

RESPONSES OF WINTER POPULATIONS OF THE FEDERAL ENDANGERED INDIANA BAT (*MYOTIS SODALIS*) TO CAVE GATING IN KENTUCKY

JOHN MACGREGOR, Daniel Boone National Forest, 1835 Big Hill Road, Berea, Kentucky 40403

ABSTRACT

During the past decade, winter populations of federal endangered Indiana bats (*Myotis sodalis*) have been monitored intensively at most of the known hibernacula located in Kentucky. This effort has resulted in the documentation of population trends for this species in individual caves throughout most of the state.

Historic information available from past bat censuses at several large hibernacula, coupled with the earliest counts at many sites that have been relatively recently discovered, indicates that Kentucky caves once harbored at least 300,000 Indiana Bats during the winter months. By 1981, numbers had fallen to just under 100,000, and by 1991, only about 84,000 Indiana bats remained in Kentucky hibernacula (MacGregor, unpublished data). The majority of the population losses have occurred at four caves (Bat Cave in Carter County, Coach Cave and Long Cave in Edmonson County, and Line Fork Cave in Letcher County) which, if taken together, once held about 260,000 Indiana Bats in the 1960s. The composite population of these four caves had dropped to about 68,000 by 1981, when the author began to systematically census Kentucky's Indiana bat hibernacula, and had further declined to about 54,000 by 1991.

At the time that the Indiana bat was first proposed and listed as an endangered species, most bat biologists felt that the major reason for the widespread population declines in the species was human disturbance to hibernacula during the winter months. In an effort to halt such disturbance, cave gates have since been constructed at the entrances to several Kentucky caves specifically to protect hibernating Indiana bats.

For two of these caves (Bat Cave and Ash Cave), the major goal of the gating process was the

exclusion of human intruders; the general feeling among those who planned and built the gates was that the bats would be able to maintain themselves indefinitely if winter disturbance and vandalism (direct killing of bats) could be eliminated. At Bat Cave, passable bat flyways were provided above both gate doors but virtually no consideration was given to the possible impacts of the upper and lower gate structures on the cave microclimate. At Ash Cave, the winter cave microclimate was maintained but the gate design necessitated that most bats had to actually land on the gate to enter the cave.

The overall state of our knowledge of winter bat ecology, and of the potential impacts of poorly-designed cave gates on hibernating bat populations, has increased considerably in recent years. Much of the current information that is available, in fact, has come to light as a direct result of cave gating projects that have inadvertently had severe adverse impacts to the very bats that the gates were designed to protect! Both Bat Cave and Ash Cave were re-gated in the 1980s, and three additional Indiana bat caves in Kentucky have been gated since then, in such a manner as to allow the free flow of air and water and the free night of bats into and out of the caves.

Eight other Kentucky caves which contain Indiana bats during the winter months have been gated for various reasons not necessarily related to

bat protection. Two of these caves (Coach Cave and Long Cave) contain gates and other entrance structures which have had, and continue to have, significant negative impacts on Indiana bat populations. The remaining six gated caves all contain relatively small winter colonies of Indiana bats; the cave gates are reducing human disturbance and maintaining these colonies but the caves themselves offer such marginal winter habitat that there is little hope that bat populations will ever increase here. Hibernating populations of Indiana bats have now been documented at 78 different caves in Kentucky. Thirteen of these have been gated. Thirty-five Kentucky caves have had winter populations of 100 or more Indiana bats; fifteen of these have harbored populations in excess of 1,000. Documented events that have negatively affected Kentucky hibernacula during the past 30 years (in addition to poorly-constructed cave gates) have included flooding at three caves, the building of fires in the entrance areas at four caves, and the direct killing of bats by vandals at five caves. Flooding may not be preventable unless, as in one case in Kentucky, it is caused directly by the mismanagement of the land directly above cave passage. Fire building and the direct killing of bats by vandals, however, are entirely preventable by the use of gates, making cave gating an extremely valuable tool in the management of winter Indiana bat populations.

The purpose of this note is to present the available information on the responses of Indiana bat winter populations to cave gates — both properly and improperly designed — so that individuals, organizations, or agencies that are considering the gating of bat caves might be able to better predict how this species might respond to such conservation efforts in the future.

