

THE PROTECTION OF THREATENED CAVE BATS

Charles E. Mohr

Division of Parks and Recreation

Delaware Department of Natural Resources and Environmental Control

Dover, Delaware 19901

ABSTRACT

Since 1966 some protection has been given by the Federal Endangered Species Act to nongame species of wildlife whose survival is in jeopardy. Representatives of cave ecosystems are included, bats being by far the most prominent and abundant. Organized cavers and loosely affiliated bat research specialists have recently taken steps to reduce and eliminate disturbances to bats in caves. Increasingly strict interpretation and enforcement of regulations affecting Endangered and Threatened Fauna have placed new responsibility on federal and state land managing agencies. Cave management procedures in particular require more information on ecosystem diversity and dynamics than is presently available. Surveys of endangered and threatened cave-dwelling bats have already been launched by federal agencies represented in this symposium. Some of the findings are reported here and guidelines for further investigations are considered.

The deliberations of this First National Cave Management Symposium establish a solid plateau from which significant, far-reaching results may be confidently predicted. We are ready to move forward because:

- (a) National legislation has provided a legal basis for protection of cave assets, including Endangered Species of cave fauna.
- (b) Federal agencies have recognized and accepted responsibility for enforcement.
- (c) Scientific data is providing a sound basis for management procedures.
- (d) Some recovery plan proposals for endangered species are ready for implementation.

Concern for the preservation of the biological, archeological, and mineralogical contents of caves has long existed, but scattered legislative action failed to provide much protection.

As long ago as 1952, the National Speleological Society cautioned its members against disturbing hibernating bats and reported the apparent disappearance of the Indiana bat, *Myotis sodalis*, from New England and Pennsylvania (Mohr 1952, 1953).

In 1966 Congress passed the first Endangered Species Act. The U.S. Fish and Wildlife Service (1966) listed two bats: the Hawaiian hoary bat, *Lasiurus cinereus semotus*, and the Indiana bat, *Myotis sodalis*, whose entire population gathers in a few caves to spend the winter.

At the Philadelphia meeting of the American Association for the Advancement of Science in 1971, the National Speleological Society conducted a symposium on cave bats. In a paper on threatened species, Mohr (1972) summarized the findings of University of Arizona biologists (Cockrum 1969 and Reidinger 1972) which strongly implicated the widespread use of agricultural pesticides in the well-documented, drastic decline of nursery populations of cave-dwelling free-tailed bats, *Tadarida brasiliensis mexicana* between 1952 and 1969. The opinion was expressed that *Tadarida*, despite its abundance was a threatened species.

In the same paper the findings of two surveys were reported. An NSS survey revealed that most grottos and regional groups were aware of the apparently harmful effect of spelunking disturbances and were willing to curtail visits to bat caves. Seventy-three

university-based bat banders, responding to a questionnaire from the U.S. Fish and Wildlife Service, agreed that banding activity sometimes had serious effects on bats. They reported collectively that 22 of the 40 North American species appeared to be declining (Jones 1971).

At the Third Annual North American Bat Research Symposium in San Diego in November 1972, resolutions were adopted, (1) urging the U.S. Fish & Wildlife Service to halt banding projects, (2) recommending that the NSS suspend caving trips to key bat caves, and (3) advising universities to drastically reduce entry into bat caves for university-related research purposes.

MEASURES TAKEN TO PROTECT BATS

The U.S. Fish and Wildlife Service established a moratorium on the issuance of bat bands on June 13, 1973.

In the most critical eastern cave area, in and surrounding West Virginia's Germany Valley karst area, an NSS moratorium on visits to bat caves was declared. On the basis of preliminary data provided by John S. Hall and others, ten caves in Virginia and West Virginia were declared off limits during a specified hibernating period. When later surveys showed that several former colonies of *Myotis sodalis* were no longer present, these caves were removed from the restricted list. Designation of the Germany Valley karst area by the U.S. Department of the Interior as a Natural Landmark has strengthened cave and bat protection.

Observation and monitoring techniques have been refined so that important studies have been carried out with a minimum of disturbance to the bats. An improved Constantine or harp trap has been developed (Tuttle 1974a, 1974c) and is being used effectively outside caves or in the entrance. Ultrasonic detectors have been used to locate and count unseen flying bats (Fenton 1970b). Photography permits population estimates (Humphrey 1971) and chemiluminescent tagging makes possible the observation of the foraging behavior of individual bats (Buchler 1975).

