Note: This is the Cave Life chapter taken from the Bonne Femme Watershed Plan, February, 2007 which was adopted by the City of Columbia, City of Ashland and Boone County Commission. The entire plan can be found at www.cavewatershed.org.

Cave Life in the Bonne Femme Watershed

Missouri is sometimes called "The Cave State" because caves are so abundant throughout Southern Missouri and the Missouri and Mississippi River border areas. The Missouri Speleological Survey has recorded the locations of about 6300 caves. Many people find caves to be fun places to explore, places to see beautiful stalactites of calcite and to challenge one's fear of the dark and unknown. Adding to the mysterious surroundings are mysterious animals. Bats, with their unique insect-catching abilities of flight and echolocation, sleep through the winter while hanging from cave ceilings in the mild year-round temperatures. Other creatures are unlike anything seen above ground. They lack color and eyes and manage to live quite well in an environment with no light or plants.

Many of these mysterious creatures remain undiscovered. Undiscovered because scientists haven't yet visited their cave – only about 1000 (about 15%) of Missouri's caves have been inventoried for cave life (Elliott, 2006a). Undiscovered because some of the animals are tiny. Undiscovered in the sense that while some have been found, they haven't yet been taxonomically described and named. Undiscovered in that while some have been described and named, we understand very little about how they live and interact with other animals.

The pink planarian existed in obscurity underground for thousands of years before being discovered by scientists in 1956 (Hyman, 1956). Fifty years later, only a little research has been conducted and still much is unknown about how the pink planarian lives or about the ways it could benefit humans. Other species of planarians were useful in the 1960's in research about how memory works (Jacobson, 1966). Planarians are one of the simplest of animals that have brains and nervous systems. The pink planarian is a flatworm about 1 inch long and about ¼ inch wide. They are white or translucent, sometimes with a pink tinge. Both male and female sexual organs exist within each individual. A cocoon of eggs is produced (Kenk, 1975). In a laboratory, pink planarians ate amphipods. One of the mysteries that remains is how pink planarians manage to catch amphipods in the wild. Amphipods are fast swimmers and pink planarians have no eyesight (and it's dark anyway). Another mystery is whether animals such as crayfish and salamanders prey upon pink planarians.

The pink planarian flatworm has been found to live no where else in the world except inside Devil's Icebox Cave. It's about an inch long and adheres to rocks in the cave stream. Missouri Department of Natural Resources file photo taken by Scott W. Schulte.

One thing that is special about the pink planarian is its rarity. This species has been found to exist in no other cave besides Devil's Icebox Cave. This means the pink planarian is "endemic," being restricted to this one habitat. Endemic can refer to areas of various size, but with cave animals, usually refers to one cave. The entire population of pink planarians exists in one cave stream, making it vulnerable to extinction should Devil's Icebox Cave Branch become polluted. One would hope that if the main cave stream became polluted, that some individuals in the underground tributaries to the main stream would survive to repopulate, but to date, none have been found in the cave tributaries (Sutton, 2004).

The pink planarian is adapted to the nutrient inputs received from hundreds of sinkholes and obviously survived agricultural practices of early Boone County that included hog lots and soil erosion. However, it's not known what effect modern chemicals, pesticides, oils, etc. may have on the pink planarian – another mystery. A 1981 ammonia pipeline break killed thousands of cavefishes, cave crayfishes, and grotto salamanders in Maramec Spring Cave, Missouri. But the more common types of cave pollution are less dramatic and occur over a long time period. These include siltation and the input of extra nutrients.

Siltation is when fine silt or dirt is washed in and is deposited in between and on top of rocks on the bottom of the cave stream. A low amount is natural, but high amounts can be very harmful. If not managed well, large amounts of silt can be washed in from construction sites and other lands that lack vegetation. Pink planarians and other cave animals move through spaces under and between rocks, so if those spaces are filled, they loose habitat. In Mammoth Cave, Kentucky, siltation in the lower level pools resulted in the absence of a previously common cave-restricted isopod and it's predator crayfish (Lewis 1980, Poulson 1996). In Missouri, siltation from a neighbor's cattle farm that had been cleared of most vegetation probably caused the severe decline of the Tumbling Creek cavesnail (Elliott et al., 2005).

