIGURE 2: MYOTIS SODALIS CLUSTER (PHOTO CREDIT R. CLAWSON)

remain active over a longer period of time at cave entrances during the swarming period than females (LaVal and LaVal, 1980). Bats mate and females enter directly into hibernation, some as early as October. Nearly all males are hibernating by late November.

Presumably, adult females store sperm through the winter and become pregnant soon after emergence from hibernation. Hall (1962) noted limited mating activity throughout the winter and in late April as the bats were leaving hibernation.

Females emerge in late March or early April, followed by males. Most populations leave by late April, but some males spend the summer in hibernacula. Migration is probably hazardous (Tuttle and Stevenson, 1977), especially in spring when fat reserves and food supplies are low. Consequently, adult mortality may be highest in late March and in April.

Females give birth to a single young in June or early July. At that time, they join together in nursery colonies beneath the loose bark of trees. Scattered records indicate that males disperse throughout the range in summer, but little is known of their roosting habits. Known maternity colonies occupy home ranges containing roost sites in riparian habitat. Loyalty for a particular reach of stream has been documented (J.B. Cope, pers. comm.). Recent evidence suggests that colonies may also occur in upland habitat (Bowles, 1981).

The young are capable of flight within a month of birth. Flying young have been taken as early as the first week in July in Iowa (Bowles, 1981), but an immature taken from beneath a concrete bridge in Indiana in late July appeared barely able to fly (Mumford and Cope, 1964). They spend the latter part of the summer accumulating fat reserves for fall migration and hibernation.

Habitat Requirements

1. Winter Habitat. Depending on local weather conditions, Indiana bats hibernate from October through April (LaVal et al., 1977b; Hall, 1962). They require specific roost sites in caves or mines that have stable temperatures below 10°C, preferably from 4° to 8°C. Only a small percentage of available caves provide for this specialized requirement. Stable low temperatures allow bats to maintain a low rate of metabolism and conserve fat reserves until spring (Humphrey, 1978). Indiana bats usually hibernate in large, dense clusters of about 300 bats per square foot (3200/meter^2, Figure 2) (Engel et al., 1976; Clawson et al., 1980). Relative humidity at roost sites during hibernation is usually above 74% (Humphrey, 1978; LaVal et al., 1977b; Hall, 1962), although Myers (1964) observed relative humidity as low as 54%. Specific cave configurations determine temperature and humidity microclimates required by these bats (Tuttle and Stevenson, 1978; LaVal and LaVal, 1980).

2. Summer Habitat. Little is known about Indiana bat summer habitat. Recent studies indicate that maternity colonies are formed mostly in riparian and floodplain areas of small to medium-sized streams (Humphrey et al., 1977; Cope et al., 1978; Sparling et al., 1979; Gardner and Gardner, 1980). Bats also have been found along tree-lined drainage ditches in Illinois (Brack, 1979).

A few Indiana bats have been captured in upland sites (Easterla and Watkins, 1969; Bowles, 1980). LaVal and LaVal (1980) suggested that most reproductively active female Indiana bats in northern Missouri, southern Iowa, and Illinois are found in riparian forests because this is usually the only forest remaining after clearing for agriculture. They have captured reproductively active females at cave entrances in the Ozarks and believe that they are foraging in non-riparian situations, because extensive forest exists there. Another possibility is that riparian foraging habitat is optimal for the Indiana bat, but in areas where they are sympatric with gray bats they may be forced, by competition, to forage away from streams. To avoid using such suboptimal habitat, it is possible that some female Indiana bats leave areas near caves that are occupied by gray bats during the summer and migrate to places where gray bats do not occur (LaVal et al., 1977a).

The three maternity colonies that have been found ranged from 50 to 100 individuals, including young (Humphrey et al., 1977; Cope et al., 1978). Humphrey et al. (1977), found a maternity colony under the loose bark of a dead bitternut hickory tree (Carya cordiformis). This colony occasionally used a living shagbark hickory tree (C. ovata) as an alternate roost.

Optimum Indiana bat foraging habitat appears to consist of streams lined on both sides with mature trees that overhang the water by more than three meters. Streams without riparian vegetation do not appear to be suitable (Cope et al., 1978). Bats forage at a height of two to thirty meters under riparian and floodplain trees (Humphrey et al., 1977). Indiana bats appear to feed primarily on Lepidoptera and aquatic insects (LaVal and LaVal, 1980; Brack and LaVal, in manuscript; Whitacker, pers. comm; Belwood 1979). Population estimates in foraging habitat range from sixty to ninety bats per kilometer of suitable stream with an average of seventy-five bats per kilometer. Riparian habitat is occupied by Indiana bats from mid-May until mid-September (Humphrey et al., 1977).

Distribution of males during the summer is not well known. A few individuals have been found in caves (LaVal et al., 1977b; Hall, 1962; Graves 1982; Brack, pers. comm.). Others have been observed feeding in floodplain and upland forests (LaVal et al., 1977a; Bowles, 1980, 1981; Brack, pers. comm.).

Causes of Decline

1. Natural Hazards. Indiana bats are subject to a number of natural hazards. In Bat Cave, Mammoth Cave National Park, an estimated 300,000 skeletons were found, apparently victims of flooding from the nearby Green River. A few other cases of hibernacula being flooded also have been recorded (Hall, 1962; DeBlase et al., 1965).

Bats hibernating in mines are vulnerable to ceiling collapse. This has occurred in Illinois (Hall, 1962) and is presently a serious concern at a mine in Missouri that is the largest known Indiana bat hibernaculum (Brady in press). Another potential hazard exists because Indiana bats hibernate in cool portions of caves that tend to be near entrances. Some bats may freeze to death during severe winters (Humphrey, 1978).

2. Human Causes.

a. Disturbance and Vandalism. The most serious cause of Indiana bat decline is human disturbance of hibernating bats. The bats enter hibernation with only enough fat reserves to last until spring. When a bat is aroused, it uses a portion of these reserves, as much as 10 to 30 days of fat supply per average disturbance (Tuttle, pers. comm.). Cavers or researchers passing near hibernating Indiana bats cause arousal (Humphrey, 1978). If this happens often, the bats likely will leave the cave too soon and die.

Vandalism also has been documented. In 1960, an estimated 10,000 Indiana bats were killed in Carter Cave State Park, Carter County, Kentucky, by three boys who tore masses of bats from the ceiling and trampled and stoned them to death (Engel et al., 1976). There are many examples of such tragedies. Bats often are misunderstood and are viewed by many people with fear and repugnance.

b. Deforestation and Stream Channelization. Forest is being destroyed throughout much of the range of the Indiana bat. Major destruction includes both stream channelization for agricultural drainage and surface mining. Conlin (1976) reported that of the 18,737 kilometers of interior streams in Illinois (not including the larger rivers such as the Illinois, Mississippi, and Ohio), 5,566 kilometers (30%) were channelized by 1976 and an additional 3,000 kilometers were proposed for channelization. If so modified, it would bring the total to 8,520 kilometers or 45.5% channelized.

There are a number of variables and unknowns that complicate an evaluation of the effects of channelization. The suitability of streams and their associated riparian forest for Indiana bat summer habitat is not known. In addition, channelization data for other states within the summer range of the Indiana bat are lacking. At least some channelized streams and drainage ditches that have riparian forest support Indiana bats (Brack, 1979).

The destruction of forest habitat could have a serious impact on Indiana bat populations. Of particular importance is the increasing demand for use of wood as fuel, which threatens dead standing trees that are potential roost sites. Further research is needed to identify optimal summer habitat and to evaluate the effects of forest destruction throughout the range of this species. It is also important to restore riparian forest cover to channelized streams and ditches, as further discussed in the "Needed Recovery Actions" section.

c. Pesticide Poisoning. Although the effects of pesticides on Indiana bats have not been studied, pesticides have been implicated in the decline of a number of insectivorous North American bats. (Mohr, 1972; Reidinger 1972, 1976; Clark and Prouty, 1976; Clark et al 1978; Geluso et al., 1976; Clark, 1981).

d. Other. Other sources of decline include indiscriminate collecting, handling and banding of hibernating bats by biologists, commercialization of hibernacula, exclusion of bats from caves by poorly designed gates, changes in cave microclimate by opening of additional entrances or blocking of air flow by poorly designed gates, and flooding of caves by reservoirs (Humphrey, 1978).

These sources are believed to be the leading factors of decline for Kentucky (Graves, 1982).

Current Status of Population and Trends

Based on censuses taken at hibernacula, the total known Indiana bat population is estimated to number about 550,000. The most recent population estimates for important hibernacula are included in Table 1.

Indiana bat populations were first systematically censused in the late 1950's (Hall, 1962). Although the total known population has increased since that time, due to newly located colonies, many known colonies have decreased in size.

The status of the Indiana bat in the three states with the largest hibernating populations is reviewed below:

Missouri: Due to its continuing collapse, the largest hibernaculum (an abandoned iron mine) may become unsuitable for occupancy by Indiana bats. The population in the third largest hibernaculum in the state has declined from 71,800 bats in 1960 to 33,000 in 1980. While the second largest hibernaculum initially experienced a decline, recent censuses show an increase in the population.

Although Missouri has done more than any other state to protect bat caves, some Indiana bat populations in gated hibernacula have continued to decline. Censusing in these caves is being reduced from yearly to every second year to see if this will reduce adverse human impacts and allow an increase in the populations. This situation should be monitored carefully to determine if gates are harmful in certain situations.

Indiana: The known population has increased greatly in recent years due to the discovery of two large hibernacula. The population appears fairly stable.

Kentucky: Kentucky has had the greatest population decline of any state since 1960. Populations in the two largest hibernacula dropped about 75% because of changes in microclimate at hibernation sites due to poorly designed gates (Humphrey, 1978).

In summary, there are three major reasons for the Indiana bat's endangered status (Brady, 1981):

(1) Hibernating populations in Missouri have shown a decline over the last seven years despite an intensive cave management program.

(2) The largest known hibernating population, at Pilot Knob Mine, Missouri, continues to be threatened by subsidence (mine collapse).

(3) Kentucky hibernating populations are not protected adequately and continue to be depressed.

On the positive side, as shown on Table 1, the majority of important hibernacula are now in public ownership and therefore easier to protect.

TABLE 1

INDIANA BAT POPULATION

State	Priority 1* Hibernacula	Priority 2** Hibernacula	Population (1980-81)
Missouri	3 (1)	8 (6)	281,700
Indiana	2 (2)	4 (1)	144,600
Kentucky	3 (2)	12 (3)	109,000
Tennessee	0	4 (2)	12,400
Arkansas	0	3 (1)	5,200
Illinois	0	1 (0)	
Virginia	0	1 (0)	
West Virginia	0	1 (0)	
New York	0	2 (2)	2,000
Pennsylvania	0	1 (1)	0
GRAND TOTALS	8 (5)	37 (16)	554,900

*Hibernacula with a recorded population greater than 30,000 since 1960.

**Hibernacula with a recorded population greater than 1,000 but less than 30,000 since 1960.

( ) - Number of caves in public ownership or or protected under cooperative agreements.

NOTE: Detailed information on individual caves is presented in Tables 2-30.

Associations with Other Listed Species

Bat hibernation caves sometimes contain environmental gradients suitable for more than one federally listed species. Since management needs and protection priorities may differ by species, we provide a list of multiple use caves and their assigned priorities in Table 22.

Critical Habitat for the Indiana Bat

The following areas (exclusive of those existing man-made structures or settlements which are not necessary to the normal needs or survival of the species) are critical habitat for the Indiana bat (Myotis sodalis):

(1) Illinois: The Blackball Mine, LaSalle County.

(2) Indiana: Big Wyandotte Cave, Crawford County; Ray's Cave, Greene County.

Kentucky: Bat Cave, Carter County; Coach Cave, Edmonson County.

(4) Missouri: Cave 021, Crawford County; Cave 009, Franklin County; Cave 017, Franklin County; Pilot Knob Mine, Iron County; Bat Cave, Shannon County, Cave 029, Washington County (numbers assigned by Division of Ecological Services, U. S. Fish and Wildlife Service, Region 6).

Tennessee: White Oak Blowhole Cave, Blount County.

West Virginia: Hellhole Cave, Pendleton County.

Pursuant to Section 7 of the Act, all Federal agencies must take such action as is necessary to insure that actions authorized, funded, or carried out by them do not result in the destruction or modification of these critical habitat areas.