Early efforts by the NSS to establish a professional relationship with federal land-managing agencies were often rebuffed. In 1957 the Cave Research Foundation

was established as a non-profit corporation in Kentucky, to (1) promote research and exploration in caves, (2) aid in cave conservation, and (3) improve the interpretation of caves to the public. Increasingly important agreements followed, culminating recently in a 20-year research agreement with the National Park Service.

In the vast, federally managed areas in the Southwest, cave exploration was sporadic, and in some areas was forbidden by agency officials prior to 1966. Founding of the Guadalupe Cave Survey in that year and its merger with CRF in 1972 has made possible numerous officially approved research projects (CRF Personnel Manual 1975) for Carlsbad Caverns and Guadalupe Mountains National Parks, Lincoln National Forest, on Bureau of Land Management holdings, as well as in Edgewood Caverns, privately owned. The survey data has been stored and manipulated in the computers of the University of New Mexico, Albuquerque.

These steps taken to protect cave bat populations were essentially voluntary actions by involved and concerned bat research workers and the organized cavers. The endangered species concept established by the 1966 legislation doubtless served as part of the motivation but it was hardly compelling.

The situation changed drastically, however, with the passage of the Endangered Species Act of 1973. All previous statutes were strengthened and federal agencies and the states became directly involved in enforcement of the act. Federal funding for endangered species programs to be administered by the states was indicated, and while to date no appropriations have been made, many state and regional programs are under way. All affected federal agencies seem to have begun to develop programs. A number of them are reported here.

According to the latest information (U.S. Fish and Wildlife Service 1974), the new law seeks "...to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions..." in which the United States has pledged its support for the conservation of wild flora and fauna worldwide.

Some important changes are as follows:

- I. The law establishes two categories of endangerment: (a) *Endangered species* are those species in danger of extinction throughout all or a significant portion of their range and (b) *Threatened species* are those species which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range; thus, under the new Act there will be two published lists – *Endangered and Threatened*;
- II. Separate listings for *Native* and *Foreign* species no longer will be used.
- III. The term *take* means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or to attempt to engage in any such conduct, and the Act outlaws *taking* of an endangered species.

Officially, the Fish and Wildlife Service of the Department of the Interior, through the Office of Endangered Species and International Activities designates species in danger of extinction and periodically publishes additions to the list, or regulations for their protection, in the *Federal Register*.

ADDITIONAL CATEGORIES

Several additional categories are considered important by some land management agencies. For example, the U.S Forest Service (1975a, 1975b) recently contracted for regional surveys of threatened species, specifying some different degrees of endangerment. The status of different species has also been evaluated in light of categories defined in the 1973 edition of the Redbook, a voluminous publication of the U.S. Department of the Interior.

- ▶ ***Peripheral*** – a species or subspecies which is at the edge of its natural range on a National Forest or Grassland and where special attention is necessary to assure survival there.
- ▶ ***Unique*** – a species which is typical of a particular limited area but not generally present elsewhere, or a species that is particularly interesting because of the niche it occupies, or because of its peculiar characteristics.
- ▶ ***Status Undetermined*** – a species or subspecies that has been suggested as possibly endangered or threatened with extinction, but

about which there is insufficient information to determine its true status. More information is needed.

For a good many years it has been apparent that more information is needed about cave bats. Until quite recently, it has been widely, but erroneously, assumed that if disturbance forced a bat population to move from its accustomed wintering site it could use almost any other cave. This supposed adaptability was thought to apply also to species such as *Myotis velifer* and *M. grisescens* that in summer occupy maternity or nursery caves.

Population studies begun in the 1950s (Twente 1955; Hall 1962; Henshaw 1972) have clearly demonstrated that each species has so narrow an optimum range of tolerable temperature and moisture parameters both for hibernation and nursery sites that there is little overlapping of microclimates chosen by other species. In addition, we now know that only very limited portions of some caves maintain the stable temperature and humidity which bats need.

If individual bats occupy microclimates not within their species preference range they expend energy (stored as fat) at a rate so wasteful that their energy resources may be exhausted before winter ends and insects are again flying. This is especially true of yearling bats which enter hibernation with less fat reserves than adults.