CAVES WITH GATES DESIGNED FOR INDIANA BAT PROTECTION

As of October 1992, five caves in Kentucky have been gated with angle iron gates designed by Roy Powers (American Cave Conservation Association) and Robert Currie (U. S. Fish and Wildlife Service). Indiana bat population data are available

for three of these caves: Bat Cave in Carter County (original gate constructed about 1970; re-gated summer 1983), Ash Cave in Lee County (original gate built in the mid-1970s; re-gated summer 1989), and Cave Branch Cave in Menifee County (gated summer 1989). A fourth cave (Line Fork Cave in Letcher County) was gated during the summer of 1991 but has not been completely censused since that time. The fifth cave (Well Cave in Menifee County) was gated during the summer of 1992 and also has not as yet been censused for bats with the cave gate in place. Indiana bat population figures for the three caves for which post-gate population figures are available are presented below:

BAT CAVE, CARTER COUNTY

Date(s)	Indiana Bat Numbers
15 Jan 1957	100000
15 Jan 1960	100000
15 Jan 1962	100000
<i>Original Cave Gate Constructed (1970?)</i>	
15 Jan 1974	40000
15 Jan 1975	40000
15 Jan 1981	51500
26 Jan 1983	43500
<i>Angle Iron Gate Constructed (1983)</i>	
23 Jan 1985	36450
10 Feb 1987	37600
7 Feb 1989	45280
28 Jan 1991	49575

Bat Cave, located at Carter Caves State Resort Park, is owned and managed by the Kentucky Department of Parks and is also (since about 1980) a Kentucky State Nature Preserve. Bat Cave was originally gated by the Kentucky Department of Parks sometime around 1970 to protect the large Indiana bat hibernaculum there shortly after vandals had entered the cave and killed about 10,000 bats (Engel *et al.* 1976). Gates were placed on both the upper and lower entrances; extensive rockwork was used to block most of each entrance and door-sized metal bar gates were installed. The rockwork associated with these gates seriously impeded the flow of cold air through the cave in winter, altering winter microclimate regimes and

raising both relative humidity levels and winter temperatures in the sections most heavily used by hibernating Indiana bats.

The precipitous drop in the winter Indiana bat population of Bat Cave, from about 100,000 in the 1960s to about 36,500 in 1985, can probably be attributed almost entirely to the design of the original cave gates. These gates and their attendant rockwork were torn out during the summer of 1983 and replaced with massive angle iron gates that extended the width of the entrance passages. The new gates allowed the original winter air flow patterns to be restored throughout Bat Cave. The gradual increase (13,000 over 8 years) in the Indiana bat winter population of the cave since that time can probably be attributed directly to this regating project.

It should be noted that bat counts that were made prior to 1983 generally tended to be “eyeball estimates” of the wintering Indiana bat population in Bat Cave. Counts from 1983–1991 were conducted by Indiana Bat/Gray Bat Recovery Team leader Rick Clawson (Missouri Department of Conservation) and are felt to be both precise and consistent.

ASH CAVE, LEE COUNTY

Date(s)	Indiana Bat Numbers
<i>Original Cave Gate Constructed (1975?)</i>	
17 Jan 1984	132
16 Feb 1988	104
<i>Angle Iron Gate Constructed (1989)</i>	
19 Jan 1990	78
6 Feb 1992	73

Ash Cave is located on lands owned and managed by the Daniel Boone National Forest. Prior to the construction of the original gate, the cave was regularly visited and vandalized. Nearly every rock formation had been broken off and carried away and the cave floor was pitted extensively where visitors had illegally dug for artifacts.

The original cave gate permitted good air flow but was virtually impassable to bats unless they landed on it and crawled through. This gate was also easily and frequently violated by “pot hunters” and local residents. At the time it was

gated, this was the only known Indiana Bat hibernaculum in the Daniel Boone National Forest.

