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GATING AS A MEANS OF PROTECTING CAVE DWELLING BATS

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INTRODUCTION

As a result of a growing awareness of the endangered status of most populations of cave bats (see Mohr 1952, 1953, 1972; Jones 1971), private and public land owners increasingly are turning to cave gating as a primary method for protection of local roosting sites. Despite the fact that the intent behind such action is highly commendable, many gates are ill-conceived and have resulted in destruction of the bat populations. From 1969 through 1976 1 have had several opportunities to visit five southeastern caves which were gated in 1969, or earlier, to protect bats. This paper presents my findings and provides suggestions for cave gating as a method for protecting endangered populations of cave bats.

RESULTS OF PAST GATING

In four of the five instances of gating that I have observed, bats abandoned their caves either immediately or within two years after gating. One abandoned cave was originally used as a hibernating site and three were occupied by maternity colonies. A hibernating population in the fifth cave suffered heavy mortality but continued to survive at a reduced size.

In 1969 the National Speleological Society purchased and gated Shelta Cave in Huntsville, Alabama, as a biological preserve (Fig. 1). The two cave entrances were gated with inadequate spacing (11¾ inches vertical, 3 inches horizontal) between bars, and the roughly 25,000 gray bats (*Myotis grisescens*) that used the cave for a maternity site completely abandoned this cave within two years. They apparently attempted to rear fewer than 100 young in the first summer after the cave was gated, then failed to return at all in subsequent years.

Georgetown Cave is on public land administered by the National Park Service and is also located in Alabama. This cave once contained a maternity colony of roughly 150,000 gray bats, but by 1969 frequent visitation by spelunkers had caused a 90 to 95 percent decline in numbers. When alerted to the problem local authorities gated the cave but were not careful to provide adequate space for the bats to enter and exit. Roughly 80 percent of the cave entrance was covered with cyclone fencing and spaces of only 5¼ inches horizontally were left open in the upper 20 percent of the entrance (Fig. 2). The remaining 10,000 bats abandoned the cave immediately, apparently refusing to enter through the spaces provided.

In 1972, a third summer colony of 5000 gray bats was found to have abandoned their cave soon after a gate was installed. The gate was placed approximately 100 feet inside in a narrow place in the entry passage and was about 4 feet wide by 2 feet high, with a 6 inch cement foundation. Spacing between bars averaged 6 inches high by 12 inches wide. Abundant tracks indicated that raccoons often visited this gate, presumably to catch bats.

The recent demise of bats living in Old Indian Cave, located in Florida Caverns State Park, is an excellent example of the kind of problems that can arise from gating a hibernation cave. By 1969 the once large populations of gray bats and southeastern bats (*Myotis austroriparius*) that used this cave had dwindled to less than 2 percent of former numbers as a result of disturbance at their hibernating roosts. When alerted, park officials quickly closed the cave to the public. In order to do so, several small breathing only entrances were plugged, and the three main entrances were gated. Parts of each entrance were filled with concrete to form foundations and plug potential access around gate sides. The three original gates provided 11½ inch horizontal and 5½ inch vertical spaces between bars to permit bat entry (Fig. 3a). Later, the second entrance was further protected against break-in by the addition of concrete posts (Fig. 3b).

