Internal Cave Gating as a Means of Protecting Cave-Dwelling Bat Populations in Eastern Oklahoma

Keith W. Martin
Department of Math and Science, Rogers State University, Claremore, OK 74017

William L. Puckette
Poteau Public Schools, Poteau, OK 74953

Steve L. Hensley
Ecological Services Office, U.S. Fish and Wildlife Service, Tulsa, OK 74127

David M. Leslie, Jr.
Oklahoma Cooperative Fish and Wildlife Research Unit, U.S.G.S. Biological Resources Division, Oklahoma State University, Stillwater, OK 74078

INTRODUCTION

Of the 45 species of bats found in North America, about 18 rely substantially on caves throughout the year. Thirteen of these species are obligate cave-dwelling bats using caves year-round. They use caves as winter hibernacula, stop-over roost sites during migration, summer roost sites, or maternity sites where adult females give birth to their young. A general correlation has been made between the degree to which a species is reliant on caves during its life cycle and consideration as an endangered or threatened species by the U.S. Fish and Wildlife Service. All North American bats listed as endangered or threatened by the U.S. Fish and Wildlife Service are cave-dwelling species or subspecies (*1-3*). Two cave-dwelling species, the gray bat (*Myotis grisescens*) and Indiana Bat (*Myotis sodalis*), and one subspecies, the Ozark big-eared bat (*Corynorhinus townsendii ingens*) are of particular interest in Oklahoma. Each is federally listed as endangered by the U.S. Fish and Wildlife Service. The gray bat and the Ozark big-eared bat are both obligate, year-round cave-dwelling bats. The Indiana bat hibernates in caves in winter and disperses during non-hibernating months to form roosts under bark and in tree cavities in hardwood forests (*4-6*).

Persistent or casual human disturbance at maternity caves and hibernacula continues to be implicated as a cause for the decline in population of most cave-dwelling bats (*7-10*). Disturbance at these caves may induce elevated mortality rates, poor recruitment, and actual colony abandonment. At hibernacula, premature arousal from bouts of torpor and hibernation ultimately consume stored energy reserves. Disturbance at maternity colonies adversely affects thermoregulatory requirements of non-volant developing young (*2,7,11-13*). Low reproductive rates, long generation times, and concentrations of populations in localized roosts are life-history characteristics indicative of North American cave-dwelling bats. Such life histories and adverse effects of human disturbance present difficult challenges as wildlife managers and bat conservationists develop management objectives for protecting and recovering declining bat populations.

Contemporary efforts for bat conservation are concentrated on protecting caves and the various types of bat colonies that they house (*7*). Most often these protection measures are intended to eliminate disturbance resulting from human entry into caves. Protection is typically accomplished by construction of gates at cave entrances, fencing of cave entrances, placing warning signs at entrances, and maintaining a close and positive rapport with private landowners. Protection for cave-dwelling bat populations by placing gates in the entrances of caves can be an effective, immediate, and long-term method to deter human access to critical bat roosts.

Proc. Okla. Acad. Sci. 80:133-137(2000)

CAVE GATING IN OKLAHOMA

Construction of restrictive structures such as gates at cave entrances has evolved considerably over the past 25 years. Original designs were constructed in cage-like fashion exterior to the cave entrance. This placement resulted in the abandonment of some caves by bats (*10,14,15*). In Ottawa County, Oklahoma, such a gate was placed over a cave entrance and resulted in eventual abandonment of the cave by a maternity colony of gray bats.

In 1980 and 1982, two additional caves inhabited by maternity colonies of gray bats in Adair and Delaware Counties, Oklahoma were gated. The exterior features of these cave entrances, however, caused the placement of gates within dark zones of the cave passages, 9 m and 15 m respectively, inside the entrance. Each cave continues to be used by maternity populations of gray bats, estimated at 9,000 and 12,500 bats, respectively, in 1999. These were the first instances of cave-dwelling populations of bats protected by an "interior" gate system in the United States. A third gray bat maternity cave in Cherokee County, Oklahoma, was gated by using the same type of placement with similar results in 1991 (*16*). The external cage protecting the original gray bat maternity colony in 1971, which was subsequently abandoned, was reconstructed in 1997. An internal gate was placed 15 m inside the cave passage, and the external cage was reconstructed to be left open during periods of bat use. A maternity colony of gray bats used the cave during maternity seasons in 1998 and 1999. Population estimates placed the colony at 25,000 bats in 1998 and 27,000 in 1999. Although general designs of gate construction continue to evolve (*17*), placement of gates within dark zones of a cave passages, such as these in eastern Oklahoma, is now an accepted protocol for cave gating throughout the United States.