PART II

Step-Down Outline

PRIME OBJECTIVE: TO REMOVE THE INDIANA BAT FROM ENDANGERED STATUS

1. Prevent Disturbance to Important Hibernacula

    1.1 Prevent Entry

        1.1.1 Erect Warning Signs

        1.1.2 Gate or Fence Cave

        1.1.3 Monitor Hibernacula

        1.1.4 Monitor Caves by Law Enforcement Agencies

        1.1.5 Discourage Human Access

    1.2 Prevent Adverse Modifications to Winter and Fall Roost Sites

        1.2.1 Prevent Adverse Modifications to and Rehabilitate the Subsurface

        1.2.2 Prevent Adverse Modifications to and Rehabilitate the Surface Watershed Surrounding Important Roost Sites

        1.2.3 Make Locations of Hibernacula Available to Appropriate Fish and Wildlife Service Offices and State Wildlife Agencies

    1.3 Protect Winter and Fall Roost Sites

        1.3.1 Identify all Indiana Bat Winter and Fall Roost Sites

        1.3.2 Evaluate Roost Sites

        1.3.3 Identify Roost Sites to be Protected

2. Maintain, Protect, and Restore Foraging and Nursery Habitat

    2.1 Prevent Adverse Modification to Foraging Areas and Nursery Roost Habitat

        2.1.1 Determine Habitat Requirements

        2.1.2 Preserve Water Quality

        2.1.3 Restore and Preserve Forest Cover along Rivers and Streams

        2.1.4 Monitor Habitat

3. Monitor Population Trends

Monitor Status of Populations in Hibernacula

Monitor Status of Populations in Summer

3.3 Monitor Residues of Toxic Chemicals

3.3.1 Sample Insects

3.3.2 Sample Bats

4. Public Education

4.1 Governmental Officials

Landowners

Warning Signs at Caves

4.4 Pamphlets

4.5 Slide Program

4.6 Ranger-Naturalist Talks

5. Research Needs

Summer Habitat Requirements

Effects of Habitat Destruction

5.3 Foraging Habitat and Prey Preferences

Effects of Winter Disturbance

Effects of Water Pollution and Siltation

Effects of Pesticide Contamination

5.7 Effects of Cave Modifications

Recovery Plan Narrative

OBJECTIVE: TO REMOVE THE INDIANA BAT FROM ENDANGERED STATUS

The most important feature of this plan is the protection of Indiana bats by gaining control of important hibernacula and protecting them from human disturbance. We also believe that, as much as possible, foraging habitat including riparian forest vegetation and dead trees must be maintained, protected, and restored. Finally, in order to evaluate the success of our efforts, a monitoring program should be established to document changes in Indiana bat populations.

The status of the Indiana bat can be reclassified from endangered to threatened following documentation of stable or increasing populations for three consecutive census periods and permanent protection at seven priority one caves. The criteria for delisting are the above and protection and documentation of increasing or stable populations for three consecutive census periods (see 3.1) at fifty percent of the priority two caves in each state.

1. Prevent Disturbance to Important Hibernacula. A number of hibernacula distributed throughout the range of the Indiana bat must be preserved if the species is to survive. Disturbance, especially from human beings, has been documented as a major factor in Indiana bat decline (LaVal et al., 1977b; Humphrey, 1978).

1.1 Prevent Entry. Preventing unauthorized entry of humans into hibernacula is the best way to curtail disturbance at these sites. Because Indiana bat usage of caves is seasonal, protection efforts should be concentrated during the hibernation period. It is best to avoid all disturbance between mid-August and early May. Entry to hibernacula should be prohibited during the period of September 1 to April 30.

1.1.1 Erect Warning Signs. Signs can be used at certain caves to discourage entry. Signs also are used in conjunction with gates to inform the public about bats. Signs should not block bat movement or air flow (See Appendix III). Figure 3 shows a properly worded sign. Criteria for the selection of caves where signs should be used are in Appendix III.

1.1.2 Gate or Fence Cave. Place a structure such as a gate or fence at the roost cave entrance to prevent unauthorized human access. The structure must permit Indiana bats to pass without danger (See Appendix III). All plans to gate or fence a cave should be reviewed by the appropriate Regional Director, because improper construction can destroy the very bat colonies that they are built to protect.

1.1.3 Monitor Hibernacula. After hibernacula are protected, they must be monitored periodically to determine if the method of protection is effective and to determine if repairs or changes in management are needed.

The information should be sent to the Region 3 Fish and Wildlife Endangered Species Office. This office should maintain a file of this census information.

1.1.4 Monitor Caves by Law Enforcement Agencies. The Law Enforcement Division of the U. S. Fish and Wildlife Service should request funds to investigate violations at Indiana bat caves. State agencies should cooperate in this effort.

1.1.5 Discourage Access. After gating, fencing, or sign posting caves, roads or trails should be closed or obliterated to further discourage access to the caves.

1.2 Prevent Adverse Modifications to Winter and Fall Roost Sites. To preserve roost habitat for Indiana bat use, adverse modifications must be prevented.

1.2.1 Prevent Adverse Modifications to and Rehabilitate the Subsurface. A number of caves that formerly were important roost sites have been modified adversely by such means as partially blocking an entrance or creating new entrances. Modifications such as these can greatly affect the air flow and, as a result, the temperature and humidity regimes (Tuttle and Stevenson, 1978). Any roost sites that are identified for protection in item 1.3.3 and that have been adversely modified should be restored. Reference to Appendix III and Tuttle and Stevenson (1978) should prevent additional adverse modification. In addition, any proposed modification to an important Indiana bat roost site may require Section 7 consultation by the appropriate Regional Director of the U. S. Fish and Wildlife Service.

1.2.2 Prevent Adverse Modifications to and Rehabilitate the Surface Watershed Surrounding Important Roost Sites. Caves are very vulnerable to changes made to the surface areas above, including areas that drain into caves. For example, deforestation can increase the amount of silt entering a cave or cause cave flooding.

1.2.3 Make Locations of Hibernacula Available to Appropriate Fish and Wildlife Service Offices and State Wildlife Agencies. Ensure that appropriate U. S. Fish and Wildlife Service offices and state wildlife agencies are provided with locations of hibernacula, so that they can be used to identify potential conflicts during Section 7 consultations and other planning activities.

1.3 Protect Winter and Fall Roost Sites. Because Indiana bats hibernate almost exclusively in caves and mines, a substantial measure of protection will be afforded the species if at least the most important of these caves are protected from human disturbance or adverse modifications. In order to accomplish this, governmental agencies, and possibly private conservation organizations as well, must afford some degree of protection over the caves. This may be by fee acquisition, lease, easement, cooperative agreement, or some other arrangement, the critical factor being that the agency can legally take whatever steps are required to reduce or eliminate disturbance to the bats.

1.3.1 Identify all Indiana Bat Winter and Fall Roost Sites. The immediate objective must be to reduce human disturbance in occupied caves. First, the locations of Indiana bat caves must be made known to appropriate Federal, state, and local agencies, and private organizations, along with options recommended for protection. Locations of most Indiana bat caves are known to bat researchers. Even those not yet known to researchers are usually known locally

to spelunkers. Access to such location lists, however, should be restricted to protect the sites.

1.3.2 Roost Site Evaluation. Certain caves that have been especially important to bats in the recent past, but are now abandoned due to heavy disturbance, probably will be recolonized if protected. Cave protection may require one of the following measures: signposting, gating, fencing, and surveillance by enforcement agents in addition to those identified in 1.1.2 above. No gating or other entrance alteration of Indiana bat caves should be attempted without careful consideration of the potential impact upon movement of both bats and air (Tuttle and Stevenson, 1978).

1.3.3 Identify Roost Sites to be Protected. After all known Indiana bat roost sites are identified, recommendations will be made on the sites to be protected and final assigned cave priorities (Appendicies I and IV) will be based on colony size and management needs.

2. Maintain, Protect, and Restore Foraging and Nursery Habitat. Indiana bats primarily forage over streams and rivers, and in adjacent riparian habitat where crepuscular and nocturnal insects occur in large numbers. Preferred foraging habitat appears to be streams with more than thirty meters of mature woody vegetation on both sides (Cope et al., 1978). Indiana bat maternity colonies located to date have numbered from fifty to one hundred females and young in recently dead trees where they roost in the space under loose bark (Humphrey et al., 1977). Populations where maternity colonies exist have been estimated at sixty to ninety bats per kilometer of suitable stream.

2.1 Prevent Adverse Modification to Foraging Areas and Nursery Roost Habitat. Destruction of forests and alteration of streams should be avoided whenever possible. Efforts also should be made to maintain large, dead trees which are potential nursery sites. Forest management should reflect the need for such trees as sites for maternity colonies. When a stream is diverted or channelized, as much riparian forest as possible should be preserved.

2.1.1 Determine Habitat Requirements. Additional data on summer habitat requirements should be gathered. Summer surveys to identify foraging and nursery habitat should be encouraged. Land management agencies should make an effort to locate potential summer habitat for Indiana bats.

2.1.2 Preserve Water Quality. Much of the insect fauna which serves as a food base for the Indiana bat is affected adversely by water pollution. Streams and lakes near known roosts should be maintained or restored to natural conditions. Individual states should insure that water quality standards are met throughout the range of the Indiana bat.

2.1.3 Restore and Preserve Forest Cover along Rivers and Streams. Where riparian forest is removed, such as a stream diversion in a surface-mined area, both sides should be planted in a band at least thirty meters wide with riparian vegetation.

2.1.4 Monitor Habitat. Additional foraging areas and nursery roosts should be identified and all such sites monitored. A system should be developed using U. S. Geological Survey infared photographs, LANDSAT images, wetland survey or other sources to monitor habitat alteration within the range of the

Indiana bat. Adjacent land use should be considered for possible detrimental effects. Survey data collected by state and federal agencies should be sent to the FWS Region 3 office. Guidelines for summer habitat survey may be requested from the Region 3 Office of Endangered Species.

3. Monitor Population Trends. In order to measure the effectiveness of the actions recommended in this recovery plan, it will be necessary to monitor the status of various populations on a regular basis. Decreasing populations will signal the need for remedial action, and increasing populations should be used to measure progress towards the prime objective of removing the Indiana bat from the endangered species list.

3.1 Monitor Status of Populations in Hibernacula. The Regional Director (Region 3) of the Fish and Wildlife Service will coordinate a monitoring system whereby each accessible Priority 1 hibernaculum and at least half of the Priority 2 hibernacula are censused every two years between mid-January and mid-February. Censuses will be conducted by experienced bat biologists to insure reliable estimates. (See Appendix VI.) Bats in small clusters may be counted individually; bats in large clusters may be estimated by multiplying the area by the number of bats per unit area ($300/ft^2$ according to LaVal and LaVal, 1980).

3.2 Monitor Status of Populations in Summer. The Regional Director (Region 3) of the Fish and Wildlife Service will maintain an information file on the summer occurrence of Indiana bats. Survey data collected by state and federal agencies should be sent to the Region 3 office. Guidelines for summer habitat surveys may be obtained from that office.

3.3 Monitor Residues of Toxic Chemicals. The possible influence of pesticides in causing the decline of North American populations of insectivorous bats has been reported. Clearly, further investigation is needed.

3.3.1 Sample Insects. Where bat mortality has been demonstrated, insect samples from known Indiana bat foraging areas should be collected and analyzed for toxic chemical residues. Significant amounts should be traced to their source, and remedial action taken.

3.3.2 Sample Bats. If unusual numbers of dead bats are found, they should be examined for cause of death, as per methods described by Clark (1981).

4. Public Education. The public must be informed of the consequences of their actions when they disturb Indiana bat roosts. In addition, knowledge of the beneficial qualities of Indiana bats should be promoted. Landowners in the vicinity of known Indiana bat roosts should be urged to leave natural forest corridors wherever possible, especially along streams. The beneficial effects of insectivorous bats should be stressed.

4.1 Governmental Officials. Governmental officials at all levels should be educated regarding the ecological role of bats. Many officials, through exaggerated fear of bats as disease vectors, believe that all bats should be destroyed. Disease problems should be put in perspective, and officials and the public should be informed that bats consume large quantities of insects, many of which may be pests. Bats also may serve as biological indicator for environmental pollutants.

4.2 Landowners. Major efforts should be made to educate and gain the cooperation of landowners. Many would cooperate if contacted by local wildlife officials or conservation groups. Cave owners should be provided with an official written statement outlining the basic problem, the value of protecting bats, and Federal and state laws and penalties for disturbing them. Additionally, Federal and state agencies should offer to post privately-owned Indiana bat caves with signs, briefly outlining reasons for protection and specific times during which entry is prohibited (see Appendix III). It is important also to inform landowners that a valuable and rare resource is involved and to generate a sense of pride and stewardship, making the protective posture a positive step.

4.3 Warning Signs at Caves. Signs can be used at certain caves to discourage entry. Signs are also used in conjunction with gates to inform the public. Signs should not block bat movement or air flow (see Appendix III). Such procedures impress the landowner that protecting bats is important enough to warrant his participation and lets him "off the hook" with neighbors and others who might otherwise think of him as unfriendly. Also, informative signs may elicit cooperation even from would-be vandals, especially if a definite time period is identified when bats are vulnerable.

4.4 Pamphlets. A carefully written brochure should be made available for distribution by state and federal agencies throughout the range of the Indiana bat. The purpose of the brochure should be to convince the public that the bats are worth protecting and that the public's cooperation is essential if bats are to be protected successfully. The need to avoid disturbance of Indiana bat caves should be emphasized. A sample brochure published by the state of Missouri is attached (Appendix V).

4.5 Slide Program. A color slide presentation should be prepared for use in parks, nature centers, schools, etc., located within the distributional range of the Indiana bat. The National Speleological Society, Boy Scout and Girl Scout troops, and other organizations whose members explore caves should receive special emphasis in these efforts.

4.6 Ranger-Naturalist Talks. These talks, given at places such as state and national parks and forests, and Corps of Engineers and TVA reservoirs, can include appropriate information on the Indiana bat. All agencies conducting natural history programs within the range of the Indiana bat should be urged to include information on the need for protection of Indiana bat habitat.