Constantine (1967a) at Carlsbad Caverns in the 1950s noted considerable temperature differences in caves of the region. During the breeding season free tail males roosted in the coldest caves; females settled in the warmest caves, where high temperatures favored rapid digestion of food and development of the young. Marginally cool caves could be occupied successfully for nursery sites only if populations were enormous enough to raise the air temperature noticeably and if the configuration of the cave assured the retention of the warmed air.

If cave microclimates can be affected by the body temperature and activity of millions of bats, or by the accumulation of fresh guano and the accompanying chemical reactions (Poulson 1972) it is not surprising that the presence of human visitors can cause serious alterations. When the public was permitted to explore a bat cave in a Florida State Park in the mid 1960s,

heat from human bodies and gas lanterns raised ambient temperature above the tolerable limit for the hibernating bats and evidently accounted for the departure of the bats (Tuttle, personal communication). When visitation was stopped, the cave temperature slowly returned to normal and the bats repopulated the cave in following winters. Through the years the NSS has encouraged cave gating. It is now recognized, however, that permanent changes in cave temperature have sometimes resulted from gates placed at the entrance or at restricted passageways within.

A new NSS publication, *Cave Gating* (Hunt and Stitt 1975) presents a diversity of gate designs, including gates designed to permit access of bats to hibernating chambers within the cave-involving just a few passages-as well as daily passage during summer if the cave is a nursery site.

There is good reason for concern that some of the gates in use at *Myotis grisescens* nursery caves impede the daily flights. Opportunities to monitor flights, such as by the bats occupying Thomas Aley's Ozark Underground Laboratory, should be taken to provide baseline information needed to protect bat populations elsewhere.

Even when the passage of bats is not impeded, changes in air circulation resulting from seemingly minor narrowing of passageways occasioned by the installation of gates can result in a disastrous rise in temperature in passages undisturbed by human visitors. At Fourth Chute Cave, Quebec, the largest colony of *Myotis leibii* in eastern United States was driven out by blocking the circulation of cold air (Mohr 1972) and at Coach Cave, Kentucky, construction of a gift shop over an air shaft has resulted in the hibernaculum of the gray bat, *Myotis grisescens*, becoming too warm (Humphrey 1975). It is clear that much greater attention must be paid to the affect of structural changes on microclimates within caves.

The role of bats in maintaining cave ecosystems is becoming more widely appreciated (Horst 1972, Poulson 1972). Major groups of cave fauna may be adversely affected by even a minor decrease of bats in a nursery cave, particularly for forms which depend directly on fresh bat guano. Less is known about aquatic food webs, but concern has recently surfaced with the realization that bats apparently have

abandoned Alabama's uniquely rich fauna preserve, Shelta Cave, beneath the NSS headquarters in Huntsville.

Bats were shut out of Ezells Cave, in San Marcos, Texas, when that cave was totally closed in the early 1960s to prevent collectors from exterminating its unique aquatic life. Recent inquiry reveals that the bats have not returned, but undetermined yet apparently adequate energy input elsewhere in that extensive cave ecosystem accounts for the continued existence of the rich invertebrate fauna and the remarkable blind salamander, *Typhlomolge (Eurycea) rathbuni*. The cave was added to the U.S. Department of the Interior's register of Natural Landmarks in November 1975.

Since bats are essential to the ecosystem in many caves of biological significance, the broad exercise of cave management expertise requires some information that only bat experts can provide.

More than 20 PhD dissertations on various phases of bat research have been published in the last ten years. Most of them involved years of field study and the use of sophisticated techniques for collecting and evaluating data. Much of the information already gathered and published applies to or is applicable to caves within the jurisdiction of land management agencies represented here. Sources of information and expertise can be found in the list of references.

As the presentations in this symposium prove, many NSS members possess and utilize professional skills useful in cave management. The aid of many other experienced, conscientious cave explorers in each region can be enlisted for the extensive explorations needed to accurately assess the presence and distribution of caves and other karst features, and the occurrence of populations of cave animals.

When scouting reports indicate the presence of bats, the services of a bat research specialist should be engaged. As already noted, determination of the season or seasons when caves are occupied by bats is important. Conservation conscious as most organized cavers/spelunkers are, they are increasingly apprehensive that they are being excluded from many of their favorite caves, particularly from many of the deep caves which have become immensely popular with vertical cavers. Certainly they want to know at

what season a cave is free of bats and therefore should be accessible to cavers. The regulatory agency can make reasonable decisions on entry to bat caves only on the basis of a knowledgeable recommendation by a bat specialist. Some species of bats can be identified only by examination of the teeth or the skulls (Barbour and Davis 1969).