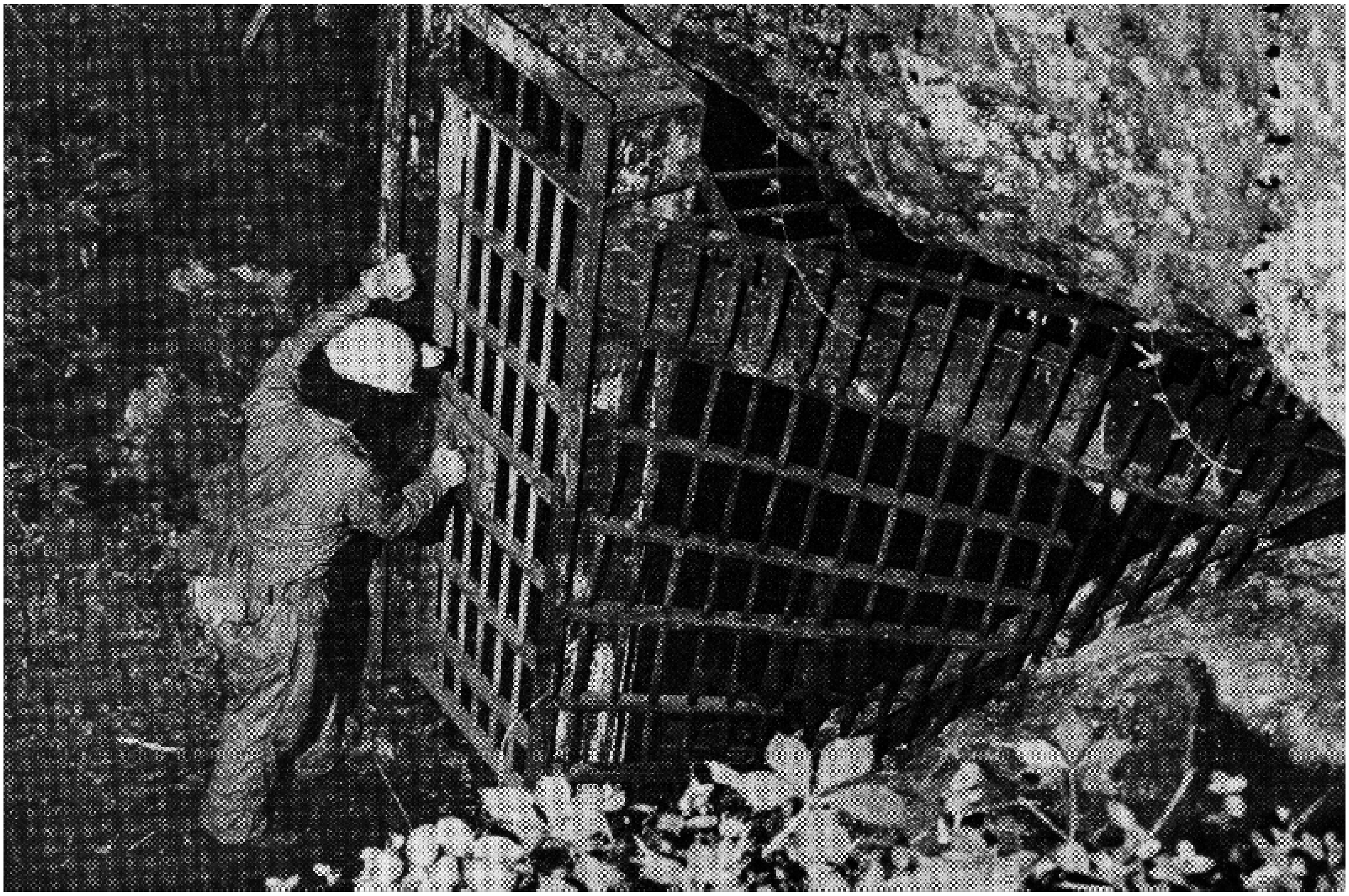

***Figure 1**: Shelta Cave gate. Note the inadequate space between the vertical bars and restrictive framing.*

Finally, Old Indian Cave became so well protected that airflow in the second entrance was approximately 80 percent blocked, while that in entrances 1 and 3 was at least significantly restricted. Through 1970 up to 1500 gray and southeastern bats continued to occasionally visit Old Indian Cave in summer, especially when disturbed in other caves. They refused, however, to use this cave on a regular basis. By 1976 fewer than 50 *Myotis* appeared to be visiting the cave at any time, and only 25 southeastern bats and two gray bats attempted to hibernate there in the winter of 1975–76.

Abandonment of the cave as a wintering site can be attributed to the blocking of entrances and a subsequent rise in cave temperature (see later section). The two gray bats that attempted to hibernate in Old Indian Cave in 1975/1976 were forced to roost within 2 feet of the cave floor where temperatures were low enough to be within their range of tolerance. Such behavior is quite abnormal and exposed the bats to greatly increased danger of predation from raccoons which frequently visited the bat roosting areas. Predation at the gates (also see later) probably contributed to the continued decline in summer use.