Twenty-two entrances to caves in eastern Oklahoma are presently protected with the use of internal gate designs. Five of these caves are inhabited by colonies of gray bats. Twelve caves inhabited by Ozark big-eared bats, and a single hibernaculum of Indiana bats are similarly protected. Additionally, four caves that contain populations of Ozark blind cavefish (*Amblyopsis rosae*) and Ozark blind crayfish (*Cambarus* sp.) are protected from human entry and vandalism by internal gates.

Population estimates for endangered species of bats in eastern Oklahoma caves were initiated in 1981. Estimates for gray bat populations were conducted in 1983, 1989, and 1999. Estimates for Ozark big-eared bat populations were conducted on an annual basis beginning in 1986. Populations of Ozark big-eared bats protected by internal gates in Oklahoma caves are sporadic and tend to fluctuate in size. Those caves that are protected with gates house clusters of 2-40 bats. The lone Indiana bat cave that is protected contains <15 bats at each monitoring period (*18*). Colonies that are protected with internal gates are located in Adair, Delaware, Cherokee, Leflore, and Ottawa counties of eastern Oklahoma.

The gray bat is the only cave-dwelling species in eastern Oklahoma that roosts in large colonies, producing substantial guano accumulations on cave floors conducive to measurement for population analysis. Historically, roost sites in caves are located in the same location from year to year. There are six maternity colonies of gray bats in eastern Oklahoma (*16,19*); four of these colonies are protected from human disturbance by internal gates. A fifth colony protected with an internal gate system is a non-maternity colony consisting of males and non-reproductive females. Population estimates conducted at each of these caves prior to installing gates in 1981, and post-installation estimates in 1999, suggest that colonies of gray bats continue to use each cave (Fig. 1). Standard methods of guano measurement intended to estimate colonial gray bat populations were established by Tuttle (*12*) and Harvey, et al. (*20*). Maternity colonies were distinguished by trapping lactating females after parturation or by noting carcasses of dead young near roost sites inside cave passages.

Each of the 22 caves that have been gated in Oklahoma have unique physical characteristics regarding passage size, location of the nearest bat roost to the entrance, and number of entrances used by bats. Internal gates are placed in such a manner as to protect the nearest historical roost area to the cave entrance. Gate distances from cave entrances range from 3-17 m. Passage area where gates are located range from 1.38 m^2 – 9.5 m^2. In contrast to some gates protecting gray bat colonies in the southeastern United States that do not completely fill the cave passage, all internal gates in Oklahoma caves completely fill cave passages. Furthermore, one of the gray bat caves that is gated in Oklahoma has two entrances that are used during entrance and exit by bats. In this particular cave, both of the entrances are protected with complete gates. Relatively small colony sizes (<30,000), relatively small gated passages, and internal positioning of grill structures probably contribute to the apparent acceptance of full passage gates by resident bat populations in eastern Oklahoma.

INHERENT EFFECTS OF CAVE GATING

Since the mid-1980s, internal gate construction has been of horizontal angle iron bars. This material and design seems to maximize protection from human entry, have nominal effects on airflow, and present limited obstruction to bat flight (*17*). With the exception of a single cave that was gated before angle iron gates became popular, all gates in Oklahoma caves are of the angle iron design.

Although placement of gates within "dark zones" of cave passages may be the most effective method to deter human access to critical bat roosts, their effects on resident bats and microclimate of cave interiors

