Actions Required to Reverse Population Decline of Endangered Indiana Bats in Kentucky

— A 3-YEAR STRATEGIC PLAN —

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Abstract: The endangered Indiana bat was once one of the most abundant mammals of the eastern U.S., and its largest populations hibernated in Kentucky caves. Millions roosted in the Mammoth Cave System alone. However it was federally recognized as endangered by 1967, and by 2001 only 380,000 remained throughout its North American range. The species has continued its precipitous decline, despite 38 years of conservation efforts. To identify causes of continued decline, Bat Conservation International compared 20 years of roost temperatures in each of the species' most important remaining hibernation caves with status trends. Populations grew or remained stable where mid-winter roost temperatures were approximately 3–6°C; the most rapid declines were linked to sites where temperatures fell the farthest outside this preferred range.

Our research strongly suggests that continuing decline of key populations can rapidly, and relatively inexpensively, be reversed through remedial actions to restore hibernation roost temperatures that were long ago altered by human activities. Summer habitat protection has become intensely controversial, costing millions of dollars annually to enforce under the Endangered Species Act. By identifying key hibernation roosts of the past and restoring required temperatures, we believe that much of today's rapid decline can be reversed. This proposal requests three years of funding for research and restorative actions that have extraordinary potential, not only to halt the species' dramatic decline, but to begin restoring key populations, beginning in Kentucky. To accomplish this, we must: 1) identify key roosts where altered temperatures require remedial action; 2) conduct 12–24-month research projects at key caves to identify the most cost-effective remedies for restoration; 3) restore air flow patterns, as suggested by site-specific research, to ensure appropriate roost temperatures; 4) document before and after conditions and impacts on population trends; 5) share progress reports and annual findings with Indiana Bat Recovery Team and other colleagues cooperating in Indiana bat recovery efforts.

Historical Background

Indiana bat populations have dropped precipitously for over 100 years. In the early 1800s, millions could still be found in single caves (Silliman 1851, Tuttle 1997). However, the range-wide population had fallen to just 880,000 by 1961, with only about 380,000 remaining in 2001 (Clawson 2002). Since its listing as endangered on 11 March 1967, the Indiana bat has been the subject of intense controversy, impacting land use planning on national forests, military bases, airports, and highways throughout most of the eastern United States (Kurta and Kennedy 2002). Costs to industry and tax payers run into the millions of dollars annually, yet the species has continued to decline.

A major cause of population decline and roost abandonment is human disturbance and microclimate alteration, such as occurs in caves mined for saltpeter (also called Nitre — potassium nitrate — KNO_3). During the War of 1812, and again during the Civil War, many eastern caves were mined for saltpeter, an essential ingredient in gunpowder. In Kentucky alone, 133 caves and 6 rockshelters have been documented as mined for saltpeter during the War of 1812. Bat guano can enrich the concentration of saltpeter in cave sediments, making bat caves a prime target for mining. Mining activity in these caves disturbed roosting bat populations, but even more importantly, physical changes to entrances and passages caused long-term harm that cannot be repaired without careful research and planning.

Many caves once held large numbers of hibernating bats, but have been abandoned for so long that they are no longer recognized as essential bat habitats. Saltpetre Cave in Carter County, Kentucky, is an excellent example of a cave that was once a bastion of survival for hibernating Indiana bats. However, the bats were probably extirpated during saltpeter extraction around 1812, and the past importance of this site was not recognized until our assessment in 1998 detected large areas of roost staining on limestone ceilings. Since it was discovered as a key historic hibernation site for the Indiana bat and was protected, a rapidly growing population has been restored. Now, with ongoing microclimate restoration, it has the potential to one day shelter more Indiana bats than are currently known from the entire state of Kentucky (Kennedy 2004a, 2004b)!

Key Research Discoveries Open Door to Reversal of Decline

Decline Linked to Inappropriate Hibernation Roost Temperatures — In 1997, Bat Conservation International (BCI) reviewed 20 years of roost temperature and population census data collected by the Indiana Bat Recovery Team at the Indiana bat's most important hibernation roosts. We compared temperatures in caves with declining, versus stable or growing populations, and the results were dramatic. At caves where roost temperatures ranged 3.0–7.2°C, populations grew by 97,339, while populations facing temperatures either above or below this range declined by 185,117.