At James Cave, in Kentucky, a gate was installed by the Park Mammoth Resort when the cave was commercialized sometime prior to 1968. The primary purpose of this gate was simple protection of the commercial cave. The entrance grating and gate are similar to the one used at Shelta Cave (Fig. 2). Gray bats are extremely loyal to their hibernating caves (Tuttle 1976) and, in this case, refused to abandon their cave even when it was difficult for them to pass through the gate. The resort manager, Mr. Patrick Moran, told me that large numbers of bat wings were removed almost daily from in front of the gate during fall and spring arrival and departure of the bats. I personally observed bat wings in front of the gate on several visits between 1968 and 1971. These clearly were left by predators that caught the bats as they attempted to pass through the gate.

FACTORS DETERMINING SUCCESS OR FAILURE OF GATES

Obviously, improperly constructed gates can be extremely damaging to populations of cave bats. In some instances poor gates have caused greater damage to bat colonies than vandals or disturbance would have caused. Gating projects should not be attempted unless the completed gate can be constructed in such a manner as

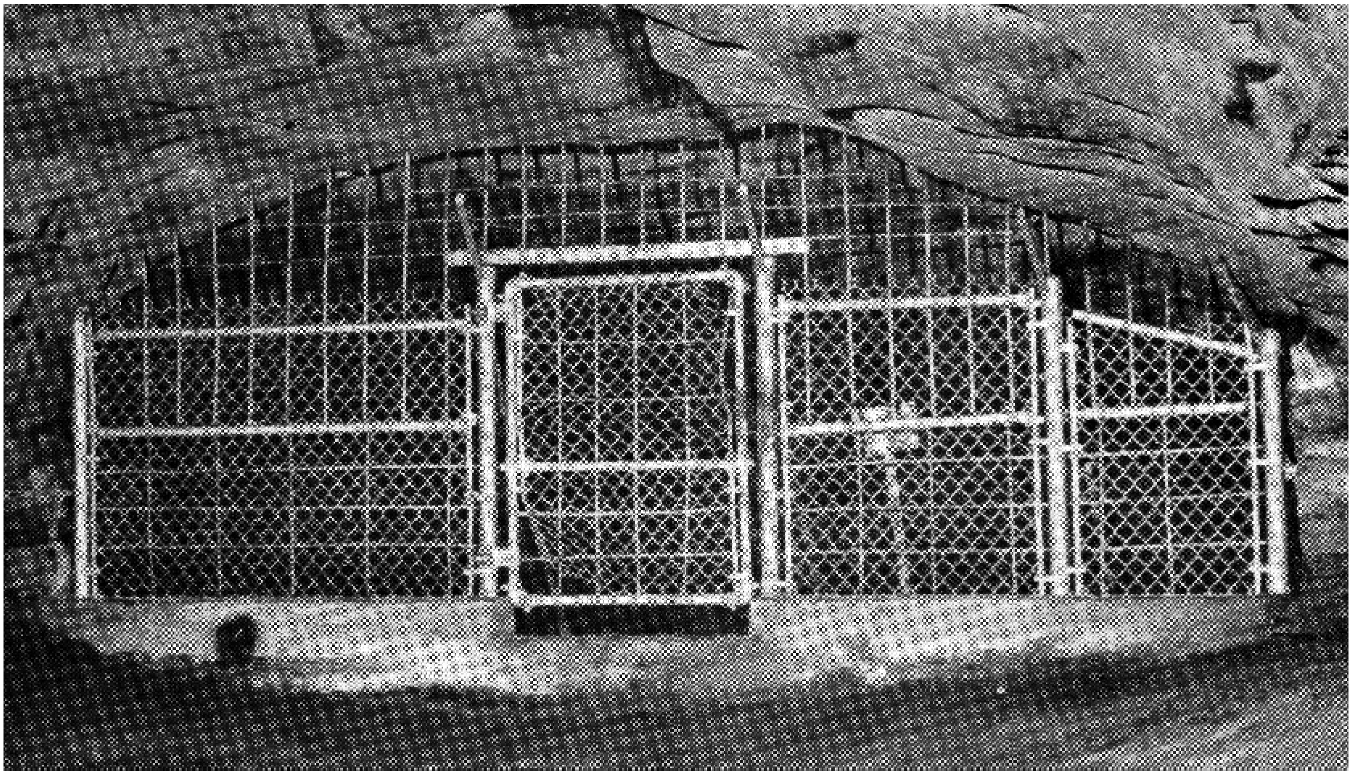

***Figure** 2: Georgetown Cave gate. Vertical bars are too narrowly spaced, and fence covering further restricts bat movement. Concrete foundation projecting above floor level alters air flow.*

to ensure that it will not restrict the free movement of either bats or air.

Air flow and cave temperature – Most hibernating bats require exceptionally cold eaves which do not freeze, while summer colonies must find unusually warm eaves (Dwyer 1971; Tuttle 1975, 1976). Since temperatures of most eaves roughly approximate mean annual above-ground temperatures, some eaves at very high latitudes may be too cold to permit use at any time of year while those at relatively low latitudes are too warm for use as winter hibernating sites but ideal for summer maternity colonies (Dwyer 1971). Caves that differ markedly in temperature from the outside mean annual temperature must