5. Research Needs. There are a number of areas of Indiana bat biology that require further investigation in order to increase management efficiency.

5.1 Summer Habitat Requirements. Although riparian forest is used as summer habitat for nursery colonies (Humphrey et al., 1977; Cope et al., 1978; Sparling et al., 1979; Gardner and Gardner, 1980), it is not known to what extent other habitat types are used. LaVal and LaVal (1980) and Bowles (1980; 1981) have captured reproductive Indiana bats in upland forests. Habitat types used by Indiana bats should be investigated and clarified as to important environmental parameters.

5.2 Effects of Habitat Destruction. The effects of forest habitat destruction should be determined. The summer range of maternity colonies

needs to be delineated and the habitats characterized. Present and projected rates of habitat destruction should be determined.

5.3 Foraging Habitat and Prey Preferences. Belwood (1979) studied the feeding ecology of Indiana bats in Indiana. There is still a need to supplement her data, especially in other parts of the range.

5.4 Effects of Winter Disturbance. Plans for further studies raise the question of potential research-related disturbance. Indiana bats are especially vulnerable to disturbance during hibernation. Observation should be limited to biennial censusing. Handling, banding or other research-related activities should be avoided during this critical period (see Appendix VI).

5.5 Effects of Water Pollution and Siltation. Because Indiana bats are found in riparian habitat and may feed largely on aquatic insects, water quality may be important to their continued existence. Studies are needed to determine the effects of water pollution and siltation on the insect prey base of these bats. The impact of water quality deterioration on food availability needs further study.

5.6 Effects of Pesticide Contamination. The accumulation of pesticide residues in insectivorous bats is well documented (Clark, 1981). However, little is known about this problem in Indiana bats. Studies should be directed towards the amount and kind of pesticide poisoning in various parts of the bat's range.

5.7 Effects of Cave Modifications. Indiana bat management is concentrated on a variety of methods such as gating or fencing caves, erecting warning signs, and attempting to preclude disturbance of hibernacula. In spite of these efforts, populations in some areas have continued to decline. Studies are needed to determine which cave management techniques are helpful or harmful to these bats.

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PART III

Implementation

Priorities in column four of the following implementation schedule are assigned as follows:

1. Priority 1 - All actions that are absolutely essential to prevent extinction of the species.

2. Priority 2 - All actions necessary to maintain the species' current population status.

3. Priority 3 - All other actions necessary to provide for full recovery of the species.

RECOVERY PLAN IMPLEMENTATION SCHEDULE
INDIANA BAT

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY			FISCAL YEAR COSTS (EST.)			CMTS/ NOTES
					FWS		OTHER				
					REGION	PROGRAM		FY 83	FY 84	FY 85	
O 4	Prevent entry to Priority one hibernacula	1.1	1	Ongoing	3,4	SE	Land-owner				Hibernacula identified in the following tables
A	Protect priority one hibernacula	1.3	1	2 years	3,4	SE	"				
M 3	Erect signs, gates or fences	1.1 1.2	1	3 years	3,4	SE	"				
O 2	Monitor caves by law enforcement	1.1.4	2	Ongoing	3,4	LE	"				
M 3	Prevent adverse modification to hibernacula	1.2	1	Ongoing	3,4	SE	"				
M 3	Protect foraging and nursery habitat	2.1	3	Ongoing	3,4,5	SE	"				
I 1	Monitor status of populations in hibernacula	3.1	1	Ongoing	3,4	SE					
I 12	Monitor toxic chemicls	3.2	3	Ongoing	3,4	SE					
O 1	Public education	4	1	1 year +	3	SE	"	20,000			
R 3	Identify summer habitat requirements	5.1	3	2 years	3	Research				60,000	
R 14	Supplement data of foraging habitat and prey preference	5.4	2	1 year	3	Research				40,000	

RECOVERY PLAN IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY			FISCAL YEAR COSTS (EST.)			CMTS/ NOTES
					FWS		OTHER				
					REGION	PROGRAM		FY 83	FY 84	FY 85	
R 4	Develop cave protection techniques	5.8	1	1 year	3	Research		52,500	56,200		FY 82 P.A. Obj. 86.c
A&M 4	Protect priority two hibernacula 50%	1.1	3	Ongoing	3,4	SE					

APPENDIX I

CAVE PRIORITY DATA

The most important action recommended in the implementation schedule is the protection of Indiana bat hibernacula. The following tables (2-5) contain a list of these caves, their location by state and county, an index number for computer purposes, priority levels (1-4) protection needs, and recommended management agencies. Priority levels were set based on the following criteria:

Priority 1. Hibernacula with a recorded population greater than 30,000 since 1960.

Priority 2. Hibernacula with a recorded population greater than 1,000 but less than 30,000 since 1960.

Priority 3. Hibernacula that require further investigation.

Priority 4. Other hibernacula of marginal significance that require no action.

ABBREVIATIONS USED IN INDIANA BAT RECOVERY PLAN

	Arkansas Game and Fish Commission
	Missouri Department of Natural Resources
	Eligible Natural Landmark
GA DNR	Georgia Department of Natural Resources
IDNR	Indiana Department of Natural Resources
KDFWR	Kentucky Department of Fish and Wildlife Resources
	Kentucky Department of Parks
KNPC	Kentucky Nature Preserves Commission
MDC	Missouri Department of Conservation
MD DNR	Maryland Department of Natural Resources
NC	Nature Conservancy
	National Natural Landmark
	National Park Service
	National Speleological Society
NYSDEC	New York State Department of Environmental Conservation
	Pennsylvania Game Commission
	Private Individual
	Tennessee Heritage Program
	Tennessee Valley Authority
	Tennessee Wildlife Resources Agency
USACE	U. S. Army Corps of Engineers
USADOD	U. S. Department of Defense
	U. S. Forest Service
USFWS	U. S. Fish and Wildlife Service
VCGIF	Virginia Commission of Game and Inland Fisheries
WVDNR	West Virginia Department of Natural Resources

TABLE 2. PRIORITY 1 CAVES FOR INDIANA BATS

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
INDIANA	CRAWFORD	BAT WING CAVE	122	1	SIGN	IDNR
INDIANA	HARRISON	TWIN DOMES CAVE	114	1	FENCE*	IDNR
KENTUCKY	CARTER	BAT CAVE (CARTER)	054	1	REPLACE GATE	KDP, KDFWR
KENTUCKY	EDMONSON	HUNDRED DOME CAVE (COACH)	019	1	COOP AGREE, MODIFY GATE	USFWS, KDFWR
KENTUCKY	EDMONSON	DIXON CAVE	024	1	FENCE*, PATROL*	NPS, KDFWR
MISSOURI	IRON	PILOT KNOB MINE**	088	1	PURCHASE, LEASE OR COOP AGREE	USFWS/MDC
MISSOURI	SHANNON	BAT CAVE	080	1	GATE	NPS/MDC
MISSOURI	WASHINGTON	GREAT SCOTT CAVE	084	1	GATE*	

* already accomplished
** cannot be surveyed

TABLE 3. PRIORITY 2 CAVES FOR INDIANA BATS

STATE	COUNTY	CAVE NAME			PROTECTION NEEDS	REC MGMT AGENCY
ARKANSAS	MADISON	HORSETHIEF CAVE (DENNEY)	127	2	PURCHASE, COOP AGREE, 1/2 GATE	AGFC OR USFWS
ARKANSAS	NEWTON	CAVE MOUNTAIN CAVE (COXLEY, BAT)	053	2	PURCHASE*, FENCE*	NPS
ARKANSAS	NEWTON	EDGEMON CAVE	100	2	GATE	AGFC OR USFWS
ILLINOIS	MONROE	FOGELPOLE CAVE		2	COOP AGREE	IL
INDIANA	CRAWFORD	WYANDOTTE CAVE	123	2	COOP AGREE	IDNR
INDIANA	GREENE	RAY'S CAVE	115	2	PURCHASE	IDNR
INDIANA	MONROE	COON'S CAVE	112	2	COOP AGREE* SURVEY TO DETERMINE NEEDS	NC, IDNR
INDIANA	MONROE	GROTTO CAVE (RICK'S)	113	2	COOP AGREE*, SIGN	NC, IDNR
KENTUCKY	BRECKINRID	WIND CAVE	124	2	NONE	KDFWR
KENTUCKY	EDMONSON	COLOSSAL CAVE	026	2	SURVEY TO DETERMINE NEEDS	NPS, KDFWR
KENTUCKY	EDMONSON	LONG'S CAVE	027	2	REPLACE GATE	NPS, KDFWR
KENTUCKY	EDMONSON	TONY'S CAVE	117	2	SURVEY TO DETERMINE NEEDS	KDFWR
KENTUCKY	HART	FRENCHMAN'S KNOB PIT	077	2	NONE	KDFWR
KENTUCKY	JACKSON	WAR FORK CAVE	066	2	NONE	KDFWR
KENTUCKY	LEE	CAVE HOLLOW CAVE	075	2	SIGN	NC, KDFWR

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
		STILLHOUS .VE				
'NTUCK	LETCHER		56			
KENTUCKY	ROCKC	.VE			.GR	
NTUC		KEHOLE				
KENTUCK		.VE				DFWR
		.VE				
MISSOUR	FRANKL					
		COPPER HOLLOW			GA'	/MDC
	PULAS	KS .VE			GATE	DC
	ULASK	GREA SP			E*	
	KI	.VE				
	HANNON	.VE			AS	/
UR					UR(	
	JE	.EN .RK				YS EC
		IMSATT				YS
ENNSYLVA						
TENNE EE					MONITO	
		MAMMOTH			UR	
					E*	TW OR NC

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
TENNESSEE	FENTRE	WOLF VE CAVE			GN	TWRA
TENNE	WARRE	HU BARDS CAVE			GATE PURCHA	NC
IR INIA		OCK HOLLOW CAVE			URVEY TO DETERM NE IF	
WE VIRG	PENDLETON	HELLHOLE CAVE	30		GATE*	VDNR

TABLE 4. PRIORITY 3 CAVES FOR INDIANA BATS

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
ALABAMA	JACKSON	FERN CAVE	012		PURCHASE*, SIGN ONLY	USFWS
ALABAMA	JACKSON	NITRE CAVE	008		COOP AGREE, SIGN	USFWS
ALABAMA	JACKSON	SAUTA CAVE	020	3	GATE*, SIGN*, PATROL, MAINT	USFWS
ARKANSAS	INDEPENDEN	HAWKIN'S CAVE	102	3	COOP AGREE, SIGN	AGFC OR USFWS
ARKANSAS	NEWTON	CORKSCREW CAVE	099	3	SIGN*	NPS
ARKANSAS	STONE	AMPHITHEATER CAVE	095	3	SIGN*	USFS
ARKANSAS	STONE	BARKSHED SALTPETER CAVE	096	3	SIGN*	USFS
ARKANSAS	STONE	BIOLOGY CAVE	097	3	SIGN*	USFS
ARKANSAS	STONE	GUSTAVISON CAVE	101		SIGN*	USFS
ARKANSAS	STONE	HIDDEN SPRING CAVE	103	3	SIGN*	USFS
ARKANSAS	STONE	ROWLAND CAVE	104	3	SIGN*	USFS
ILLINOIS	HARDIN	CAVE SPRING CAVE	129	3	PURCHASE, GATE	USFS OR IL
ILLINOIS	LaSALLE	BLACKBALL MINE	128	3	SURVEY TO DETERMINE NEEDS	
KENTUCKY	ADAIR	JONES CAVE	067	3	COOP AGREE	KMPC/USFWS
KENTUCKY	BRECKINRID	BIG BAT CAVE	070	3	SURVEY TO DETERMINE NEEDS	
KENTUCKY	EDMONSON	BAT CAVE	035		SURVEY TO DETERMINE NEEDS	NPS

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
KENTUCKY	EDMONSON	JESSE JAMES CAVE	018	3	PURCHASE, MODIFY GATE	HPS/USFWS
KENTUCKY	ESTILL	PRAIRIE HALL CAVE	059	3	SURVEY TO DETERMINE NEEDS	
KENTUCKY	HART	RIDER'S HILL CAVE	078	3	SURVEY TO DETERMINE NEEDS	
KENTUCKY	JACKSON	BOWMAN SALTPETER CAVE	058	3	SURVEY TO DETERMINE NEEDS	
KENTUCKY	JACKSON	1813 CAVE	065	3		
KENTUCKY	JESSAMINE	CHRISMAN'S CAVE (CHRISMAM'S)	071	3	SURVEY TO DETERMINE NEEDS	
KENTUCKY	LEE	ARMINE BRANCH CAVE (WOLF HOLLOW)	073	3	SURVEY TO DETERMINE NEEDS	KMPC
KENTUCKY	LEE	ASH CAVE	069	3	SURVEY TO DETERMINE NEEDS	
KENTUCKY	PULASKI	HINTON HOLLOW	045	3	INFORMATIVE SIGN, COOP AGREE	KMPC
KENTUCKY	ROCKCASTLE	CROOKED CREEK (GOOCHLAN)	044	3	COOP AGREE	KMPC
KENTUCKY	ROCKCASTLE	CROOKED CREEK ICE CAVE (ICE)	060	3	COOP AGREE	
KENTUCKY	ROCKCASTLE	GREAT SALTPETER CAVE	061	3	COOP AGREE	
KENTUCKY	TAYLOR	BOONES CAVE	068	3	SURVEY TO DETERMINE NEEDS	KMPC