A new gate for Ash Cave was planned and constructed during the summer of 1989. The rationale for building it included the slowly decreasing Indiana bat population in the cave, the frequency with which the existing gate was violated, the difficulty provided by the existing gate to the free traffic of bats, and the extensive amounts of faint ceiling stains that were observed in the cave (possibly indicating the former existence of a large winter bat colony there).

The new gate has been effective at keeping humans out of the cave. Many broken and damaged cave formations are beginning to recover, but the Indiana bats have not increased in numbers. Since rebuilding the Ash Cave gate, we have checked winter temperatures and humidity levels throughout the cave and determined that only a relatively small section of passage is capable of meeting the winter needs of Indiana bats (midwinter temperatures 4–8°C, relative humidity less than 100%). In fact, the only portion of the cave that seems suitable for hibernating Indiana bats is a low section beneath a ledge, well within the reach of a raccoon and thus making the bats that roost there very susceptible to predation.

There are two additional large (1000+) Indiana bat hibernacula nearby (within a mile). Disturbance to both of these has been appreciably reduced in recent years - each has been marked with USPS bat signs and caving groups have been cooperative in leaving the caves alone during the winter months. It may be that bats that had been disturbed at these other caves once moved into Ash Cave in mid-winter and that Ash Cave no longer functions as a refugium for these bats.

CAVE BRANCH CAVE, MENIFEE COUNTY

Date(s)	Indiana Bat Numbers
30 Dec 1983	176
19 Dec 1985	282
9 Feb 1988	354
1 Dec 1988	366
<i>GATED SUMMER 1989</i>	
19 Jan 1990	418

Cave Branch Cave is also owned and managed by the Daniel Boone National Forest. The cave was un gated until after it was acquired by the Forest Service (with assistance from The Nature Conservancy) in 1989. The cave was previously visited fairly frequently by vandals. Fresh trash and spray paint graffiti was always observed during bat census visits.

A temperature profile of Cave Branch Cave was made during the winter of 1988, prior to cave gate construction, by the author and Robert Currie. Winter temperature data indicated that the one large room in the cave where Indiana bats were known to hibernate had the potential to harbor several thousand additional bats. There has apparently been a good Indiana bat response to the gating of this cave.

**CAVES WITH INDIANA BAT
POPULATIONS THAT ARE NEGATIVELY
IMPACTED BY GATES AND OTHER
STRUCTURES**

***COACH (HUNDRED DOME) CAVE,
EDMONSON COUNTY***

Date(s)	Indiana Bat Numbers
15 Jan 1960	100000
15 Jan 1975	4500
15 Jan 1982	550
27 Jan 1983	600
21 Jan 1985	424
11 Feb 1987	250
8 Feb 1989	50
29 Jan 1991	48

The privately owned and managed Coach Cave is located at Park Mammoth Resort. The upper entrance to the cave was completely closed when a gift shop was constructed over it in the early 1960s. This structure effectively halted the flow of cold air into the lower entrance during the winter months by preventing the upper entrance from functioning as a chimney in cold weather. Without the warm air rising and escaping through the upper

entrance, cold air from outside was not longer being pulled into the lower entrance to maintain the low temperatures required by the bats. In addition to warming the critically important hibernation passages, the presence of the gift shop prevented many of the incoming bats from gaining access to Coach Cave through their preferred entrance route.

The gift shop burned two years after it was constructed. If the debris that was left had been cleared away immediately afterward, or even within a few years after the fire, the Indiana bat population in Coach Cave might have been well on the way to recovery by now. Unfortunately, the upper entrance has remained almost entirely blocked by sheet metal and foundation debris, the Indiana bat section remains too warm in winter for the bats, and the ever-dwindling population has probably fallen to such a low level that recovery is virtually inconceivable. The remnant winter Indiana bat population uses a small pit area near the lower entrance as a hibernation site.