do so as a result of circulation of outside air into the cave (briefly, cold air settling in during the winter or out in the summer). Consequently, the direction and intensity of positive or negative effects brought about by a gate's restriction of air flow will differ markedly with latitude and with the use made of the cave by its bats.

If the mean annual temperature of a region falls within the range tolerable for bat hibernation, restriction of air flow in or out of hibernating caves should be of minimal importance. Such conditions, however, exist in the United States only in the northernmost areas, if at all. As mean annual temperature increases, restriction of air flow in or out of hibernation eaves becomes increasingly problematic. Especially in eaves located south of about 37° north latitude, even slight restriction may cause a rise in temperature that is intolerable for hibernating bats. Summer maternity colonies face the opposite problem, requiring the highest cave temperatures available. They also may be adversely affected by restriction of cave air flow, particularly in the northernmost caves used.

Predation at cave entrances – Many birds, mammals, and reptiles prey opportunistically on bats (Gillette and Kimbrough 1970), and large bat colonies are known to attract a variety of these predators to cave entrances (Constantine 1948). Predation is sometimes a serious source of mortality for colonial cave bats even when gates are not present. Rice (1957) believed that predation was "the most important mortality factor among populations of *Myotis austroriparius* in Florida", and I have observed evidence of extensive predation at entrances of eaves occupied by *Myotis grisescens* as far north as central Kentucky.

Restrictive gates often cause bats to slow down and circle in front before entering. This increases vulnerability to predators that wait for emerging and returning bats. I have observed both raccoons and feral house cats catching slowly circling bats in mid-air in front of gated entrances. I also have observed single gray rat snakes catching four or more bats in a few minutes while hanging