The conclusion that population decline resulted from inappropriate hibernation roost temperatures was also strikingly supported by observations at Great Scott Cave in Missouri. Censuses documented a population gain of 22,800 from 1976 to 1979, when mid-winter roost temperatures averaged 4.8°C, but numbers declined by 46,625 after a blockage restricted air flow and raised temperatures to 8.1°C, beginning in1980 (Elliott and Clawson 2001, Tuttle and Kennedy 2002).

Five-year, Range-wide Research Confirms early Findings — To further test the hypothesis that inappropriate hibernation roost temperatures are the primary cause of continuing population decline, BCI organized a range-wide study, begun in1998, to document temperature profiles at the species' most important known hibernation roosts. We led a thorough investigation of 15 sites in six states and installed 60 temperature/humidity dataloggers that tracked conditions at 3–hour intervals through an entire annual cycle.

Results further confirmed that populations of Indiana bats are stable or growing in most protected hibernation roosts where temperatures are adequate. Relatively stable temperatures between 3 and 6°C appear to be preferred, and range-wide, protected populations are stable or growing where they occupy these temperatures (Tuttle and Kennedy 2002). This is well illustrated at the Magazine Mine in Illinois, where such ideal conditions are apparently responsible for dramatic and continuing growth (Kath 2002). Our research is on-going, now including 23 caves and mines in nine states, and Indiana bat populations are stable or growing wherever hibernation temperatures fall within their ideal range (Tuttle and Kennedy, 2002).

Where roost temperatures have been unacceptably altered, most problems have resulted from entrance or passage enlargement or restriction during commercialization or nitrate mining, some from road construction. Cave entrances also open or close naturally over long periods, meaning that periodic monitoring of key Indiana bat hibernation roosts is essential.

Why Protection of Roosts Has Often Failed to Reverse Population Decline — Early Indiana bat recovery efforts focused almost entirely on protection of hibernation roosts from human disturbance. When many of those had been protected without significant recovery, it was assumed that summer habitat loss posed the primary threat, and efforts shifted to preservation of habitats used by summer colonies.

It is increasingly clear why past protection so often failed to restore populations. In cases of failure, key hibernation roost temperatures had been altered without being restored, or caves of last resort, that may have even served as periodic death traps, had been protected simply because they still contained displaced bats. Such

remnant groups sometimes appeared healthy because they could build for years, even decades at a time before an unusual weather event caused severe losses. An apparently thriving population at Rays Cave, Indiana, had been assigned critical habitat status due to recent growth. Yet, our monitoring clearly shows that despite currently adequate temperatures, 100-year weather events could kill massive numbers there (Tuttle and Kennedy, 2002).

In some cases, currently protected caves that serve as dangerous mortality traps are near potentially ideal hibernation caves that remain unprotected because they simply have not contained bats in historical times, and evidence of past use has not been recognized. For over 20 years Bat Cave, in Kentucky's Carter Caves State Resort Park, had been accorded critical habitat status and was gated and protected as the region's primary Indiana bat hibernation site. Bat Cave not only floods periodically, but also provides only marginal roosting temperatures, undoubtedly explaining fluctuating populations that have declined overall. In contrast, the park's adjacent Saltpetre Cave never floods and provides far better temperatures, but it had been opened to year-round commercial tours. There, we found abundant, but previously overlooked, roost stains that clearly documented past use by hundreds of thousands of Indiana bats. Most of the cave's bats had apparently been driven out and died during extensive saltpeter mining during the War of 1812, but a dwindling number had survived in Bat Cave. Based on our findings in 1998, commercial winter tours were stopped in Saltpetre Cave, and Indiana bat numbers have already grown as follows: 475 in 1999, 1,225 in 2001, 3,100 in 2003 and 6,088 in 2005 (Tuttle and Kennedy 2002; Kennedy 2004a, 2004b; 2005 Indiana Bat Recovery Team census).

Since 1999 BCI has funded microclimatic research in Saltpetre Cave, and several options have been identified for restoring the even better roost temperatures that undoubtedly prevailed prior to passage and entrance alterations. We began restoration of formerly lower temperatures in the summer of 2003 and will continue those efforts in 2005 and 2006. Given the already dramatic growth in Indiana bat numbers, we are especially optimistic about recovery prospects as we continue to improve this key site.