LONG CAVE, EDMONSON COUNTY

Date(s)	Indiana Bat Numbers
15 Jan 1947	50000
15 Jan 1953	2000
15 Jan 1962	2000
15 Jan 1969	6000
15 Jan 1978	5057
16 Feb 1982	7527
21 Jan 1985	3717
12 Feb 1987	2801
7 Jan 1988	2646
12 Jan 1989	2669
1 Feb 1991	1249

Long Cave is owned and managed by the National Park Service and is located within Mammoth Cave National Park. The present cave gate has been in place since some time prior to 1982. The cave entrance lies at the bottom of a steep sinkhole. A thick concrete wall blocks most of the natural opening. A metal gate has been built to fit a 2 x 3 foot opening in the wall. The concrete wall seriously impedes the flow of air into Long Cave, and the gate is difficult for bats to fly through (we

have used night vision equipment to observe and videotape bats that are attempting to pass through it in late summer). The gate is due for replacement in early summer of 1993. Bob Currie (USFWS) has obtained maximum and minimum temperatures throughout the year at a number of points in the cave, and some data on Indiana bat cluster sizes and roost locations is also available. This will allow good documentation of the impacts of the rebuilt gate on the recovery of the winter population.

OTHER GATED CAVES THAT HARBOR INDIANA BATS

THORNHILL (WIND) CAVE, BRECKINRIDGE COUNTY

Date(s)	Indiana Bat Numbers
8 Dec 1963	3680
Winter 1977	0
27 Feb 1986	82
13 Jan 1987	71 (66 dead)

Thornhill Cave is privately owned. The winter Indiana bat population in this cave was a large one until most of the bats were killed by flooding in the mid-1960s (DeBlase *et al.* 1965). Bat populations in Thornhill Cave never really recovered after the flood. There were still fewer than 100 Indiana bats in the cave when it was censused in 1986. Vandals entered Thornhill Cave in midwinter of 1987 and killed most of the bats that were hibernating there, including at least 66 Indiana bats. Only five living Indiana bats were found when the cave was censused during the recovery of the carcasses.

The cave was gated with a round bar gate by members of the Louisville Grotto shortly after the bat kill had taken place. The bat population there has not been censused since that time. The lack of bat recovery here after the flood event of the 1960s (thru 1986) indicated that it may be virtually impossible for Indiana bat populations to recover in some caves after a certain low population point has been reached.

SALTPETER CAVE, CARTER COUNTY

Date(s)	Indiana Bat Numbers
28 Jan 1983	13
10 Feb 1987	39

Saltpeter Cave is owned and managed by the Kentucky Department of Parks (Carter Caves State Resort Park). This cave is open for tours throughout the year. There is a small but variable winter Indiana bat population that hibernates in pockets in the ceiling near the entrance. A large room-sized cage gate stands above the entrance, permitting the free flow of cold air into Saltpeter Cave in winter.

BAT CAVE (MCNP), EDMONSON COUNTY

Date(s)	Indiana Bat Numbers
19 Dec 1959	present
27 Mar 1960	present
16 Feb 1982	212
20 Mar 1985	66
4 Feb 1987	70
1 Mar 1990	57

Bat Cave is owned and managed by the National Park Service and is located at Mammoth Cave National Park. The round bar gate on this cave permits good air flow and bat access. The cave itself, however, does not appear to offer good conditions for hibernating Indiana bats. Much of the passage is too warm and/or humid to support heavy winter use by this species.

Bat Cave contains some extensive deposits of bat bones. These can be seen in layers (interspersed with layers of silt) in crawlways near the entrance. It has been postulated that these are the bones of Indiana bats which have been trapped in the cave and drowned by flooding from the Green River. If this is the case, then Bat Cave probably once had either a radically different upper passage configuration, or else had at least one additional entrance that would have allowed the development of suitable Indiana bat temperature and humidity regimes during the winter.

The interspersed of the bat bones with other layers of sediment would seem to indicate that several different flood events had taken place here over

time. The dozen or so bat skulls that the author has examined in Bat Cave have included those of big brown bats (*Eptesicus fuscus*) and Eastern pipistrelles (*Pipistrellus subflavus*) in addition to those of bats of the genus *Myotis*.