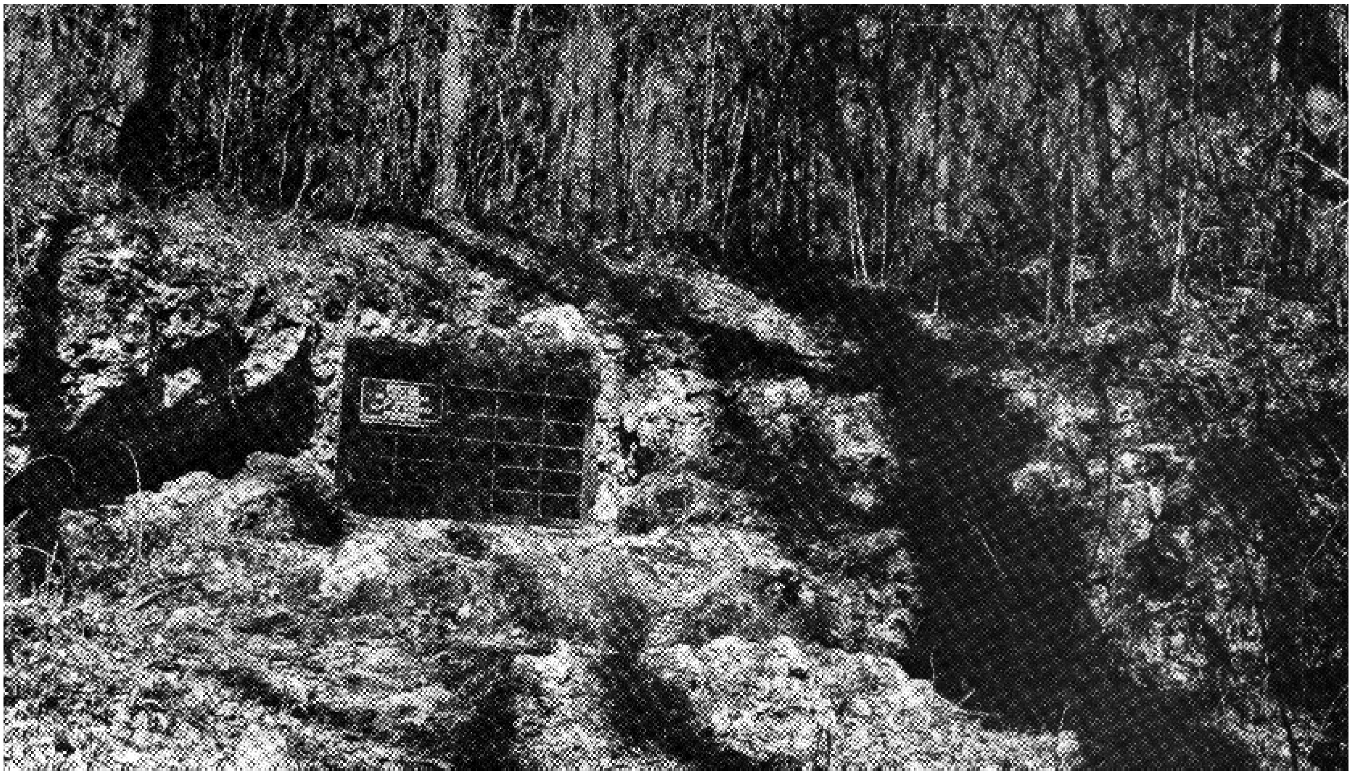

Figure 3a*: Gates at Old Indian Cave, Florida. Main Gate. Note cement-filled areas at sides and poorly-located sign which restricts air flow. Small entrance size makes increase in predation particularly severe.*

from the bars of a gate. Pack rats are known to be potential predators of bats (Cockrum 1952), and I have twice seen individuals waiting on the cross bars of gates where bats emerged. Screech owls frequently are heard and seen near cave entrances where bats emerge, and I have observed successful attacks on bats.

Although the problem of predation at cave entrances may be serious at either winter or summer caves, it is especially problematic at summer sites. Here emergence and return occurs daily over a period of several weeks or months annually, permitting predators to develop behavior appropriate to a particular situation. Also, young bats that are just learning to fly may frequently alight on gate bars, becoming especially easy prey. Even when they do not land, they often circle repeatedly while flying very slowly.

RECOMMENDATIONS FOR PROTECTING BAT CAVES

Gating – Hunt and Stitt (1975) have prepared a valuable guide to cave gating which may be purchased from the publishers of these Proceedings. Those contemplating gating as a means of protecting caves should carefully consider their discussion of general considerations of gating.

A major problem involves gate location. As pointed out by Hunt and Stitt, "it is simplest to build an effective gate in a relatively tight passage, since it is not only easier to fill in around the gate, but the restricted space affords little room for the gate-breaker to work in." However, it is very important to note that gates placed in tight places will cause maximum damage in terms of restricting movement of both bats and air. Gates at bat eaves always should be built in the largest possible places in the cave entrance or in an inner passage where the diameter is large. Locations well within the cave are advantageous in reducing predation but are difficult to patrol. Several of Hunt and Stitt's (1975) gate designs should be avoided whenever possible and never installed at eaves used by bats. These include wall gates, drum-type gates, interior steel plate gates, and water gates. Chain gates and open grid door wall gates also would seriously threaten bat use of caves in most places. Open grid wall and door gates have not been tested adequately but have proven unsuitable in several cases where cave entrances less than five feet in diameter have been involved. Hunt and Stitt's bat cave gate is the best general design yet developed, but even it may be unsuitable in some instances (especially at maternity caves).