GUIDELINES ARE BEING DEVELOPED

Fortunately, some regional or statewide surveys of cave bat populations have already been made or are underway (Findley 1973, Greenhall 1973, Hall 1975, Harvey 1975, Humphrey 1975, Humphrey and Tuttle 1975, Mumford 1975, Tuttle 1975a, and Whitaker 1975). In addition, the *Recovery Plan for the Indiana Bat* (U.S. Fish and Wildlife Service 1975) identifies caves with critical bat populations. From a management standpoint the following broad generalizations may be helpful. Bats may use caves in one or more of these three ways:

- ▶ **For hibernation** — with wide variations, from September 15 to May 1 – about 20 of 40 North American species over-winter in caves.
- ▶ **For nursery sites** — almost exclusively pregnant females, from about May 1; and after June 15, by bat mothers and young until mid-August. The species are primarily *Tadarida* and *Myotis velifer* in the West, and *Plecotus townsendii* and *Myotis grisescens* in the Southeast and Central States. In many cases nursery caves are located far from the hibernacula, sometimes involving exhausting flights of hundreds of miles, making the security of the distant cave extremely critical (Tuttle 1974b).
- ▶ **An additional use** of caves by bats has been widely recognized only since the 1960s. In spring, and again in late summer, far more bats can be seen *swarming* around certain cave entrances-and often entering briefly-than occupy them during hibernation. The purpose of this swarming or *staging* is unknown but the caves may be as important to bats as certain wildlife refuges are for migrating waterfowl.. It may aid juvenile bats to make suitable selection from among a variety of caves they *sample* and it probably is needed to provide the adults opportunities to mate before going into hibernation. Even non-cave species — tree bats — join the swarming assemblages.

Travel routes and distances flown are unknown for most species but 15 years of banding gray bats, *Myotis grisescens*, has provided Merlin D. Tuttle (1974b) with an impressive volume of data on travels, longevity (many reach 15 years of age), growth, feeding strategy, microclimate needs, and threats to survival. Much that he has learned about this species is useful in designing protective measures for other cave species.

Severe penalties can be imposed for interference with officially listed Endangered Species – such as *Myotis sodalis* and *M. grisescens*. Even experts cannot carry on studies without an explicitly worded permit from the Office of Endangered Species. This applies also to federal agencies contracting for faunal studies within their jurisdiction.

NEW INTERPRETATIONS OF THE LAW

At the Fish and Wildlife Service, Division of Law Enforcement, I learned that successful prosecution of violations of the Endangered Species Act in the Federal Courts probably will have to be based on expert testimony by a qualified biologist, establishing positive identification of the specimen as an Endangered Species, and testimony as to the nature of the offense: *taking, harming, or harassing*. The September 26, 1975, issue (Part 11) of the *Federal Register* contains two extremely important regulations: The first states that the “similarity of appearance” of several different species (in this situation, alligators) making it difficult for law-enforcement personnel to determine the species with certainty, would be grounds for granting endangered species protection to rare and common alike. If this new regulation is applied to bats (and it can be under the Act), it is possible that most bat species might be protected by the Act – certainly a good many species look very much alike.

Second, according to the notice cited above: *Harass* in the definition of *take* in the Act means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering.

Harm in the definition of *take* in the Act means an act or omission which actually injures or kills wildlife, including acts which annoy it to such an extent as to significantly disrupt essential behavioral patterns,

which include, but are not limited to, breeding, feeding or sheltering; significant environmental modification or degradation which has such effects is included within the meaning of *harm*.

DOES CAVING DISTURB BATS?

Some cavers, chaffing under the NSS moratorium on visits to specified bat caves, have argued that they were sufficiently aware of the presence of bats to be able to quickly but quietly pass by them and do their exploring without the bats' knowledge. In other cases, known bat roosts are located in remote sections of caves and could be barred from access by cavers while permitting travel elsewhere.

According to a recent unpublished study of the impact of sound on hibernating bats, even the quiet tread of cavers over rocky cave surfaces has a highly disturbing effect on hibernating bats. A more generally recognized effect of even minimal disturbance- sound, lights, and especially heat from lanterns-is the onset of arousal which inevitably continues to complete arousal and flight.