How Volunteer Cavers Can Help — Only relatively large, complex caves with multiple levels and entrances normally trap and store sufficient cold air to support Indiana bat hibernation. However, these are also the most attractive for commercialization and caver exploration and consequently were the first to lose their bats. By training cavers to recognize such caves and check them for roost stain evidence of past bat use, discoveries of great importance can still be made, as we are already demonstrating at Saltpetre Cave. Such critically important sites can be easily detected and reported by people who explore caves, especially by members of the National Speleological Society, who make enthusiastic and reliable volunteers and visit thousands of caves annually within the Indiana bat's range, especially in Kentucky.

An Exciting Opportunity to Reverse Decline — Now that we are able to document thriving recovery at widely separated locations where appropriate hibernation temperatures are being provided, formerly obscure problems are becoming apparent. A relatively narrow range of hibernation temperatures is essential to survival, and without restoring them, nothing else may matter. Armed with this knowledge, we have an exciting opportunity to reverse over 100 years of decline, and there is no place better suited to serve as a model for recovery success than Kentucky. It is, however, urgent that we begin before further losses occur. Like the now extinct passenger pigeon, Indiana bats appear to rely on numbers for survival. Hibernation temperatures required by Indiana bats can be restored, sometimes quickly and inexpensively (Tuttle and Kennedy 2002).

Leadership

BCI conducted the pioneering research that first documented the key role of hibernation roost temperatures in Indiana bat survival. It also has established an extensive, range-wide network of collaborating biologists and cavers, making it ideally qualified to lead urgently needed research and restoration efforts. We have documented both the need and feasibility of our approaches, and we are prepared to proceed as soon as we receive required funding. Our proposed restoration actions are achievable, and the anticipated results are clearly measurable.

Our initial focus on a few critically important caves, when successful, will have maximum impact in restoring Indiana bats and in encouraging further efforts at additional locations. Considering that 38 years of recovery efforts have failed to halt this species' decline, it is exciting to consider that a single three-year project at critically important hibernation caves could have sufficient impact to reverse the overall downward trend for the species. We won't know till we try, but results thus far are very encouraging. Furthermore, by training and collaborating with members of the National Speleological Society, we may discover and restore additionally important sites not yet recognized.

The project leader is Dr. Merlin Tuttle, founder and President of BCI. He is a world leader in bat conservation, has more than 40 years of personal field experience with endangered gray and Indiana bats, and organized the first Indiana Bat/Gray Bat Recovery Team. He also was the one who first compared Indiana bat population trends with roost temperatures, discovering this to be a key determinant of survival.

Dr. Tuttle will be assisted by BCI Cave Resources Specialist, Jim Kennedy, who led all data collection and analysis for the first definitive research on the temperature requirements of hibernating Indiana bats (Tuttle and Kennedy 2002) and co-edited the most up-to-date publication on Indiana bat conservation and management (Kurta and Kennedy 2002). He also has 19 years of field experience in monitoring Indiana bat hibernation sites.

Partnerships

We have already contacted many interested partners in Kentucky, and identified other potential partners. The preliminary list presented below is not exclusionary, as future partners will doubtless be identified and incorporated into these plans.

State and Federal Wildlife Agencies — The Kentucky Department of Fish and Wildlife Resources (KDFWR) is a major partner whose Endangered Species Biologist, Traci Wethington, is providing information on known hibernation roosts, census data, and support to initiate new cave assessments. John MacGregor, also with KDFWR, is another key partner, with extensive knowledge of bat roosts in Kentucky from his work with the State as well as with the Daniel Boone National Forest. John and Traci would both be involved in any workshops designed to train cavers and biologists in recognition and restoration of Indiana bat hibernation caves in Kentucky, and likely in follow-up work at important hibernation caves identified during field surveys. Traci also heads the Kentucky Bat Working Group (KBWG), a part of the Southeastern Bat Diversity Network (SBDN), which supports our work through its network of bat researchers and conservationists. This proposal has already been adopted by the KBWG, and was accepted as a high priority project at the SBDN meeting in mid-February, 2005.

State and Federal Land Managers — Two other important partnerships are ongoing, resulting from years of collaboration with Kentucky State Parks (KSP) and Mammoth Cave National Park (MCNP). State Naturalist Carey Tichenor and former naturalist John Tierney have been very supportive of our work at Carter Cave State Resort Park (CCSRP), and have many other contacts across the state for potential assistance. CCSRP has offered to host our first training workshop, and is a perfect location for such an event. Another potential workshop venue is at MCNP, where we already have cooperative hibernation cave research and restoration projects in progress. Mark Depoy, MCNP Natural Resources Director, and Rick Olson, MCNP Ecologist, have been very helpful in assisting our work in that area.