A "good gate" for a bat cave is one that minimizes restriction of air flow and that does not cause bats to reduce their speed of entry or exit. In order to minimize

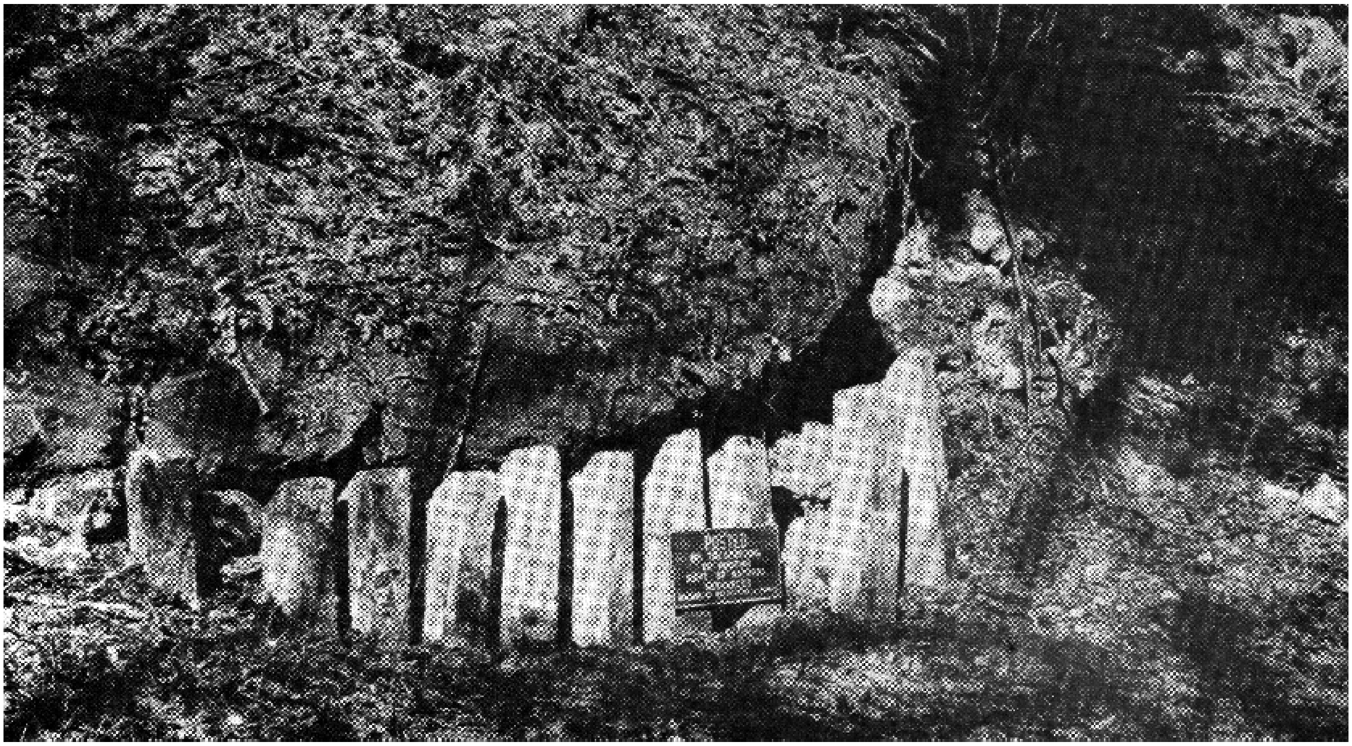

***Figure 3b**: Old Indian Cave, Florida. Second Entrance. Original gate (like the one shown above including concrete blocking) already restricted bat and air movement. Concrete posts, added later, almost totally closed the entrance. Uninformative signs such as these probably do little to engage the cooperation of cavers.*

interference with the bats, a gate should have the least number of vertical bars possible and the greatest width possible between horizontal bars. These considerations unfortunately must be balanced carefully against the increased possibility of vandals breaking or squeezing through the gate when spaces are too large. Consequently, the greatest allowable distance between horizontal bars is about 6 inches. Distance between vertical bars can be as much as 3–4 feet (never less than 2 feet), depending on strength of construction materials. Staggering of vertical bars will provide added protection against forced entry.