	COUNTY	CAVE NAME	INDEX		PROTECTION NEEDS	REC MGMT AGENCY
KENTUCKY	TRIGG	COOL SPRINGS CAVE	079		COOP AGREE, GATE, SIGNS	KMPC/USFWS
NEW YORK	ALBANY	HAILES CAVE	093	3	GATE?	NYSDEC
TENNESSEE	BLOUNT	BULL CAVE	040	3	SURVEY TO DETERMINE NEEDS	NPS
TENNESSEE	BLOUNT	KELLEY RIDGE CAVE	051	3	SURVEY TO DETERMINE NEEDS	
TENNESSEE	CAMPBELL	MEREDITH CAVE	009	3	COOP AGREE, MODIFY CAVE	TWRA
TENNESSEE	CAMPBELL	NORRIS DAM CAVE	004	3	GATE*, SIGN*	TVA
TENNESSEE	CAMPBELL	UNNAMED CAVE	023	3	SURVEY TO DETERMINE NEEDS	
TENNESSEE	FENTRESS	COBB CREEK SALTPETRE CAVE	050	3	SIGN	TWRA
TENNESSEE	FENTRESS	DRAGON'S BREATH CAVE	049	3	SURVEY TO DETERMINE NEEDS	TVA/TWRA
TENNESSEE	FENTRESS	XAHADU CAVE	048	3	SURVEY TO DETERMINE NEEDS	
TENNESSEE	FENTRESS	YGORASIL'S CAVE	039	3	COOP AGREE	TWRA
TENNESSEE	FENTRESS	ZARATHUSTRA'S CAVE	047	3	SIGN	
TENNESSEE	FRANKLIN	CAHEY HOLLOW CAVE	006	3	COOP AGREE, SIGN ONLY	TWRA
TENNESSEE	GRAINGER	INDIAN CAVE	005	3	COOP AGREE	TWRA
TENNESSEE	HAWKINS	PEARSON CAVE	003	3	COOP AGREE	TWRA OR USFWS
TENNESSEE	LINCOLN	BAT CAVE	042	3	COOP AGREE OR PURCHASE	TWRA

	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
TENNESSEE	MARION	HICKAJACK CAVE	002	3	FENCE*, SIGN*	TVA
TENNESSEE	HAURY	BENDERMAN CAVE	041	3	PERIODIC INSPECTION	TWPA
TENNESSEE	MONTGOMERY	BELLAMY CAVE	007	3	COOP AGREE*, FENCE*, INSP.	TWRA
TENNESSEE	STEWART	TOBACCOPORT CAVE	020	3	COOP AGREE, PRUCHASE?	TWRA
TENNESSEE	UNION	JOLLEY SALTPETER CAVE	126		SURVEY TO DETERMINE NEEDS	TWRA
TENNESSEE	WHITE	INDIAN CAVE	052		SURVEY TO DETERMINE NEEDS	
TENNESSEE	WHITE	LOST CREEK CAVE (DODSON)	109	3	COOP AGREE, SIGN	TWRA
VIRGINIA	BATH	STAR CHAPEL CAVE	135	3	SURVEY TO DETERMINE NEEDS	VCGIF
VIRGINIA	LEE	CUMBERLAND GAP SALTPETRE CAVE	038	3	SIGN	NPS
WEST VIRG	POCOHONTAS	CASS CAVE	131	3	SURVEY TO DETERMINE NEEDS	WVDNR
WEST VIRG	POCOHONTAS	MARTHA'S CAVE	132		FENCE*	WYDNR
WEST VIRG	TUCKER	BIG SPRINGS CAVE	133		GATE*	WYDNR
WEST VIRG	TUCKER	CAVE HOLLOW CAVE	134		SURVEY TO DETERMINE NEEDS	WYDNR

TABLE 5. PRIORITY 4 CAVES FOR INDIANA BATS

STATE	COUNTY	CAVE NAME			PROTECTION NEEDS	REC MGMT AGENCY
ALABAMA	BLOUNT DR	CRUMP CAVE	022	4	NONE	
ALABAMA	LAUDERDALE	SALTPETRE CAVE	034	4	NONE	
ALABAMA	MORGAN	HUGHES CAVE	021	4	NONE	
GEORGIA	DADE	CASE CAVE	036	4	NONE	
GEORGIA	DADE	SITTON'S CAVE	037	4	NONE	
INDIANA	CRAWFORD	SALTPETER CAVE	121	4	NONE	
INDIANA	GREENE	CLYFTY CAVE	116	4	NONE	
INDIANA	MONROE	BUCKNER'S CAVE	120	4	NONE	
INDIANA	MONROE	GROTTO CAVE	119	4	NONE	
KENTUCKY	BARREN	INDIAN CAVE	043	4	INFORMATIVE SIGN	
KENTUCKY	EDMONSON	MAMMOTH CAVE	046	4	NONE	
KENTUCKY	ESTILL	PETER CAVE	076	4	NONE	
KENTUCKY	GRAYSON	BIG SLOUGH BRIDGE, JUNCTION 54	105	4	NONE	
KENTUCKY	LEE	CAVE HOLLOW PIT	074	4	NONE	
MARYLAND	GARRETT	JOHN FRIEND CAVE	106	4	NONE	
MARYLAND	WASHINGTON	ROUND TOP MINE NO. 4	107	4	NONE	
MISSISSIP	TISHOHINGO	ABANDONED CHALK MINE (TRIPOLI)	017	4	NONE	

STATE	COUNTY	CAVE NAME			PROTECTION NEEDS	REC MGMT AGENCY
NORTH CAR	JACKSON	KITCHEN'S CAVE	033	4	NONE	
OKLAHOMA	ADAIR	ADAIR CAVE	111	4	NONE	
OHIO	ADAMS	BLACK RAIN CAVE		4	NONE	
OHIO	HIGHLAND	DRY CAVE		4	NONE	
OHIO	HOCKING	CLEAR CREEK CAVE #1		4	NONE	
OHIO	HOCKING	CLEAR CREEK CAVE #2		4	NONE	
OKLAHOMA	PUSHMATABA	BOWERS TRAIL CAVE	110	4	NONE	
TENNESSEE		ENGLISH CAVE	126	4	NONE	
TENNESSEE	BEDFORD	WARD CAVE	032	4	NONE	
TENNESSEE	MONTGOMERY	BLUE SPRING CAVE	016	4	NONE	
TENNESSEE	MONTGOMERY	COLEMAN CAVE	025	4	NONE	
TENNESSEE	MONTGOMERY	COOPER CREEK CAVE (FOSTER'S)	028	4	NONE	
TENNESSEE	PERRY	ALEXANDER CAVE	030	4	NONE	
TENNESSEE	WHITE	UPPER CAVE	031	4	NONE	

APPENDIX II

ACKNOWLEDGEMENTS

We are especially indebted to those official consultants who helped us prepare this plan: John Bowles, James Cope, Michael Harvey, Stephen Humphrey and Ralph Jordan.

The following persons, due either to their knowledge, experience, or position, have been contacted, or contributed in the Indiana bat recovery effort. The list is not necessarily complete, and does not include team members. Names are listed alphabetically.

Bagley, Fred
Barr, Donald
Brack, Virgil
Caire, William
Chitwood, Ken
Currie, Robert
Davis, Wayne
Elder, William
Eager, Dan
Estes, Jerry and Beth
Gardner, Gene
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Jordan, Dennis
LaVal, Margaret L.
Lucas, Eldon
MacGregor, John
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Myers, Richard
Rabinowitz, Alan
Rossi, David
Russell, Donald R.
Saugey, David
Sheldrake, Thomas
Stack, Holly
Sullivan, Arthur L.
Tipton, Virginia
Visscher, Larry
Warnock, John
Wilson, Ronald
Woody, Jack
Zinn, Terry

APPENDIX III

CAVE MANAGEMENT

CAVE MANAGEMENT

Signs, fences and gates may be required to reduce or eliminate human disturbance at Indiana bat caves.

Signs

At a cave that is infrequently visited, or easily observed by its owner, a sign alone may be adequate to prevent disturbance. Under certain circumstances, a sign might call unnecessary attention to a cave, in which case the manager might opt for placement of the sign inside the cave. Signs must be of durable construction and fixed solidly in place to minimize vandalism. They should not be placed where bat movement or air flow might be impeded. They must be located where the potential violators can see them, and should be placed just behind the gate or fence if such a structure has been erected.

Wording will vary from cave to cave, depending on the history of use of the cave by both bats and people. If law enforcement officials are to have a strong case against violators, the sign must contain a warning message similar to that of the upper half of the sign shown in Figure 3. If potential vandals are undeterred by the warning message, they might be more responsive to an interpretive message, as exemplified by the one shown on the lower half of the sign in Figure 3. This sign is used at Indiana bat hibernacula in Missouri.

At certain caves it may be acceptable to permit entry of visitors during the summer when bats are not present. A smaller sign containing that message, plus information on how to obtain a key to a gated cave or other pertinent details, might deter potential vandals, and encourage the cooperation of spelunkers.

Fences

Although fences may not afford the same level of protection as steel gates, the presence of a fence makes it clear that unauthorized entry is illegal. Fences may be less expensive than gates, but are easier to climb or cut. Nevertheless, some caves are impractical to gate, due to size or configuration of entrances, or because gating would result in probable abandonment of the cave by bats. Chainlink, barbed wire-topped fences (Figure 4), with posts set in concrete are best. Barbed wire should not extend into flight space required by bats. Several fences have proven highly effective in reducing human disturbance. Fences have been used successfully to protect gray bat caves with flooded entrances adjacent to reservoirs (Figure 5).

Gates

Gates must be used only with extreme care to avoid detrimental effects. They should not be horizontal or used in entrances smaller than six feet in diameter. Gates in small entrances are most likely to restrict air flow or increase bat vulnerability to predation (Tuttle, 1977; Tuttle and Stevenson, 1978), leading to abandonment by the bats.

Welded steel bar gates provide the most secure means of preventing human entry into a cave. Even the best-designed and well-built gate can be vandalized. Routine inspections will identify damage so that repairs can be made promptly.

Each gate must be designed specifically for the cave to be protected, considering numbers of bats, air flow, and entrance size and shape. In spite of the number of variables involved, certain generalizations about gate design can be made.

Gates should be constructed of steel bars of sufficient size to be invulnerable to bolt cutters. Steel bars 3/4 inch to 1-inch in diameter (ASTM* A 242) are recommended. All welds should be made carefully, using arc welding equipment.

Access openings in gates should be constructed to the same standards with the most durable hinges, hasps, and locks. In a situation where vandalism seems likely, weak-link design may be employed. The lock, hasp, or some other easily replaceable portion of the gate should be relatively weak so that vandals will not try to breach the main body of the gate. Locks should be chosen with care as many common types are extremely easy to force open.

Free ends of all bars should be grouted into solid rock. In some caves, it may be necessary to pour a concrete footing (although it should not rise above original ground level), or to dig through a deep clay or gravel fill to reach the underlying floor.

Openings in gates through which bats are expected to fly should be approximately six inches vertically and at least twenty-four inches horizontally. Lengths greater than twenty-four inches between vertical bars increase the probability that the bars can be spread by the use of hydraulic jacks.

A simple vertical gate (Figure 6) may be inappropriate at caves with small or sinkhole entrances. Horizontal gates have two serious drawbacks: (1) Bats are reluctant to fly up through such a gate; (2) A horizontal gate may become blocked with debris, preventing entry and exit by bats, as well as blocking normal air flow. A solution is provided by a "cage" gate similar to that shown in Figure 7. Cage gates should be constructed with at least a five-foot height.

Restrict Approach to Cave

People often locate caves with the aid of trails and roads. Obliteration of jeep and foot trails may greatly reduce human traffic to the caves. The Tennessee Valley Authority has blocked boat approaches to two of its caves, preventing access. Other opportunities for restricting approach may present themselves at specific cave sites.