In northern Ontario, Fenton (1970a) studied hibernating little brown bats, *Myotis lucifugus*, Renfrew Mine. He weighed bats at the beginning and end of the 1965-66 and 1966-67 seasons and determined that both males and females lost weight at the rate of 0.013 grams per day, dropping 2.5 grams during a 193-day period-a loss of 25 percent of the October body weight. Similar losses were recorded from more northern hibernacula and from ones farther to the south.

Young bats have less time to accumulate fat, and they go into hibernation weighing about half a gram less than adults. Such weight differences may account for lower survival rates of juvenile bats, according to Fenton and others. Fenton tabulated loss of weight by banded bats which had been disturbed at least three times and found that they weighed significantly less than those disturbed only once.

By the end of the winter energy reserves may be insufficient to meet the demands of the first feeding forays, when emerging insects may be scattered and scarce, or the bats may be too weak to make long flights to their summer territories.

Since weight loss of this degree occurs in a notably successful and adaptable species such as *M. lucifugus* evidently somewhat tolerant of disturbance-it may well be a serious factor with *M. sodalis* (Henshaw 1972), possibly instrumental in its disappearance in the Northeast following the first wave of cavers and bat banders, prior to 1950. According to Hall (1975b) *M. sodalis* is so intolerant of disturbance that the banding of an entire hibernating colony has been followed by total disappearance of the bats.

The recently completed *Recovery Plan for the Indiana bat* by a team of wildlife and bat experts (U.S. Fish and Wildlife Service 1975) predicts recovery for the species but does not indicate how caves in the Northeast and Pennsylvania might be repopulated. Attempts to transfer bat populations from houses and tunnels in Pennsylvania (Mohr 1942) were totally unsuccessful and recent evidence of the extreme *loyalty* - philopatry - of bats to their accustomed caves (Tuttle 1974b) leaves little hope for reestablishing deserted hibernating sites.

The need for determining the feasibility or possibility of rescuing populations doomed by cave destruction or inundation is urgent. Long scheduled construction already underway is about to drive bat colonies out of Blanchard Springs Caverns, the Forest Service's preeminent cave attraction in Arkansas.

In Missouri, a single dam will flood scores of caves, including important bat caves. In order to assemble the data needed to prepare an acceptable Environmental Impact Statement, the Army Corps of Engineers is financing an investigation by the University of Missouri, with the cooperation of the U.S. Fish and Wildlife Service and the Missouri Conservation Commission. The 18-month study headed by Richard K. LaVal is entitled *An ecological survey of the myotine bat populations to be affected by the construction of Meramec Park Lake in Crawford County, Missouri*. Six species of *Myotis* are being studied.

Underway since July 1975, the survey team plans to visit more than 100 caves, banding a sampling of not more than 10 percent of the bats that can be netted outside hibernating caves. Only observations involving a minimum of disturbance will be carried on. At present, there are no plans to attempt to move any colonies. Five major *Myotis sodalis* hibernating

colonies and two major *M. grisescens* nursery caves are in the study area.

THE NEED FOR INTERPRETATION

Most of the studies already authorized by the agencies represented in this symposium recognize the problems of public relations and the need for improving the bat's image. Public-awareness of the importance of bats in the ecosystem can be improved through interpretive literature, visitor center displays, and trailside (or cave tour) talks. An agency's role in the protection of endangered or threatened species of bats can be the basis for an admission of pride in its program. Incidentally, since contact with the public is not limited to interpretive personnel it is important that the entire staff be well informed about bats.

This awareness should encompass another aspect of visitor relations - the agency's responsibility to advise, calmly, that along with *not* feeding the bears and deer, that no one should ever pick up or touch a bat, since along with most mammals, bats are capable of transmitting rabies. In the unlikely event of a bat bite, it is imperative that the bat be captured with caution, and delivered to a public health laboratory for a swift, routine examination for rabies (the fluorescent antibody test). An unpleasant 21-shot series of duck embryo antirabies vaccine injections is unavoidable unless the biting animal is tested for rabies, and proved negative. It should be noted that bats are now second to skunks as carriers of rabies. Foxes are third.

Incidentally, airborne rabies virus (Constantine 1967b) is considered a hazard only in huge maternity colonies such as the one in Frio Cave in Texas, where entrance during summer is barred because of two human rabies deaths there.