Since it is impossible to construct a vandal-proof gate, “the most effective gate, both from a protection and a cost standpoint, may be the strong, well-designed and well-constructed gate, which is deliberately left with a weak link so that forcing entry to the cave does not destroy the entire gate” (Hunt and Stitt 1975). The “weak link” used most is the gate (or fence). An explanatory sign (inside the gate but out of the way of bats and air flow) should detail reasons for protecting the cave, penalties for trespassing, and the address of the person, organization, or agencies who control access. When endangered species are involved the penalties for violations are potentially serious (Federal Register 1975).

Fencing – Chain link or cyclone fences built around but not directly in front of or over cave entrances provide a good means of protecting bat caves, and may be the only satisfactory means of protection where predation or restriction of air flow are potentially problematic. When constructed well back from the cave entrance, fencing does not hinder exit or entry of bats. Other advantages are that fences are relatively inexpensive, easy to install, easy to patrol, and easy to repair when vandalized. Easily read signs can be placed inside as suggested above, explaining reasons for protecting the cave and potential penalties for trespassing.

Disadvantages include the fact that fences are often conspicuous, thereby attracting attention, that they may not be aesthetically pleasing, and that they often must be patrolled more frequently than gates. Although fences may be more easily violated than gates, this is at least partially balanced by their greater ease of repair. The incorporation of a “weak link” into the fence can also minimize repair costs.

Hunt and Stitt (1975) have pointed out that several strands of barbed wire should be attached “at the top of the fence, overhanging on each side and supported by angle-iron projecting from the top of each support post.” They further suggest that “a concrete footing along the bottom of the fence will help prevent persons wriggling under,” but note that the bottom of the wire fence should not be embedded in the concrete, as that would make repair more difficult.

Considerations for fencing versus gating – Fencing may prove to be the only alternative for protecting bats in many caves with small (less than 5 ft. diameter) or vertical entrances, or in southern caves where predators such as gray rat snakes may present special problems. Another risk, sometimes necessitating use of a fence, exists in areas of heavy public use, where people may throw fireworks into bat caves or kill emerging bats with switches if they are not prevented from approaching a cave entrance too closely. Aside from the potential disadvantages of weakness and marring of the surrounding landscape, fences appear, in many cases, to be best suited for protection of bat caves: when constructed well away from cave entrances they have no known effect on air flow or bat movement.

Unfortunately, since few past gates have been designed adequately to meet the needs of bats, we have very little knowledge regarding the extent to which they may be useful, and there is a possibility of overreacting against them due to some of the disastrous results thus far observed. Obviously fences are not esthetically pleasing and, in areas which cannot be patrolled frequently, they may not prove adequate to stop determined vandals. For these reasons alone, there is much incentive to use gates whenever possible. Even using rather undesirable gate designs, Yalden and Morris (1975) have reported at least limited success in protecting British bat hibernation caves. Certainly there is reason to believe that carefully designed gates may prove adequate for protection of many hibernating bat populations, especially in northern areas. For reasons already discussed, gates are least likely to meet the needs of bats when used at caves occupied by summer maternity colonies. If gates are used at such sites they should be restricted to caves with entrances at least live feet or more in height and preferably of even greater width.

Although examples presented in this paper are limited to gray and southeastern bats, the problems and solutions discussed are not unique to these species. Protection of cave-dwelling bats is a complex problem which needs much additional study, and it is vital that any gating or fencing be followed up by careful observation of the impact on the bats being protected. Only through such measures will we be able to evaluate our success in protecting populations of endangered bats and further improve our methods.