Local, Regional, and National Caving Groups — The above-mentioned partners all have information on known and potential hibernation caves to contribute to this project, but organized cavers will become an invaluable resource. The collective knowledge represented by cavers throughout the state cannot be understated. BCI has a long track record of involving cavers in bat research and conservation projects. Several local chapters of the National Speleological Society (NSS), known as grottos, have assisted with the ongoing restoration work at Saltpetre Cave, and have already pledged to assist with extensive additional work there. The Kentucky

Speleological Survey (KSS) will provide maps and cave reports, as well as co-sponsorship of training workshops. Brent David Ray, President of the KSS, has pledged his organization's support for data-gathering, local land-owner contacts, and workshop sponsorship.

Academic Researchers — BCI has supported student research through its Student Scholarship Program since 1990, and other research and conservation projects since 1998 through the North American Bat Conservation Plan (NABCP) Conservation Fund. There will be ample opportunity for students and professors alike to undertake much-needed research on hibernating physiology and cave microclimates. Currently, no specific research projects are being negotiated, but qualified researchers will definitely be advised and supported.

Project Scope and Duration

Some aspects of this project should continue until the Indiana bat has recovered sufficiently to be down-listed from endangered status. However, the primary objectives can be completed in three years. In this period, our goals are to train a corps of volunteers to identify important but previously unrecognized hibernation caves, especially those mined for saltpeter, in order to focus future conservation and restoration efforts on key sites that require restoration or currently remain unrecognized. Specifically, we will:

① Develop and distribute educational and training aids (book, poster) to assist cavers, consultants, and land managers in identifying and prioritizing hibernation caves;

② Provide training workshops for volunteer cavers and wildlife management professionals;

③ Investigate Kentucky saltpeter caves as likely former hibernation roosts, making recommendations for future management;

④ Facilitate much-needed research on cave modifications that have adversely altered hibernation roosts;

⑤ Restore required roost temperatures at Saltpetre Cave and document a positive population response;

⑥ Expand experimentation and research on how to restore required temperatures at Coach Cave; and

⑦ Collaborate with the National Park Service to restore required Mammoth Cave System temperatures sufficiently, at least in isolated sections, such as Long Cave, to reverse some of the system's downward population trends.

Literature Cited

Clawson, R. L. 2002. Trends in population size and current status. Pp. 2–8, *in* The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, *eds*.). Bat Conservation International, Austin, Texas. 253 pp.

Elliott, W. R., and R. L. Clawson. 2001. Temperature data logging in Missouri bat caves. Pp. 52–57, *in* 1999 National Cave and Karst Management Symposium Proceedings (G. Thomas Rea, ed.). Southeastern Cave Conservancy, Inc., Chattanooga, Tennessee. 221 pp.

Kath, J. A. 2002. An overview of hibernacula in Illinois, with emphasis on the Magazine Mine. Pp. 110–115, *in* The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, *eds*.). Bat Conservation International, Austin, Texas. 253 pp.

Kennedy, J. 2004a. Restoration, not just conservation, of bat caves — need, methods, and case study of a *Myotis sodalis* hibernaculum. Pp. 93–100, *in* 2003 National Cave and Karst Management Symposium Proceedings (G. Thomas Rea, ed.). NCKMS Steering Committee, Gainesville, Florida. 118 pp.

Kennedy, J. 2004b. Ecological restoration at Saltpetre Cave, Carter Caves State Resort Park, Carter County, Kentucky. Unpublished report to Bat Conservation International. 6 pp.

Kurta, A., and J. Kennedy, *eds*. 2002. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, Texas. 253 pp.

Silliman, B. 1851. On the Mammoth Cave of Kentucky. American Journal of Science and Arts (Second Series) 11:332-339.

Tuttle, M. D. 1997. A Mammoth discovery. Bats 15:3-5.

Tuttle, M. D., and J. Kennedy. 2002. Thermal requirements during hibernation. Pp. 68–78, *in* The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, *eds*.). Bat Conservation International, Austin, Texas. 253 pp.