With the exception of the Ozark Underground Laboratory in Missouri, the presence of rare fauna in a privately owned cave has not generated much enthusiasm for guaranteeing its protection. The first non-governmental organization to exhibit concern for biologically important caves has been The Nature Conservancy. It owns Ezells Cave in Texas and several bat caves in Illinois. It advanced funds to the NSS for the purchase of Shelta Cave. Recently it completed a report for the U.S. Department of the Interior (Humke 1975) on the preservation of significant ecosystems.

Among the recommendations in the Nature Conservancy report is a proposal to Congress to establish an interagency commission - a National Ecological Reserve Board - and a Nationwide Ecological Reserve System consisting of protected natural areas representing the full spectrum of biological communities, ecosystems, features, habitat, and form. The proposed legislation now being drafted would establish a National Registry of Ecological Reserves to record and describe areas and sites of national, state, and local significance. Caves, of course, are recognized as significant, and as possessing peculiar preservation problems.

In conclusion, it can be said that the deep concern for bats arising from the studies of federal, university, and speleology associated individuals over a 40-year period has gained for bats strong protection under the Endangered Species Act of 1973. It seems probable that all species of bats will benefit though only two from the continental United States are listed. It appears that increasingly significant studies, carried on within the constraints of the Act and supported in some degree by that legislation, will further enlarge our understanding and appreciation of these unique airborne animals. There can be little doubt that the participating agencies in this symposium are dedicated to implementing many of the proposals to the limit of their resources.

REFERENCES

- Barbour, Roger W., and Davis, Wayne H. 1969. Bats of America. University Press of Kentucky, Lexington. 286 pp.
- Buchler, Edward R. 1975. A chemiluminescent tag for tracking bats and other small nocturnal mammals. *Journal of Mammalogy* 57(1):173-176.
- Cockrum, E. Lendell. 1969. Migration of the guano bat *Tadarida brasiliensis*. Pp. 303-306, in *Contributions in Mammalogy* (J.K. Jones, Jr., ed.). University of Kansas Museum of Natural History, Miscellaneous Publication 51.
- Constantine, Denny G. 1967a. Activity patterns of the Mexican free-tailed bat. *University of New Mexico Publications in Biology* 7, 79 pp.
- Constantine, Denny G. 1967b. Rabies transmission by air in bat caves. *Public Health Service Publication* 1617, HEW, Washington, 79 pp.