Resource Groups and Agencies

The following groups and agencies have had experience with bat cave management, and can be consulted for advice when management actions are being planned:

*American Society of Testing Material

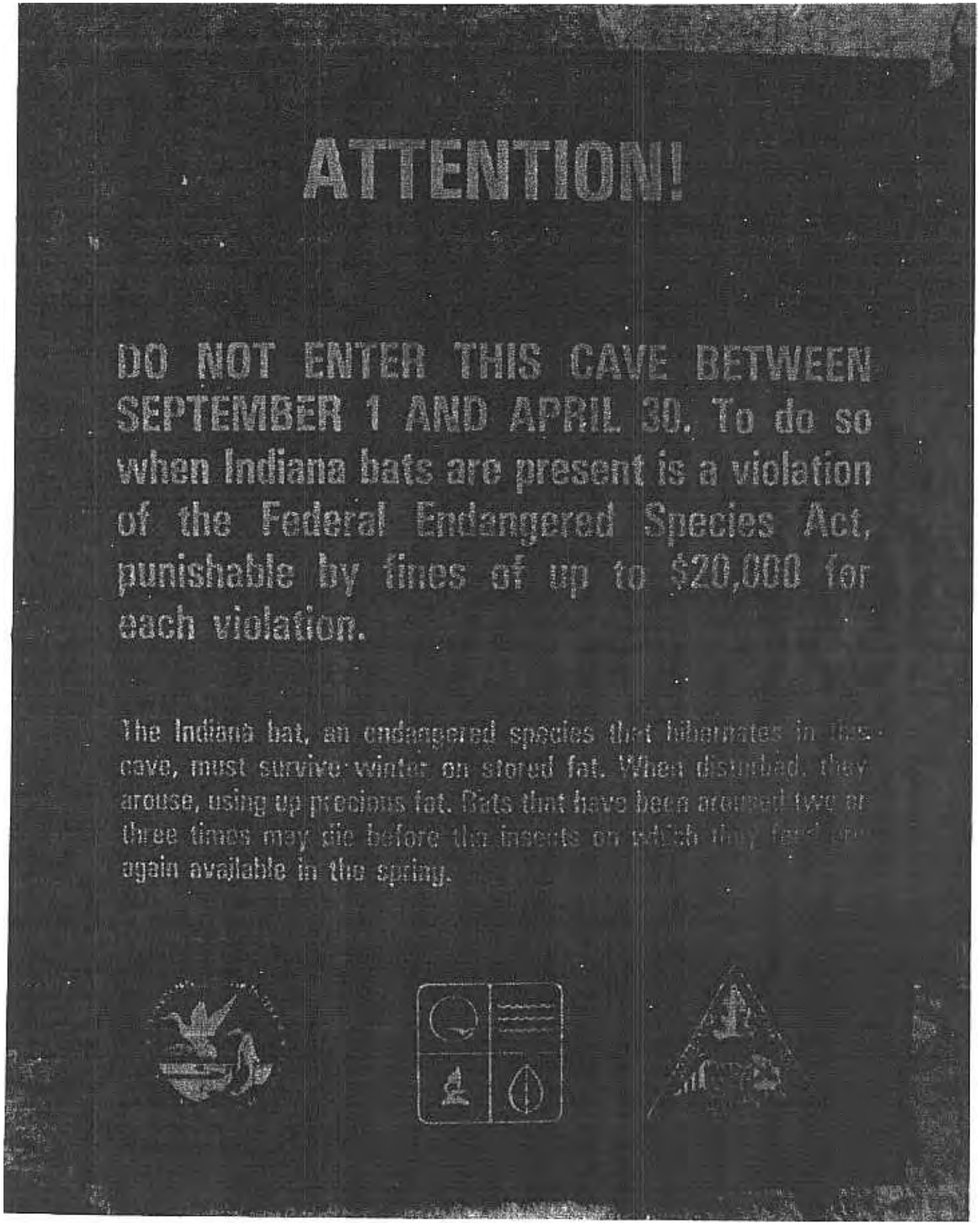
(1) The Recovery Team

U. S. Fish and Wildlife Service, Region 4

Missouri Department of Conservation

U. S. Army Corps of Engineers, St. Louis District

Tennessee Valley Authority



GURE 3. WARNI SIGN USED MISSOUR DEPAR MENT OF CONSERVA

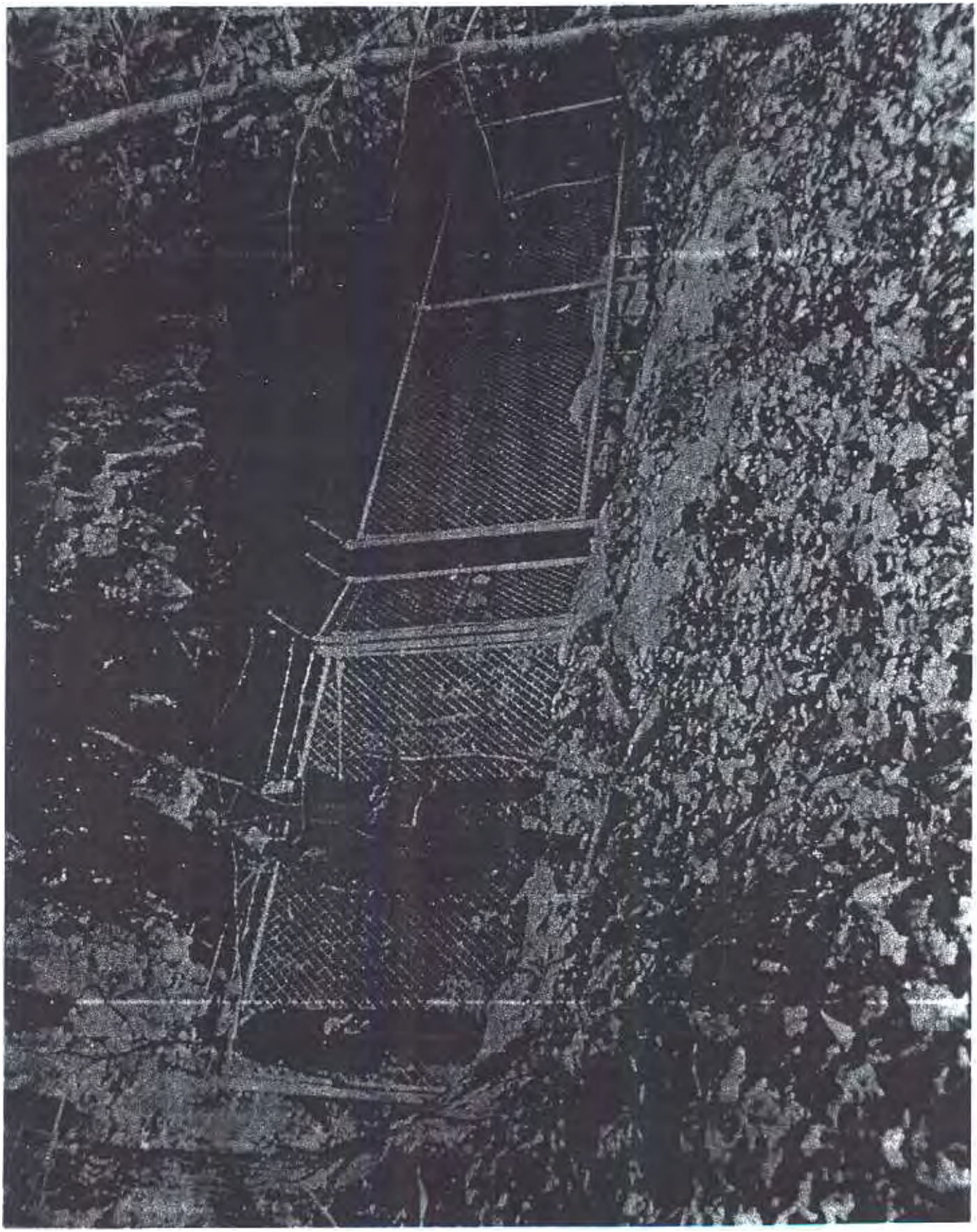


FIGURE 4: FENCE ERECTED AT NORRIS DAM CAVE, TENNESSEE, BY THE TENNESSEE VALLEY AUTHORITY (PHOTO CREDIT, R. CURRIE).

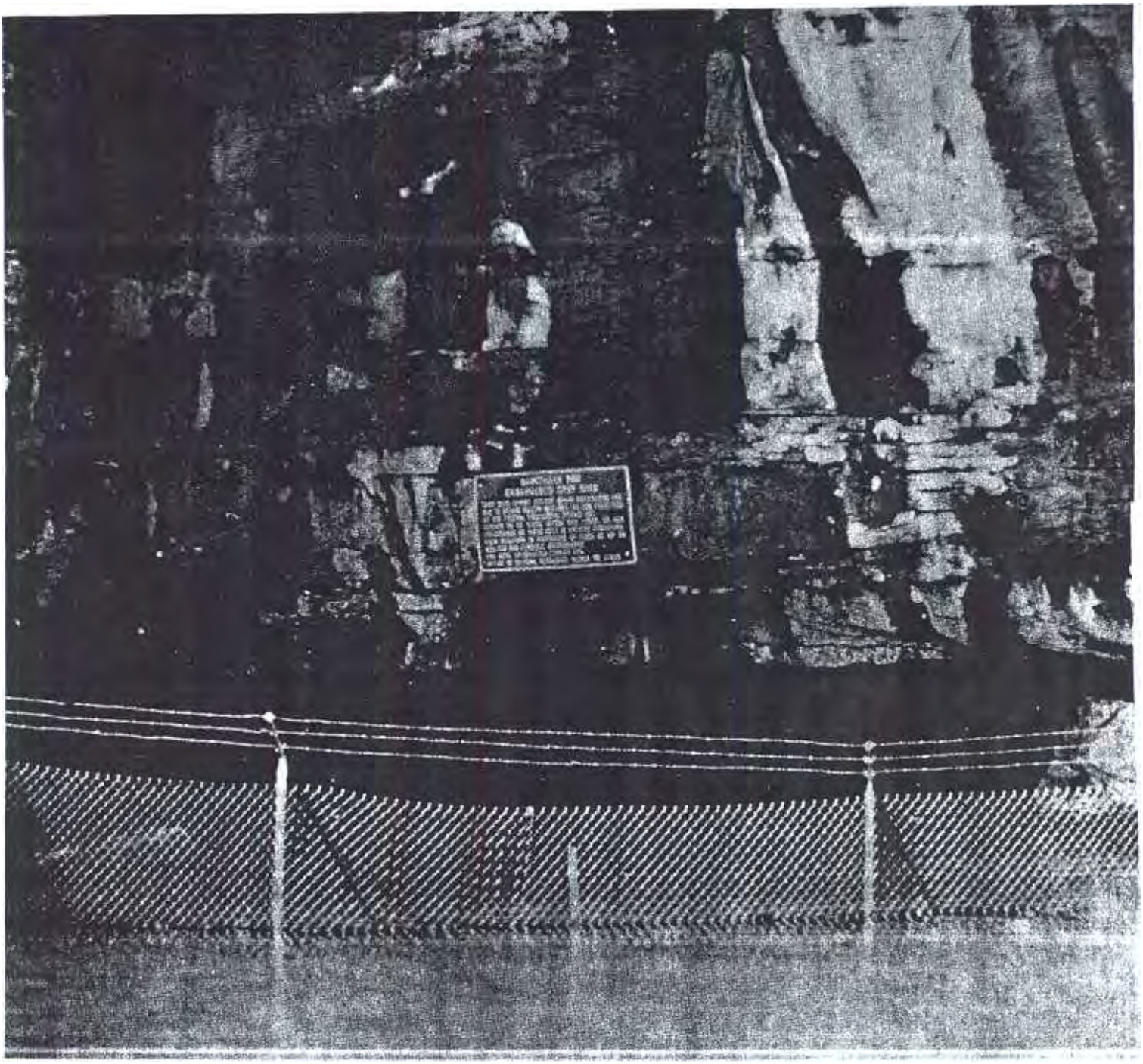


FIGURE 5: FENCE ERECTED AT HAMBRICK CAVE, ALABAMA BY THE TENNESSEE VALLEY AUTHORITY (PHOTO CREDIT, TENNESSEE VALLEY AUTHORITY).

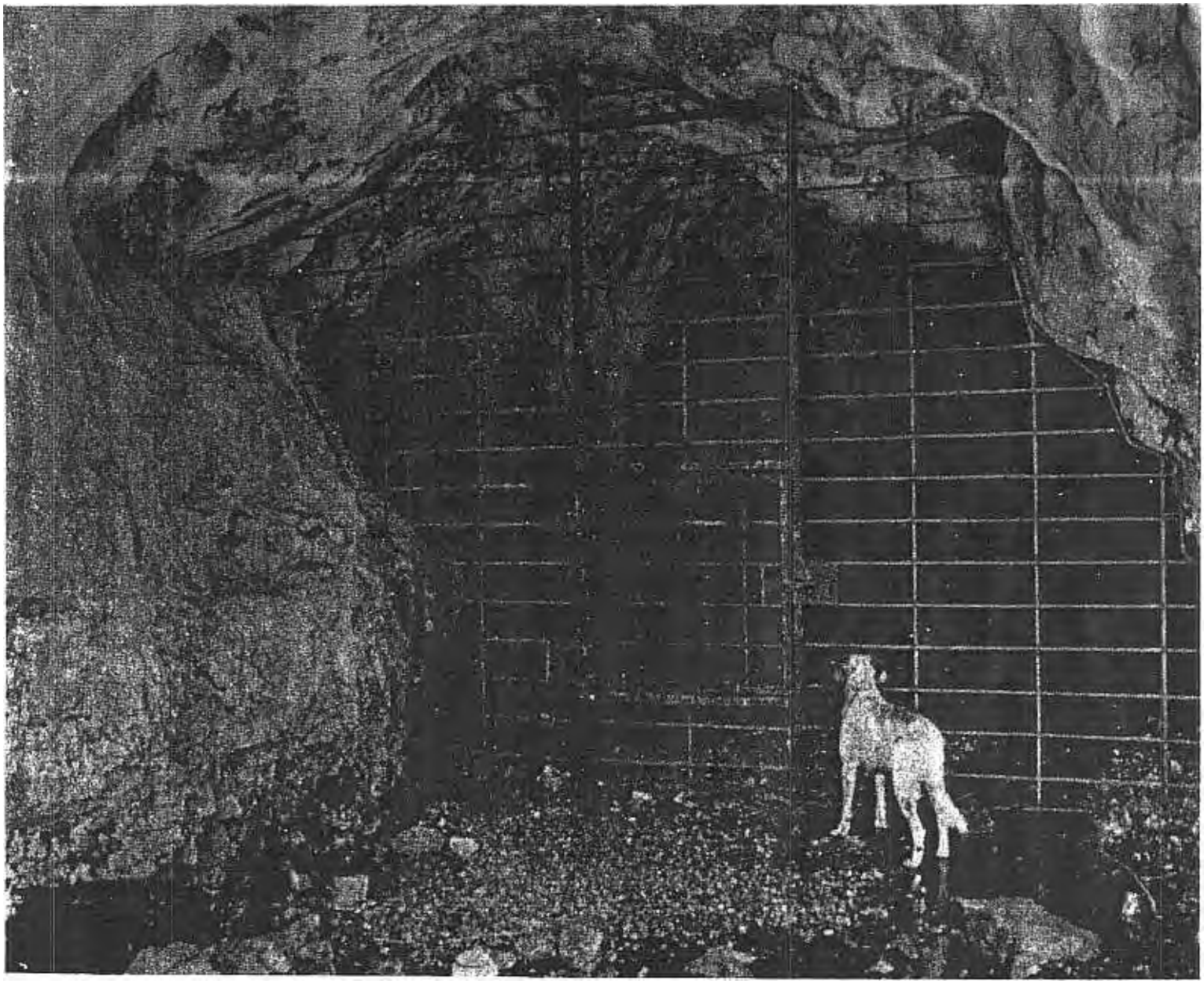


FIGURE 6: GREAT SCOTT CAVE GATE ERECTED BY THE MISSOURI DEPARTMENT OF CONSERVATION (PHOTO CREDIT, R. CLAWSON).