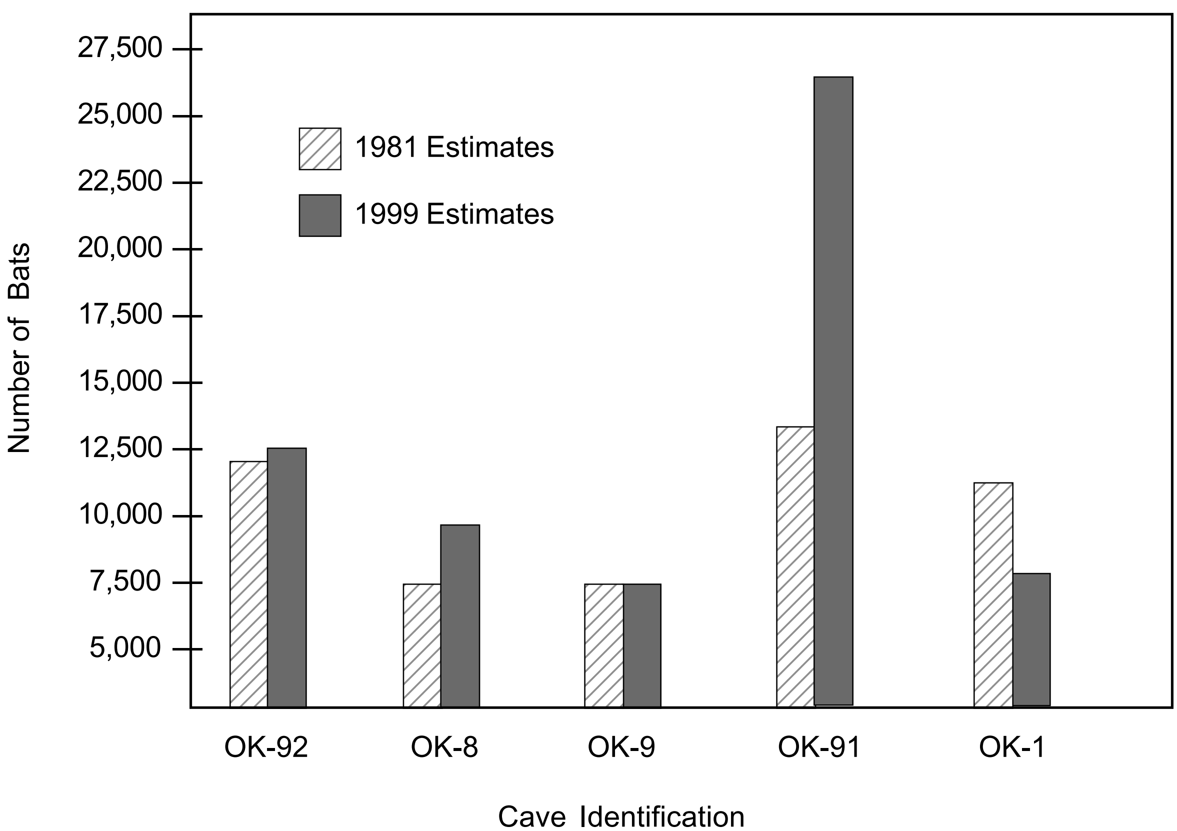

Figure 1. Population estimates of gray bats at five caves before and after they were protected by internal gate/grill systems in Oklahoma. Pre-gating estimates (1981 estimates) are from Grigsby and Puckett (*19*). Cave OK-1 is inhabited by a bachelor colony. The remaining caves are inhabited by maternity colonies.

have not been measured completely (*14,21-23*). Various designs of gate construction and resulting effects on bat flight have been tested (*17*). However, effects that gates have on the microclimate of cave interiors has not. It is suspected that cave gates alter airflow in cave passages (*21,22,24*). Altered airflow, in turn, may affect ambient temperature, humidity, and substrate temperature. Roost substrate temperatures influence body temperature and ultimately metabolic rates of hibernating bats (*21,25*). Fetal and neonatal growth rates are affected directly by sub-optimal temperatures of pregnant females and juveniles. Poor thermoregulation in these bats may result in slow maturation, thus reducing survival and natality (*26,27*). Also it is suspected that cave gates interrupt or impede the exit of large colonies of bats from roost caves. An increase in swarming activity before exiting or entering a cave that is gated may increase the risk of predation (*10,14,17*).

An unenviable dilemma still faces cave biologists and managers in protecting declining populations of cave-dwelling species of bats. The benefits of gating caves, and ultimately altering internal ambient cave conditions and bat flight, are weighed against persistent human entry and disturbance to critical bat roosts. Five of the six known maternity colonies of gray bats in Oklahoma are protected by internal gate systems. The remaining maternity colony has experienced human entry and disturbance during each of the past two maternity seasons. Although 12 Ozark big-eared bat caves are protected, they are typically protecting small groups of bats, and none are maternity caves. One maternity colony is relatively obscure, and human disturbance appears to be non-existent. The largest hibernating population contains between 225-325 individuals annually. This colony, and the remaining maternity colonies are more conspicuous and are susceptible to human disturbance. Cave biologists have been reluctant to construct internal gates in these remaining caves inhabited by gray bat and Ozark big-eared bat populations. In each instance, roost areas are either located in close proximity to the cave entrance or are located in large caverns requiring expensive and elaborate gate designs. These challenges and the inherent effects of internal gates on bat populations may be precluded if population monitoring at these caves indicate persistent declines or abandonment because of human disturbance.

ACKNOWLEDGMENTS

Many individuals, private landowners, and organizations have provided assistance in gathering data, constructing gates and have contributed time, resources, and efforts to protecting the endemic bat species of Oklahoma. In particular we would like to thank the Tulsa Regional Grotto of the National Speleological Society and the Tulsa Nature Conservancy. Financial support was provided by Federal Aid, Cooperative Endangered Species Conservation under Project E-9 and E-22 of the Oklahoma Department of Wildlife Conservation, Rogers State University, and the Oklahoma Cooperative Fish and Wildlife Research Unit (Oklahoma State University, U.S.G.S. Biological Resources Division, Oklahoma Department of Wildlife Conservation, and Wildlife Management Institute, cooperating).