- Endangered Species Act. 1973. Public Law 93-205, 93rd Congress, S. 1983, 21 pp.
- Federal Register. 1975. Endangered and threatened wildlife and plants, Part II. September 26, 44412-44429.
- Fenton, M. Brock. 1970a. Population studies of *Myotis lucifugus* (Chiroptera: Vespertilionidae) in Ontario. Life Science Contributions, Royal Ontario Museum 77. 34 pp.
- Fenton, M. Brock. 1970b. A technique for monitoring bat activity with results obtained from different environments in southern Ontario. Canadian Journal of Zoology 48(4):847-851.
- Findley, J. S. 1973. The status of Southwestern bat populations. Pp. 12-17, in Symposium on Rare and Endangered Wildlife of the Southwestern United States. New Mexico Department of Game and Fish, Santa Fe. 167 pp.
- Greenhall, Arthur M. 1973. Indiana bat: a cave-dweller in trouble. National Parks and Conservation Magazine 47(8):14-17.
- Hall, John S. 1962. A life history and taxonomic study of the Indiana bat, *Myotis sodalis*. Reading Public Museum and Art Gallery Science Publication 12:1-68.
- Hall, John S. 1975a. Status of the Indiana bat, (*Myotis sodalis*), in the Monongahela National Forest in West Virginia. Pp. 17-24, in Distributional studies of the Indiana bat (*Myotis sodalis*) on three National Forests of the Eastern Region (E. Ownse, ed.). United States Department of Agriculture Forest Service, 64 pp.
- Hall, John S. 1975b. The status of two endangered bat species in West Virginia. Unpublished presentation at the Sixth Annual North American Bat Research Symposium, Las Vegas, Nevada.
- Harvey, Michael J. 1975. Endangered Chiroptera of the southeastern United States. Unpublished presentation at the 29th Annual Conference of the Southeastern Association of Game and Fish Commissioners, St. Louis.
- Henshaw, Robert E. 1972. Niche specificity and adaptability in cave bats. National Speleological Society Bulletin 34(2):61-70.
- Horst, Roy. 1972. Bats as primary producers in an ecosystem. National Speleological Society Bulletin 34(2):49-54.
- Humke, John W. (ed.) 1975. The preservation of natural diversity; a survey and recommendations. Report by The Nature Conservancy for the U. S. Fish and Wildlife Service. 212 pp; appendices.
- Humphrey, Stephen R. 1971. Photographic estimation of population size of the Mexican free-tailed bat, *Tadarida brasiliensis*. American Midland Naturalist 86:220-223.
- Humphrey, Stephen R. 1975. Status, winter habitat, and management of the endangered Indiana bat, *Myotis sodalis*. Unpublished presentation at the Sixth Annual North American Bat Research Symposium, Las Vegas, Nevada.
- Humphrey, Stephen R., and Tuttle, Merlin D. 1975. *Myotis grisescens*. In Rare and endangered plants of Florida (J.N. Lane, ed.). Florida Audubon Society (in press).
- Hunt, Geoffrey and Stitt, R. R. 1975. Cave Gating. National Speleological Society, Huntsville, Alabama. 43 pp.
- Jones, Clyde. 1971. The status of populations of bats in the United States. Unpublished presentation at the Second Annual Symposium on Bat Research, Albuquerque, New Mexico.
- Mohr, Charles E. 1942. Bat tagging in Pennsylvania Turnpike tunnels. Journal of Mammalogy 23:375-379.
- Mohr, Charles E. 1952. A survey of bat banding in North America, 1932-1951. National Speleological Society Bulletin 14:3-13.
- Mohr, Charles E. 1953. Possible causes of an apparent decline in wintering populations of cave bats. National Speleological Society News 11:4-5.
- Mohr, Charles E. 1972. The status of threatened species of cave-dwelling bats. National Speleological Society Bulletin 34(2):33-47.
- Mumford, Russell E. 1975. The status of the Indiana bat (*Myotis sodalis*) and the Eastern woodrat (*Neotoma floridana*) on the Wayne-Hoosier National Forest in Indiana. Pp. 1-15, in Distributional studies of the Indiana bat (*Myotis sodalis*) on three National Forests of the Eastern Region (E. Ownse, ed.). United States Department of Agriculture Forest Service, 64 pp.
- Poulson, Thomas L. 1972. Bat guano ecosystems. National Speleological Society Bulletin 34(2):55-59.
- Reidinger, R. F., Jr. 1972. Factors influencing Arizona bat population levels. Ph.D. Dissertation, Arizona State University, Tucson. 172 pp.
- Tuttle, Merlin D. 1974a. An improved trap for bats.

- Journal of Mammalogy 55:475–477.
- Tuttle, Merlin D. 1974b. Population ecology of the gray bat (*Myotis grisescens*). Ph.D. dissertation, University of Kansas.
- Tuttle, Merlin D. 1974c. Bat trapping: results and suggestions. *Bat Research News*, 15:4–7.
- Tuttle, Merlin D. 1975. *Myotis grisescens*. In Proceedings of the workshop on endangered species (B. Hillestad, *ed.*). Southeast Section of The Wildlife Society, Tall Timbers Research Station (in press).
- Twente, John W. 1955. Aspects of a population study of cavern-dwelling bats. *Journal of Mammalogy* 36:379–390.
- U. S. Fish and Wildlife Service. 1966. Rare and endangered fish and wildlife of the United States. Bureau of Sport Fisheries and Wildlife Research Publication 34.
- U. S. Fish and Wildlife Service. 1970. United States list of endangered fauna, May 1974. 22 pp.
- U. S. Fish and Wildlife Service. 1975. Recovery plan for the Indiana bat. September 1975. 34 pp.; appendices.
- U. S. Forest Service. 1975. Endangered, threatened, and unique mammals of the Southern National Forests: distribution, populations, habitat requirements. 132 pp.
- Whitaker, John O., Jr. 1975. Bats of the caves and mines of the Shawnee National Forest of southern Illinois, with particular emphasis on *Myotis sodalis*, the Indiana bat. Pp. 25–64, in *Distributional studies of the Indiana bat (Myotis sodalis) on three National Forests of the Eastern Region* (E. Ownse, *ed.*). United States Department of Agriculture Forest Service, 64 pp.