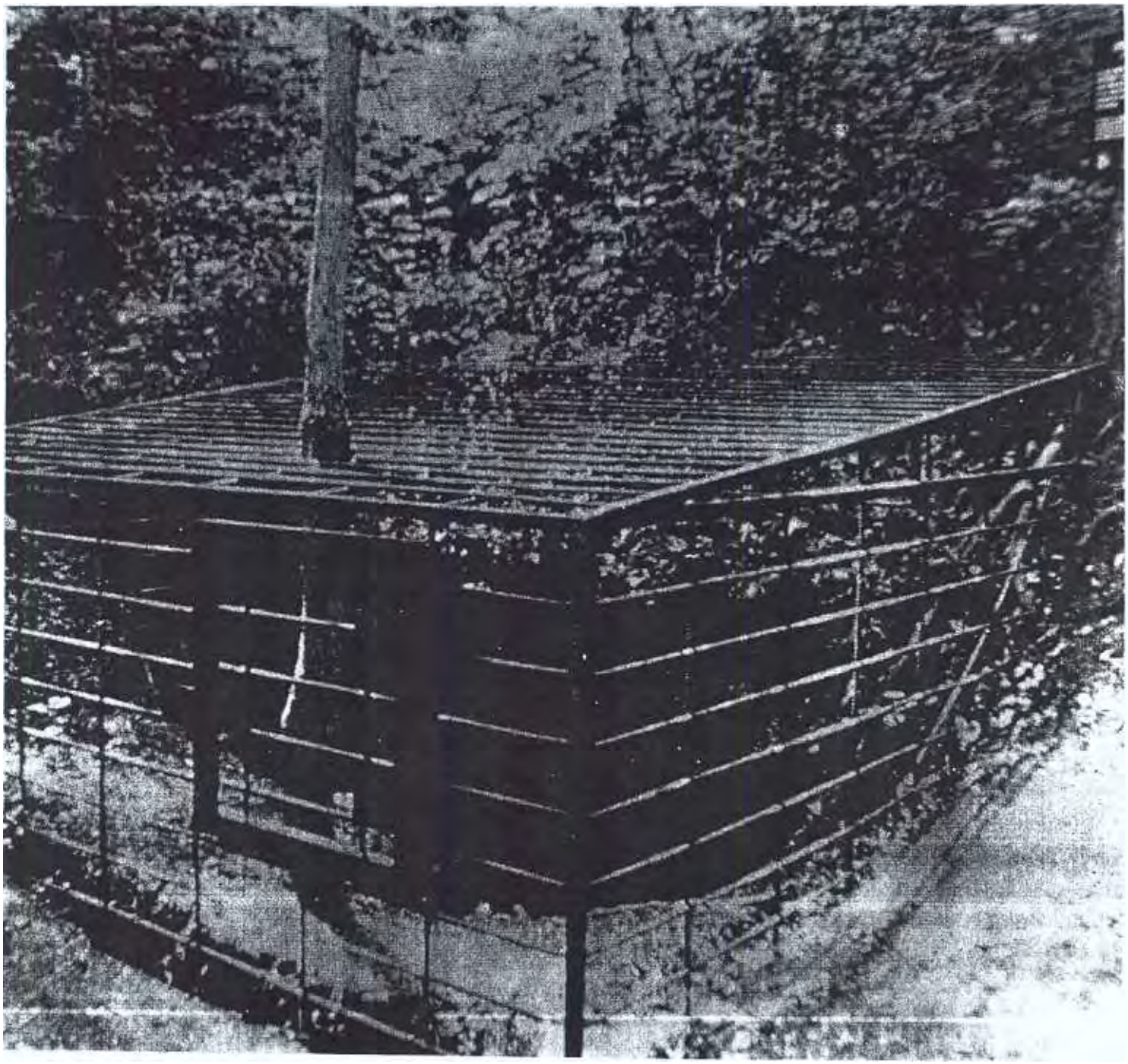


FIGURE 7: BEAR CAVE GATE ERECTED BY THE MISSOURI DEPARTMENT OF CONSERVATION (PHOTO CREDIT, R. CLAWSON).

APPENDIX IV

HIBERNACULA BY STATE

TABLE 6. INDIANA BAT CAVES IN ALABAMA

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
ALABAMA	JACKSON	FERN CAVE	012	3	PURCHASE*, SIGN ONLY	USFWS
ALABAMA	JACKSON	NITRE CAVE	008	3	COOP AGREE, SIGN	USFWS
ALABAMA	JACKSON	SAUTA CAVE	020	3	GATE*, SIGN*, PATROL. MAINT.	USFWS
ALABAMA	BLOUNT DR	CRUMP CAVE	022	4	NONE	
ALABAMA	LAUDERDALE	SALTPETRE CAVE	034	4	NONE	
ALABAMA	MORGAN	HUGHES CAVE	021	4	NONE	

TABLE 7. INDIANA BAT CAVES IN ARKANSAS

STATE	COUNTY	CAVE NAME			PROTECTION NEEDS	REC MGMT AGENCY
ARKANSAS	MADISON	HORSETHIEF CAVE (DENNEY)	127		PURCHASE, COOP AGREE, 1/2 GATE	AGFC OR USFWS
ARKANSAS	NEWTON	CAVE MOUNTAIN CAVE (BOXLEY, BAT)	053	2	PURCHASE*, FENCE*	NPS
ARKANSAS	NEWTON	EDGEMON CAVE	100	2	GATE	AGFC OR USFWS
ARKANSAS	INDEPENDEN	HANKIN'S CAVE	102	3	COOP AGREE, SIGN	AGFC OR USFWS
ARKANSAS	NEWTON	CORKSCREW CAVE	099	3	SIGN*	NPS
ARKANSAS	STONE	AMPHITHEATER CAVE	095	3	SIGN*	USFS
ARKANSAS	STONE	BARKSHED SALTPETER CAVE	096	3	SIGN*	USFS
ARKANSAS	STONE	BIOLOGY CAVE	097	3	SIGN*	USFS
ARKANSAS	STONE	GUSTAFSON	101	3	SIGN*	USFS
ARKANSAS	STONE	HIDDEN SPRING CAVE	103		SIGN*	USFS
ARKANSAS	STONE	ROWLAND CAVE	104		SIGN*	USFS

TABLE 8. INDIANA BAT CAVES IN GEORGIA

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
GEORGIA	DADE	CASE CAVE	036	4	NONE	
GEORGIA	DADE	SITTON'S CAVE	037	4	NONE	

TABL IANA LL

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
LL IS	MONROE	FOGEL POLE CAVE			COO GREE	
LLINOIS		CAVE PRING			URCHA GATE	FS OR

TABLE 10. INDIANA BAT CAVES IN INDIANA

STATE	COUNTY	CAVE NAME	INDEX		PROTECTION NEEDS	REC MGMT AGENCY
INDIANA	CRAWFORD	BAT WING CAVE	122	1	SIGN	IDNR
INDIANA	HARRISON	TWIN DOMES CAVE	114	1	FENCE*	IDNR
INDIANA	CRAWFORD	WYANDOTTE CAVE	123	2	COOP AGREE	IDNR
INDIANA	GREENE	RAY'S CAVE	115	2	PURCHASE	IDNR
INDIANA	MONROE	COON'S CAVE	112	2	COOP AGREE*, SURVEY TO DETERMINE NEEDS	NC, IDNR
INDIANA	MONROE	GROTTO CAVE (RICK'S)	113	2	COOP AGREE*, SIGN	NC, IDNR
INDIANA	CRAWFORD	SALTPETER CAVE	121	4	NONE	
INDIANA	GREENE	CLYFTY CAVE	116	4	NONE	
INDIANA	MONROE	BUCKNER'S CAVE	120	4	NONE	

TABLE 11. NDIANA BAT CAVES IN KENTUCKY

STATE	COUNTY	CAVE NAME			PROTECTION NEEDS	REC MGMT AGENCY
KENTUCKY	CARTER	BAT CAVE (CARTER)	054		REPLACE GATE	KDP, KDFWR
KENTUCKY	EDMONSON	HUNDRED DOME CAVE (COACH)	019		COOP AGREE, MODIFY GATE	USFWS, KDFWR (OUTSIDE BOUNDARY)
KENTUCKY	BRECKINRID	WIND CAVE	124	2	NONE	KDFWR
KENTUCKY	EDMONSON	COLOSSAL CAVE	026	2	SURVEY TO DETERMINE NEEDS	NPS, KDFWR
KENTUCKY	EDMONSON	DIXON CAVE	024	1	FENCE*, PATROL*	NPS, KDFWR
KENTUCKY	EDMONSON	LONG'S CAVE	027	2	REPLACE GATE	NPS, KDFWR
KENTUCKY	EDMONSON	TONY'S CAVE	117	2	SURVEY TO DETERMINE NEEDS	KDFWR
KENTUCKY	HART	FRENCHMAN'S KNOB PIT	077	2	NONE	KDFWR
KENTUCKY	JACKSON	WAR FORK CAVE	066	2	NONE	KDFWR
KENTUCKY	LEE	CAVE HOLLOW CAVE	075	2	SIGN	NC, KDFWR
KENTUCKY	LEE	STILLHOUSE CAVE	055	2	LEASE, FENCE, GATE	KNPC, USFS, KDFWR
KENTUCKY	LETCHER	WATER CAVE	056	2	SIGN	KDFWR
KENTUCKY	ROCKCASTLE	CLIMAX CAVE	062	2	GATE, COOP AGREE, SIGN	KDFWR
KENTUCKY	ROCKCASTLE	SMOKEHOLE CAVE	057		COOP AGREE	KDFWR

	COUNTY	CAVE NAME	INDEX	PR	PROTECTION NEEDS	REC MGMT AGENCY
KENTUCKY	ROCKCASTLE	WATERFALL CAVE	063	2	GATE, COOP AGREE	KDFWR
KENTUCKY	ADAIR	JONES CAVE	067	3	COOP AGREE	KNPC/USFWS, KDFWR
KENTUCKY	BRECKINRID	BIG BAT CAVE	070	3	SURVEY TO DETERMINE NEEDS	KDFWR
KENTUCKY	EDMONSON	BAT CAVE	035	3	SURVEY TO DETERMINE NEEDS	NPS, KDFWR
KENTUCKY	EDMONSON	JESSEE JAMES CAVE	018	2	PURCHASE, MODIFY GATE	OUTSIDE BOUNDARIES, KDFWR
KENTUCKY	ESTILL	PRAIRIE HALL CAVE	059	3	SURVEY TO DETERMINE NEEDS	KDFWR
KENTUCKY	HART	RIDER'S HILL CAVE	078	3	SURVEY TO DETERMINE NEEDS	KDFWR
KENTUCKY	JACKSON	BOWMAN SALTPETER CAVE	058	3	SURVEY TO DETERMINE NEEDS	KDFWR
KENTUCKY	JACKSON	1813 CAVE	065	3		KDFWR
KENTUCKY	JESSAMINE	CHRISMAN'S CAVE (CRISMAN'S)	071	3	SURVEY TO DETERMINE NEEDS	KDFWR
KENTUCKY	LEE	ARMINE BRANCH CAVE (WOLF HOLLOW)	073	3	SURVEY TO DETERMINE NEEDS	KNPC, KDFWR
KENTUCKY	LEE	ASH CAVE	069	3	SURVEY TO DETERMINE NEEDS	KDFWR
KENTUCKY	PULASKI	MINTON HOLLOW	045	3	INFORMATIVE SIGN, COOP AGREE	KNPC, KDFWR