REFERENCES

1. Harvey MJ, Altenbach JS, Best TL. Bats of the United States. Little Rock (AR): Arkansas Game and Fish Commission 1999. 64 p.
2. McCracken GF. Cave conservation: special problems of bats. National Speleological Soc Bull 1989;51:49-51.
3. Pierson, ED. Tall trees, deep holes, and scarred landscapes: conservation biology of North American bats. In: Kunz TH, Racey P, editors. Bat biology and conservation. Washington, D.C.: Smithsonian Institution Press: 1999. p 309-325.
4. Humphrey SR, Richter AR, Cope JB. Summer habitat and ecology of the endangered Indiana Bat, *Myotis sodalis*. J Mammal 1977;58:334-346.
5. Kurta A, King D, Teramino JA, Stribley JM, Williams KJ. Summer roosts of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. Am Mid Nat 1993;129:132-138.
6. Laval RK, Laval ML. Ecological stud-

ies and management of Missouri bats, with emphasis on cave dwelling species. Terrestrial Series, Missouri Department of Conservation No. 8. 1980. 53 p.
7. American Society of Mammalogists. Guidelines for the protection of bat roosts. J Mammal 1992;73:707-710.
8. Barbour RW, Davis WH. Bats of America. Lexington (KY): University of Kentucky Press; 1969. 286 p.
9. Humphrey SR. Kunz TH. Ecology of a Pleistocene Relic, the western big-eared bat (*Plecotus townsendii*), in the southern Great Plains. J Mammal 1976;57:470-494.
10. Tuttle MD. Status, causes of decline, and management of endangered gray bats. J Wildl Mgmt 1979;43:1-17.
11. Thomas DW, Dorais M, Bergeron JM. Winter energy budgets and costs of arousals for hibernating little brown bats, *Myotis lucifigus*. J Mammal 1990;71:475-479.
12. Tuttle MD. Population ecology of the gray bat (*Myotis grisescens*): factors influencing growth and survival of newly volant young. Ecology 1976;57:587-595.
13. U.S. Fish and Wildlife Service. Gray bat recovery plan. Washington, D.C.: U.S. Fish and Wildlife Service; 1982. 94 p.
14. Tuttle MD. Gating as a means of protecting cave dwelling bats. In: proceedings national cave management symposium. Speleobooks, Albuquerque, N.M. 1977. p. 77-82.
15. Clark BK, Clark BS, Leslie DM Jr, Gregory MS. Characteristics of caves used by the endangered Ozark Big-eared Bat. Wildl. Soc. Bull. 1996;24:8-14.
16. Grigsby EM, Puckette WL, Martin KW. Comparative numbers of gray bats (*Myotis grisescens*) at six maternity caves in northeastern Oklahoma. Proc Okla Acad Sci 1993;73:35-38.
17. White DH, Seginak JT. Cave gate designs for use in protecting endangered bats. Wildl Soc Bull 1987;15:445-449.
18. Saugey DS, Heidt GA, Heath DR, McDaniel VR. Hibernating Indian Bats (*Myotis sodalis*) from the Ouachita Mountains of southeastern Oklahoma. Southwest Nat 1990;35:341-342.
19. Grigsby EM, Puckette WL. A study of three endangered species of bats occurring in Oklahoma. Albuquerque (NM): U.S. Fish and Wildl Serv; 1982. 53 p.
20. Harvey MJ, Cassidy JJ, O'Hagan GG. Endangered bats of Arkansas: distribution, status, ecology and management. Report to Arkansas Game and Fish, U.S. Forest Service and National Park Service-Buffalo National River. Little Rock (AR): Arkansas Game and Fish Commission. 1981. 137 p.
21. Humphrey SR. Status, winter habitat, and management of the endangered Indiana Bat (*Myotis sodalis*). Florida Scientist 1978;41:65-76.
22. Richter AR, Humphrey SR, Cope JB, Brack V Jr. Modified cave entrances: thermal effects on body mass and resulting decline of endangered Indiana Bats (*Myotis sodalis*). Conservation Biol 1993;7:407-415
23. Tuttle MD, Stevenson DE. Variation in the cave environment and its biological implications. In: Aley T, Rhoades D, editors. Proceedings of the 1976 National Cave Management Symposium. Albuquerque (NM): Speleobooks; 1977. p. 108-120.
24. U.S. Fish and Wildlife Service. A recovery plan for the Ozark big-eared bat and the Virginia big-eared bat. Twin Cities (MN): U.S. Fish and Wildlife Service; 1984. 61 p.
25. McNab BL. The behavior of temperate cave bats in a subtropical environment. Ecology 1974;55:943-958.
26. Studier EH, O'Farrell MJ. Biology of *Myotis thysanodes* and *Myotis lucifigus* (Chiroptera: Vespertilionidae)-I. Thermoregulation. Comp Biochem Physiol 1972;41A:567-595.
27. Humphrey SR. Nursery roosts and community diversity of nearctic bats. J Mammal 1975;56:321-346.

Received: April 24, 2000; Accepted: July 11, 2000