COLOSSAL CAVE, EDMONSON COUNTY

Date(s)	Indiana Bat Numbers
15 Jan 1953	6000
17 Feb 1982	349
20 Jan 1985	445
12 Feb 1987	498
13 Jan 1989	614
1 Feb 1991	556

Colossal Cave is also located at Mammoth Cave National Park. The present cave entrance is artificial. It was constructed after the original entrance collapsed and became filled with rubble some time after 1953. The existing cave gate does not seem to be impacting Indiana bat numbers in Colossal Cave. The entrance takes in a considerable flow of cold air in winter and the section of the cave used by the bats appears to be capable of harboring a much larger population than is presently there. The fate of the fairly large colony of 6,000 Indiana bats that inhabited Colossal Cave prior to the entrance collapse is unknown.

(JESSE) JAMES CAVE, EDMONSON COUNTY

Date(s)	Indiana Bat Numbers
15 Jan 1980	1293
27 Jan 1983	700
21 Jan 1985	230
11 Feb 1987	160
6 Jan 1988	30
8 Feb 1989	75
29 Jan 1991	1

This privately owned and managed cave, like Coach Cave, is located at Park Mammoth Resort. James Cave serves as a major (USFS Priority 1) hibernaculum for about 200,000 gray bats (*Myotis grisescens*). These overwinter in a deep, cold pit section that also harbors a few Indiana bats. The

present gate has been in place for many years. It appears adequate for air flow but the spaces between the bars are oriented vertically and it is difficult for bats to fly through. Many bats land momentarily on the gate while entering and leaving the cave, others must change speed and direction to fly in or out. In either case, the bats which use James Cave are quite vulnerable to predators when passing the entrance.

In October 1989, the heads and wings from about 85 gray bats were found beside the gate, apparent victims of a family of feral cats that had taken up residence in a deep crevice at the cave entrance. The declining Indiana bat population here appears to have been caused more by the presence of overwhelming numbers of gray bats, also federally endangered, than by any aspect involving the cave gate.

GREAT SALTPETER CAVE, ROCKCASTLE COUNTY

Date(s)	Indiana Bat Numbers
15 Jan 1964	10
10 Jan 1978	10
6 Feb 1981	0
4 Mar 1990	0

Great Saltpeter Cave, a long-time tourist attraction that has now been closed to the public for several years, is privately owned. The existing round bar gates have been in place for many years. These gates may slightly restrict bat access, but the flow of cool air throughout the cave tends to be very good. The entire cave is cold and windy except for a few warm, humid side passages. Very few bats of any species hibernate in Great Saltpeter Cave, and very little potential exists here for Indiana bats in winter.

DISCUSSION

In the overall picture, it has been demonstrated repeatedly that properly designed and constructed cave gates can make it possible for declines at Indiana bat hibernating sites to be halted and/or reversed. It has also been shown that improperly

designed cave gates and other structures, even if placed on only one entrance of a multiple-entrance cave, can bring about drastic declines in Indiana bat populations. In fact, virtually the entire historical drop in Indiana bat numbers in Kentucky since the 1950s and 1960s can be directly attributed to the impacts of cave gates and buildings on the flow of cold air through cave systems during the critical winter months.

There may be something to be said for managing Indiana bat populations by keeping cave locations secret, putting closure signs within the entrances so as not to attract attention to the caves from the outside, soliciting the assistance of the organized caving community in circulating information on which caves should not be visited in winter, and visiting the caves only once every second winter for a bat census. Twelve caves located on or adjacent to the Daniel Boone National Forest in Rockcastle and Jackson Counties in Kentucky were managed in this way. These caves collectively showed a decline of only 37 Indiana bats over a ten year period (1981–1991). Fifteen additional caves on or near the Daniel Boone in Lee and Menifee counties were managed in a similar manner and showed a net increase of 574 Indiana bats over the same time period.

The problem with this method of management, however, lies in the occasional and unpredictable case of cave vandalism that usually comes about

when local residents enter sensitive caves during critical periods of the year and either kill hibernating bats outright or damage populations by making frequent visits to the caves or by building campfires in cave entrances. Over the past 10 years in Kentucky, nine of the 78 known Indiana bat sites (11.5%) have been impacted by the direct killing of bats or by campfires. Numerous other Indiana bat caves show evidence of similar activities having taken place in the past. For this reason, it seems imperative that as many as possible of the most significant remaining Indiana bat caves be equipped with properly designed and maintained cave gates.

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