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
KENTUCKY	ROCKCASTLE	CROOKED CREEK (GOOCHLAN)	044	3	COOP AGREE	KNPC, KDFWR
KENTUCKY	ROCKCASTLE	CROOKED CREEK ICE CAVE (ICE)	060	3	COOP AGREE	KDFWR
KENTUCKY	ROCKCASTLE	GREAT SALTPETER CAVE	061	3	COOP AGREE	KDFWR
KENTUCKY	TAYLOR	BOONES CAVE	068	3	SURVEY TO DETERMINE NEEDS	KNPC, KDFWR
KENTUCKY	TRIGG	COOL SPRINGS CAVE	079	3	COOP AGREE, GATE, SIGNS	KNPC/USFWS,KDFWR
KENTUCKY	BARREN	INDIAN CAVE	043	4	INFORMATIVE SIGN	KDFWR
KENTUCKY	EDMONSON	MAMMOTH CAVE	046	4	NONE	
KENTUCKY	ESTILL	PETER CAVE	076	4	NONE	
KENTUCKY	GRAYSON	BIG SLOUGH BRIDGE, JUNCTION 54 &	105	4	NONE	
KENTUCKY	LEE	CAVE HOLLOW PIT	074	4	NONE	

TAB IANA BA IN MAR LA

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
MAR LAND	GARRE	FR ND			ON	
MARYLAND	WAS INGTON	TO IN NO				

TABLE NDIANA BA CAVE IN IS

STATE	COUNTY	CAVE NAME		PROTECTION NEEDS	REC MGMT AGENCY
IS	SHOMINGO	ABANDONE CHALK TRIPOLI)	NE 01	NONE	

TABLE 14. INDIANA BAT CAVES IN MISSOURI

STATE	COUNTY	CAVE NAME	INDEX	PR	PROTECTION NEEDS	REC MGMT AGENCY
MISSOURI	IRON	PILOT KNOB MINE	088		PURCHASE, LEASE OR COOP AGREE	USFWS/MDC
MISSOURI	SHANNON	BAT CAVE	080	1	GATE, PURCHASE OR LEASE	NPS/MDC
MISSOURI	WASHINGTON	GREAT SCOTT CAVE	084	1	GATE*	MDC
MISSOURI	CRAWFORD	ONYX CAVE	087	2	GATE*	USACE/MDC
MISSOURI	FRANKLIN	BEAR CAVE (MUD SINK)	081	2	GATE*	DNR/MDC
MISSOURI	FRANKLIN	COPPER HOLLOW CAVE	083	2	GATE*	DNR/MDC
MISSOURI	PULASKI	BROOKS CAVE	082	2	GATE	ARMY/MDC
MISSOURI	PULASKI	INCA CAVE (GREAT SPIRIT)	085	2	FENCE*	MDC
MISSOURI	PULASKI	RYDEN CAVE	089	2	GATE*	MDC
MISSOURI	SHANNON	MARTIN CAVE	086	2	PURCHASE OR LEASE, GATE	NPS/MDC
MISSOURI	WASHINGTON	SCOTIA MINE	090	2	PURCHASE, GATE	MDC

LE INDIANA BA CAVE NEW YORK

STATE	COUNTY	CAVE NAME		PROTECTION NEEDS		REC MGMT AGENCY
NEW YORK	EFFERSON	GLEN	ARK CAVE	COO	GRE	YSDEC
NEW YORK	ONDAGA	IMS	TT CAVE	COOP	GR	DE
NEW ORK	ANY	HA	CAVE	GATE		YS EC

ABLE NDIANA BA CAVE NORTH CAROL NA

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
CAROLINA	ACKSON	TCHE CAVE			NONE	

TABLE 17. INDIANA BAT CAVES IN OHIO

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
OHIO	ADAMS	BLACK RUN CAVE		4	NONE	
OHIO	HIGHLAND	DRY CAVE		4	NONE	
OHIO	HOCKING	CLEAR CRK CAVE #1		4	NONE	
OHIO	HOCKING	CLEAR CRK CAVE #2		4	NONE	

LE NDIANA BA' VE IN OKLA OMA

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
KLAHOMA	DAIR	ADAIR CAVE			NONE	
KLAHOMA	USHMA ABA	BOWE IRAI VE			NONE	

ABLE INDIANA BA CAVES IN PENNS ANIA

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
PENNSYL ANIA	LAIR	ANO CR EK NE #1	94		COO GR GAT	PGC

TABLE 20. INDIANA BAT CAVES IN TENNESSEE

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
TENNESSEE	BLOUNT	BLOWHOLE CAVE (WHITE OAK)	015	2	SIGN, MONITOR	NPS
TENNESSEE	CAMPBELL	NEW MAMMOTH CAVE	001	2	COOP AGREE*, GATE*	USFWS
TENNESSEE	FENTRESS	WOLF RIVER CAVE	013	2	SIGN	TWRA
TENNESSEE	WARREN	HUBBARDS CAVE	011	2	GATE, PURCHASE*	NC
TENNESSEE	BLOUNT	BULL CAVE	040	3	SURVEY TO DETERMINE NEEDS	NPS
TENNESSEE	BLOUNT	KELLEY RIDGE CAVE	051	3	SURVEY TO DETERMINE NEEDS	
TENNESSEE	CAMPBELL	MEREDITH CAVE	009	3	COOP AGREE, MODIFY GATE	TWRA
TENNESSEE	CAMPBELL	MORRIS DAN CAVE	004	3	GATE*, SIGN*	TVA
TENNESSEE	CAMPBELL	UNNAMED CAVE	023	3	SURVEY TO DETERMINE NEEDS	
TENNESSEE	FENTRESS	COBB CREEK SALTPETRE CAVE	050	3	SIGN	TWRA
TENNESSEE	FENTRESS	DRAGON'S BREATH CAVE	049	3	SURVEY TO DETERMINE NEEDS	TWRA
TENNESSEE	FENTRESS	XAHADU CAVE	048	3	SURVEY TO DETERMINE NEEDS	
TENNESSEE	FENTRESS	YGDRASIL'S CAVE	039	3	COOP AGREE	TWRA
TENNESSEE	FENTRESS	ZARATHUSTRA'S CAVE	047	3	SIGN	
TENNESSEE	FRANKLIN	CAMEY HOLLOW CAVE	006	3	COOP AGREE, SIGN ONLY	TWRA

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
TENNESSEE	GRAINGER	INDIAN CAVE	005	3	COOP AGREE	TWRA
TENNESSEE	HAWKINS	PEARSON CAVE	003	3	COOP AGREE	TWRA OR USFWS
TENNESSEE	LINCOLN	BAT CAVE	042	3	COOP AGREE OR PURCHASE	TWRA
TENNESSEE	MARION	HICKAJACK CAVE	002	3	FENCE*, SIGN*	TVA
TENNESSEE	MAURY	BENDERMAN CAVE	041	3	PERIODIC INSPECTION	TWRA
TENNESSEE	MONTGOMERY	BELLANY CAVE	007	3	COOP AGREE*, FENCE*, INSP.	TWRA
TENNESSEE	STEWART	TOBACCOPORT CAVE	010	3	COOP AGREE, PURCHASE?	TWRA
TENNESSEE	UNION	JOLLEY SALTPETER CAVE	125	3	SURVEY TO DETERMINE NEEDS	TWRA
TENNESSEE	WHITE	INDIAN CAVE	052	3	SURVEY TO DETERMINE NEEDS	
TENNESSEE	WHITE	LOST CREEK CAVE (DODSON)	109	3	COOP AGREE, SIGN	TWRA
TENNESSEE		ENGLISH CAVE	126	4	NONE	
TENNESSEE	BEDFORD	WARD CAVE	032	4	NONE	
TENNESSEE	MONTGOMERY	BLUE SPRING CAVE	016	4	NONE	
TENNESSEE	MONTGOMERY	COLEMAN CAVE	025	4	NONE	
TENNESSEE	MONTGOMERY	COOPER CREEK CAVE (FOSTER'S)	028	4	NONE	

STATE	COUNTY	CAVE NAME		PROTECTION NEEDS	REC MGMT AGENCY
	RY	AL XAN	CAVE	ON	
TENNESSEE	WH TE	PE	VE		

TABLE NDIANA BA CAVE VI IA

STATE	COUNTY	CAVE NAME	PROTECTION NEEDS	REC MGMT AGENCY
IA	SE	OCKY HO LOW VE	URVEY TO DETERM NE EDS	VDG
GI IA	BATH	STAR HAPE VE	URVE TO DE RM NE NEEDS	VD IF
IA	LEE	UM LAND GA AL PETR VE		NPS

TABLE 22. INDIANA BAT CAVES IN WEST VIRGINIA

STATE	COUNTY	CAVE NAME	INDEX	PRTY	PROTECTION NEEDS	REC MGMT AGENCY
W. VIRGINIA	PENDLETON	HELLHOLE CAVE	130	2	GATE*	WYDNR
W. VIRGINIA	POCOHONTAS	CASS CAVE	131	3	SURVEY TO DETERMINE NEEDS	WYDNR
W. VIRGINIA	POCOHONTAS	MARTHA'S CAVE	132	3	FENCE*	WYDNR
W. VIRGINIA	TUCKER	BIG SPRINGS CAVE	133	3	GATE*	WYDNR
W. VIRGINIA	TUCKER	CAVE HOLLOW CAVE	134	3	SURVEY TO DETERMINE NEEDS	WYDNR

TABLE 23. CAVES WITH BOTH INDIANA BATS AND GRAY BATS PRESENT

CAVE NAME	STATE	INDIANA BATS INDEX	INDIANA BATS PRIORITY	GRAY BATS INDEX	GRAY BATS PRIORITY
FERN	AL	012	3	170	1
NITRE	AL	008	3	147	2
SAUTA	AL	020	3	134	1
CAVE MOUNTAIN (BOXLEY)	AR	053	2	003	2
CAVE SPRING	IL	129	3	111	1
BOONES	KY	068	3	274	3
COOL SPRINGS	KY	079	3	252	1
HUNDRED DOME (COACH)	KY	019	1	211	2
JESSE JAMES	KY	018	3	209	1
JONES	KY	067	3	261	2
WOLF HOLLOW (ARMINE BRANCH)	KY	073	3	278	3
BAT	MO	080	1	098	2
GREAT SCOTT	MO	084	1	109	2
INCA (GREAT SPIRIT)	MO	085	2	092	1
BELLAMY	TN	007	3	145	1
CANEY HOLLOW	TN	006	3	143	2

CAVE NAME	STATE	INDIANA BATS INDEX	INDIANA BATS PRIORITY	GRAY BATS INDEX	GRAY BATS PRIORITY
HUBBARDS	TN	011	2	169	1
MEREDITH	TN	009	3	150	3
NICKAJACK	TN	002	3	133	1
NORRIS DAM	TN	004	3	137	2
PEARSON	TN	003	3	130	1
TOBACCOPORT	TN	010	3	158	1

APPENDIX V

FACT SHEET ON BATS

WD 8/80

FACT SHEET ON BATS

Only in the last 50 years has man learned much about bats and their life history. Their nocturnal habits, affinity for eerie places like caves, and silent, darting flight have made them the subjects of a great deal of folklore and superstition through the years. Active at a time when most people prefer to be indoors and able to function when and where man's most important sense, sight, is denied him, it is no wonder that bats seem supernatural. Actually, bats are superbly adapted creatures that have evolved to exploit resources such as night-flying insects and dark caverns that are unavailable to diurnal and sight-dependent animals.

Bats are the only mammals capable of true flight. Their fore limbs have the same general configuration as other mammals', but the bones of the fingers are greatly elongated to support membraneous wings. The hind limbs are modified to allow them to alight and hang, head-down, by their toes.

Bats feed at night. Most locate their food and navigate by uttering a continuous series of ultrasonic cries that return as echoes when the cries hit solid objects. In the daytime they seek shelter in a wide variety of places: caves, mines, buildings, rock crevices, under tree bark and amid foliage. When resting or hibernating, bats can lower their body temperature to nearly match the environment and thus lower their metabolism and conserve energy.

Most bats congregate in nursery colonies in the

spring. The young are born in May or June. Most Missouri bats produce one young per year; several species produce two, and one produces up to four. The young are fed on milk until they are capable of foraging on their own. Summer colonies disperse in July and August, when the bats begin migration to hibernation sites. A variety of sites are used for hibernation—caves, mines, buildings and hollow trees. Before hibernating, bats accumulate fat reserves to last throughout the foodless winter.

Bats are an important part of the natural system. They help control nocturnal insects, some of which are agricultural pests or annoying to man. Many forms of cave life depend upon the nutrients brought in by bats and released from their guano (feces). And bats have contributed much to man's knowledge through scientific studies of their echolocation abilities, their biology and certain aspects of their physiology.

Bat populations have been declining at an alarming rate in recent years. Some of the more important causes of this decline are destruction of habitat, pesticides and disturbance. Loss of roosting and foraging habitat has resulted from reservoir construction, watershed development, forest conversion, urbanization and cave commercialization. Lethal levels of pesticides have been found in dead bats in several studies. Vandalism and disturbance have eliminated or greatly reduced bats in a number of caves. Three species of bats in Missouri are on the federal Endangered Species List and are protected by the Endangered Species Act of 1973. All bats are protected by the Wildlife Code of Missouri.