NOTE ADDED IN PROOF

Since I submitted this paper, Hall (7th Annual North American Symposium on Bat Research 1976) has reported evidence of predation on a maternity colony of the Virginia big-eared bat (*Plecotus townsendii*) at a gate in West Virginia, and Bill Sconce (personal communication) has reported predation on Indiana bats (*Myotis sodalis*) at Wyanotte Cave, in Indiana. Apparently Indiana bats often refuse to fly through the gate at this wintering cave and are caught by predators as they land to crawl through. Both gates reportedly provide spaces of at least 12 inches between vertical bars.

A Tennessee cave, not discussed previously because it was not gated, nonetheless serves as an excellent example of the detrimental impact of partial air flow blockage in the entrance of a hibernating cave. In 1969 this cave contained 133 Indiana bats and 117 gray bats. In 1970, following strict owner protection from disturbance, there were 183 Indiana bats and 490 gray bats. Sometime between 1970 and 1973 the owner blocked approximately 30 percent of the cave entrance in order to protect his water pipes there from freezing. This resulted in a rise in cave temperature of roughly 2°F (possibly more but not detected due to timing of visits). Even though the cave remained protected from disturbance during the period from 1970 to 1974, in 1974 there were only 60 Indiana bats (a 67 percent reduction) and 65 gray bats (an 87 percent reduction). Other species also declined noticeably but were not carefully censused. The 1969 January air temperature of approximately 52°F in the area of heaviest use was already near the upper limit normally tolerated by hibernating bats in that region, so even a slight shift upward would have been expected to be detrimental to this cave's hibernating bat population, as was observed.

These further observations are submitted in order to verify that problems involving blockage of air flow and gate-associated predation are not unique to gray or southeastern bats and they they are widespread.

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REFERENCES

Cockrum, E. L. 1952. Mammals of Kansas. Publication of the Museum of Natural History, University of Kansas, 7:1–303.

Constantine, D. G. 1948. Great bat colonies attract predators. National Speleological Society Bulletin 10:100.

Dwyer, P. D. 1971. Temperature regulation and cave-dwelling in bats: an evolutionary perspective. Mammalia, 35:424–453.

Federal Register. 1975. Endangered and threatened wildlife and plants, part II. Sept. 26, 44412–44429.

Gillette, D. D. and J. D. Kimbrough. 1970. Chiropteran mortality. Pp. 262–283, *in* About bats: a chiropteran symposium (B. H. Slaughter and D. W. Walton eds.). Southern Methodist University Press, Dallas.

Hunt, G. and R. R. Stitt. 1975. Cave Gating. Speleobooks, Albuquerque, New Mexico, i–v + 43 pp.

Jones, C. 1971. The status of populations of bats in the United States. Second Annual Symposium on Bat Research, Albuquerque, New Mexico. Unpublished.

Mohr, C. E. 1952. A survey of bat banding in North America, 1932–1951. National Speleological Society Bulletin 14:3–13.

Mohr, C. E. 1953. Possible causes of an apparent decline in wintering populations of cave bats. National Speleological Society News, 11:4–5.

Mohr, C. E. 1972. The status of threatened species of cave-dwelling bats. National Speleological Society Bulletin 34:33–47.

Rice, D. W. 1957. Life history and ecology of *Myotis austroriparius* in Florida. Journal of Mammalogy 38:15–32.

Tuttle, M. D. 1975. Population ecology of the gray bat (*Myotis grisescens*): factors influencing early growth and development. Occasional Papers of the Museum Natural History, University of Kansas, No. 36, pp. 1–24.

Tuttle, M. D. 1976. Population ecology of the gray bat (*Myotis grisescens*): philopatry, timing and patterns of movement, weight loss during migration, and seasonal adaptive strategies. Occasional Papers of the Museum Natural History, University of Kansas, No. 54, pp. 1–38.

Vandel, A. 1965. Biospeleology. Pergamon Press, New York, V–XXIV + 525 pp.

Yalden, D. W. and P. A. Morris. 1975. The Lives of Bats. Quadrangle/The New York Times Book Co., 247 pp.