All of the bats that occur in Missouri are insectivorous. They can be divided into two groups—those that roost only in trees and those that spend at least a portion of the year in caves.

Among the tree bats, red bats and hoary bats roost amid the leaves while silver-haired bats roost under loose bark and evening bats prefer cavities. Red bats are probably the most commonly seen species in the state. Occurring statewide, they emerge at dusk to forage along woods edges, over streams, along roads and frequently around street lamps in towns. In winter, they may be seen on warm afternoons foraging in forest openings. The hoary bat, so named because of white tips on its rich, dark brown fur, is the largest Missouri bat, weighing over an ounce and having a 15-inch wingspan. Silver-haired bats are primarily a northern species while evening bats raise young in Missouri but migrate south for the winter.

The remaining species occupy caves all or part of the year. Gray bats, Indiana bats and Ozark big-eared bats are on the federal Endangered Species List. Gray bats and Indiana bats are threatened with extinction largely because of their habit of amassing in very large numbers (up to hundreds of thousands) in only a few caves. Thus they are extremely vulnerable to disturbance (each time they are awakened from hibernation they use up vital fat reserves), destruction from natural catastrophes such as flooding or wanton slaughter by people, and loss of important caves to commercialization, inundation by reservoirs, or other causes. There now may only be a few hundred Ozark big-eared bats in existence. They are known from only a very few caves in southwest Missouri, northwest Arkansas and eastern Oklahoma.

Gray bats live underground year-round and thus are found only in areas with suitable caves (mostly the southern half of the state). Their summer caves are easily recognized because of the huge mounds of guano that accumulate beneath the bat roosts. The roosts themselves usually are evident as brown stains on the cave ceiling. In June and July, when flightless young are present, disturbance can lead to mass mortality as frightened females drop their young in the panic to flee from the intruder. Such clusters of gray bats are usually noisy, so if you enter a cave with a strong guano smell and hear bats, please turn around and leave immediately. Gray bats are known to hibernate in four caves in Missouri; three of them have pit (vertical) entrances that make human access difficult thus limiting disturbance. One of these caves is commercialized, but the owners are taking steps to protect the bats.

Indiana bats hibernate in a few cold caves in the Ozarks, and more than half of the entire world population winters in Missouri. They form dense clusters of hundreds or thousands of bats on cave ceilings, usually within or just beyond the twilight zone near the cave's entrance. At this time they are highly susceptable to disturbance by cave explorers. In summer, Indiana bats disperse and form small colonies. They live under tree bark and are not likely to be seen. Relatively little is known about their summer ecology because they are so difficult to locate.

Little brown bats hibernate in small numbers in many caves in Missouri. In summer, they sometimes form colonies in barns and attics. Keen's bats hide in crevices in caves and are rarely seen even though numbers of them can be trapped at cave entrances at night.

Eastern pipistrelle bats are pale in color and can be found hibernating singly in most caves in the state. Big brown bats hibernate in cold sites just inside cave entrances. They sometimes form colonies in barns and attics where their guano may create an odor problem. When a single bat is found inside a house, it is most likely a big brown that entered looking for a place to roost for the day.

Eastern and Ozark big-eared bats occur in small numbers in Missouri. They are easily recognized as they have huge ears that are nearly as long as the rest of their body. Least bats have been found in a few caves in the state, and free-tail bats were identified from a couple of locations.

At present, bat management consists primarily of protecting habitat. Some of the caves known to be occupied by endangered species have been acquired or leased. Caves that are especially critical to the survival of these species are being gated with welded steel bars set in concrete or rock. However, during the times of the year when the endangered bats are not present, these caves can be visited without harm to the bats. Many caves used by endangered species are posted with signs that explain which species is present and at what time of year entrance into the cave would disturb the bats. They also give some information on why the bats need protection. Entering a bat cave could lead to prosecution under the Endangered Species Act and bring a fine of up to $20,000.

If you have bats in your house or other building and wish to evict them, the best method is to block all access holes when the bats are out so that they cannot return. The best time is in the fall or winter after the bats have left for hibernation. Alternatively, you could wait until the bats have left to forage at dusk and then block up the holes. However, don't do this between May 15 and July 15 when flightless young might be present as they would die and create an additional odor problem. Killing the bats without stopping up their access holes may alleviate the problem for the time being, but the conditions that attracted the bats in the first place would still exist and other bats probably would use the site in the future. It has recently been found that spraying pesticides on a bat colony is not a good method of control, for several reasons—(1) not all the bats are killed, (2) dying bats fall near the treatment site and are likely to come in contact with humans and their pets, and (3) as above, the conditions that initially attracted the bats are not changed.

Appendix I gives a simple key and descriptions of the cave bats most likely to be encountered in Missouri. It also has identification tips to help distinguish the two endangered *Myotis* species from other, similar bats. Also attached is a page of drawings that depict several key characters to separate bats of the genus *Myotis* in Missouri. If you encounter endangered species or find any bats with numbered plastic bands on their wings, please send the number, color of band, date, locality and any other pertinent information to Richard Clawson, Fish and Wildlife Research Center, 1110 College Avenue, Columbia, Missouri 65201.

Bats need friends. They have suffered from misinformation and superstition for many years. As we learn more about these furry little "angels of the night" we realize their importance in the natural scheme of things. An enlightened public, realizing that the system is composed of many parts and that each has a role to play in maintaining the balance, will ultimately prove to be the bat's best friend.

This publication is made possible by the 1/8 of 1% sales tax dedicated to conservation in Missouri.

APPENDIX I

A SIMPLIFIED KEY TO MISSOURI CAVE BATS

A. Usually roosting in large clusters (hundreds or thousands)

1. Fur on back gray; guano piles under cave roosts; bats usually seen only in spring, summer or fall ..... **Gray Bat**
2. Fur on back brownish gray; no guano piles under roosts; bats usually seen only in cold caves in late fall, winter and early spring **Indiana Bat**

B. Usually roosting singly or in very small clusters (fewer than 20)

1. Large size (total length 4" to 5"); fur on back dark brown ..... **Big Brown Bat**
2. Small size (total length less than 4")

a. Fur on back pale yellowish or pale reddish-brown ..... **Pipistrelle Bat**

b. Fur on back dark glossy brown

Ears long (about 3/4") ..... **Keen's Bat**

Ears shorter (usually 5/8" or less) ..... **Little Brown Bat**

A MORE DETAILED GUIDE TO IDENTIFICATION AND HABITS OF MISSOURI CAVE BATS

Gray Bat (*Myotis grisescens*) — ENDANGERED — Medium size; grayish color; usually in large active clusters; in absence of bats, evidenced by piles of bat guano and reddish-brown ceiling stains; in many caves in summer, few in winter.

Indiana Bat (*Myotis sodalis*) — ENDANGERED — Small size; grayish brown color, grayish ears and membranes; torpid clusters (often large) in cold caves in winter; no guano piles; mostly in a few caves in eastern Ozarks.

Little Brown Bat (*Myotis lucifugus*) — Small size; brown, glossy fur; blackish ears and membranes, as singles, pairs or small clusters; in most caves in winter, often near twilight.

Keen's Bat (*Myotis keenii*) — Small size; much like little brown bat, but much longer ears; roosts in crevices, so rarely seen, but a few do roost in the open on low ceilings.

Big Brown Bat (*Eptesicus fuscus*) — Much larger than others listed here; brown color; dark ears and membranes; noisy and belligerent; singles and small groups in most caves, near entrance.

Eastern Pipistrelle Bat (*Pipistrellus subflavus*) — Smallest of our cave bats; pale color and very small size make it easy to recognize; singles in winter, sometimes also in summer; most caves in state, well past twilight in constant temperature zone.

IDENTIFICATION OF INDIVIDUAL BATS IN THE HAND

Identification of individual bats in hand can be difficult. The key to Missouri cave bats may prove adequate, especially if roosting conditions were observed. Otherwise the following drawings will be very useful. They use the color of the fur, as revealed by blowing in the center of the back to part the fur; the position of attachment of the tail membrane; the length and density of distribution of hairs on the toes; and the degree of development of a fleshy keel on the calcar, which is a cartilaginous supporting structure on the rear edge of the tail membrane. These are the characters used by bat biologists to distinguish among these species.

How To Distinguish Certain Species of *Myotis* By The Hind Foot And Fur

Gray Bat
Myotis grisescens

Hairs medium long and sparse

Wing attached to ankle

No keel on calcar

Little Brown Bat
Myotis lucifugus

Hairs long and dense

Wing attached along side of foot

No or slight keel on calcar

Indiana Bat
Myotis sodalis

Hairs short and sparse

Wing attached along side of foot

Well developed keel on calcar

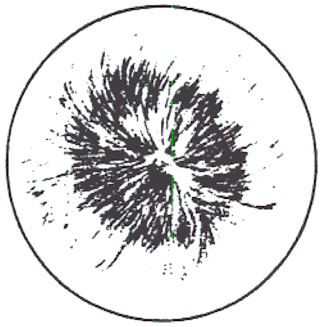
Keen's Bat
Myotis keenii

Hairs medium long and sparse

Wing attached along side of foot

Poorly developed keel on calcar

Tips not contrasting with bases



Tips contrasting with bases

APENDIX VI

Guidelines for Banding and Census Taking

RECOMMENDED BANDING GUIDELINES

Banded Indiana bats rarely are recaptured away from the original banding site. Far less than one percent are ever seen again at another location. Therefore, even when many thousands of bats are banded, the resulting data on movement patterns are minimal. Also, large numbers can be caught only at hibernating caves, where the disturbance is maximally stressful and often a cause of greatly increased mortality. For these reasons, banding of Indiana bats should be prohibited except in cases when limited numbers are used in studies of summer foraging behavior.

Bats netted in areas where they forage can be marked with reflector tape-covered bands for later recognition, using a spotlight or night vision scope and infrared light source. Colored bands applied to the left or right wing permit recognition of individuals or small groups and may greatly facilitate investigations of Indiana bats foraging behavior.

RECOMMENDATIONS FOR INDIANA BAT CENSUSES

Censuses should be conducted between January 15 and February 15 and should not be repeated more often than once every other year in any given cave. They should be conducted by a well trained individual, accompanied by at least one and rarely more than two assistants. After the initial census it is essential for consistency and speed of censusing that each subsequent team include at least one member who participated in the last census in that cave.

Each Indiana bat hibernating cave to be censused should be mapped by the census takers during the bats' summer absence. Assistance from local cavers may be especially valuable at that time. During the next winter census all Indiana bat roosting areas should be described and numbered with reference to the map, such that future censusers can easily locate and determine the boundaries of each numbered roosting area.

Those conducting Indiana bat censuses must be familiar enough with the bats' appearance and roosting behavior so that only an occasional bat need be handled to confirm identification. Where few bats are found they may be counted individually, but where there are many clustered bats only the area covered by each cluster should be determined. A steel tape may prove useful. Numbers of bats or the areas covered by clusters should be recorded for each numbered roost. After leaving the cave the areas covered by clusters can be summed into a total square foot figure and multiplied by 300 (the average number of Indiana bats/ft^2, see LaVal and LaVal, 1980) to obtain estimates of total bats present.

Since disturbance is a major cause of Indiana bat decline, it is imperative that disturbance during censusing be minimized. Limiting the censusing team to two or three individuals, prior exploration and mapping, use of numbered sites, and calculations based on square feet covered by clusters all serve to accomplish this end. Additionally, bright headlights should not be shined directly on the bats more than necessary, and all human sounds should be kept to a minimum. Non-essential data taking, such as determining the sex ratios, should be eliminated, and census takers should leave roosts as soon as possible.

When an accurate, quick reading, digital thermometer is available, a single air and a single wall temperature should be recorded at an easily locatable place in the most important roost area. The exact location and height above the cave floor must be recorded, and the thermometer must be calibrated if such readings are to be useful and comparable over time. Also, care must be taken to record the temperature soon after arrival and well away from the potential influence of human body heat.

Each census report should include date of census, time of cave entry and exit, names and affiliations of all those who participated, the number of Indiana bats present at each numbered roost, and a copy of the cave map (with description of numbered roosts). Notes on numbers of other species observed, air, wall, and outside temperatures (with time of day taken), and any notes on gates and evidence of human or other disturbance, should be included when possible. Hopefully, consistence of census takers, techniques and reporting will greatly increase the validity of future censuses.

Recipients-Draft Indiana Bat Recovery Plan

Region 2, FWS, Albuquerque, NM
Region 4, FWS, Atlanta, GA
Region 5, FWS, Newton Corner, MA
Region 6, FWS, Denver, CO
Area Offices, FWS, Annapolis, MD
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Austin, TX
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Illinois Department of Conservation
Missouri Department of Conservation
Indiana Department of Natural Resources
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Kansas Fish and Game Commission
State Biological Survey of Kansas
Georgia Department of Natural Resources
Virginia Commission of Game and Inland Fisheries
Tennessee Department of Conservation
Arkansas Game and Fish Commission
Alabama Department of Conservation and Natural Resources
Missouri Department of Natural Resources
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