Caves naturally have very little food available for animals. Species adapted to caves can live in these conditions but most animals can not. Because caves are naturally poor in food supply, it is a threat when extra nutrients from fertilizers, manure, etc. are carried in from the land. Too much food supply can cause a population explosion of species of amphipods and isopods that live both above and below ground. This increased competition for space disrupts the cave ecology and harms species that live only in caves. The result is a replacement of the cave-restricted species with species that also exist on the land. Species replacements are common knowledge among cave biologists. In Mammoth Cave, Kentucky, a rotting staircase in one area caused an amphipod to dominate and replace the previous resident - a cave-restricted isopod (Lewis 1987, Poulson 1996). A severe case of sewage pollution in Hidden River Cave, Kentucky caused the disappearance of cavefish and cave crayfish (EPA 1981, Lewis 1989, Quinlan 1977).

The amphipod on the left (*Crangonyx forbesi*) lives both above and below ground, while the amphipod on the right (*Bactrurus brachycaudus*) is restricted to underground habitats. Photos taken by William R. Elliott, courtesy of the Missouri Department of Conservation.

It is no mystery that each animal needs a habitat. Some animals are more restricted in what can serve as habitat for them. Cave-restricted species (also called troglobites) live their entire lives inside caves and cannot survive outside of caves. Other species (called troglophiles) sometimes like to live in caves, but also live above ground. For example, a salamander that normally lives in leaf litter and under logs above ground can find its way into a cave and survive there as well. If a temporary toxic pollution event occurring in a cave, a troglophile species would loose only a small percentage of its population and could repopulate the cave when conditions improve because individuals from above ground could again find their way into the cave. But, the entire population of a cave-restricted species could be wiped out from the cave with no nearby individuals available to repopulate. The only way both categories of animals can continue to exist is if cave habitats are managed primarily for the sake of cave-restricted species. The natural world is healthier when a greater number of native species (biodiversity) are present because each is unique and plays a role within its ecosystem. Protecting biodiversity is a goal among biologists. In part, biologists are admitting that much remains a mystery. Since we don't understand all of the intricacies of relationships among animals in an ecosystem it's prudent, as Aldo Leopold advised, to "keep all of the parts," just in case we learn that something is more important than previously realized. It's hard to get research dollars devoted to obscure little cave animals, so many are not researched. They may hold the secrets that will unlock mysteries that can benefit people, someday… if we keep all of the parts.

Missouri has 83 cave-restricted species, 68 described and 15 not yet described, (Elliott, 2007). Troglobites found in Missouri caves include white and blind cavefishes, the grotto Salamander, millipedes, crustaceans (crayfishes, isopods and amphipods) and planarians. Sometimes an animal is not only restricted to cave habitats, but also restricted to just one particular cave (endemic). That is the case with the pink planarian and with a new species of isopod that was collected by Mick Sutton in 2003. Both live in the stream inside Devil's Icebox Cave. Because it is endemic, the pink planarian is listed as a species of conservation concern by the Missouri Conservation Department in categories defined as "critically imperiled" in Missouri (S1) and "globally imperiled" (G2G3) (MDC, 2006). A difficult process is involved in becoming classified as "endangered" by the U.S. Fish and Wildlife Service - something not yet attempted for the pink planarian.

The number of endemic and cave-restricted species recorded for a particular cave affects how it ranks among other caves of Missouri in biodiversity. This scoring system was developed by William R. Elliott, Missouri Department of Conservation Cave Biologist as a means of evaluating and communicating the relative biological importance of Missouri caves (Elliott, 2007, 2000a, Elliott and Ashley, 2005.) In addition to being the 7th longest cave in Missouri with 6.25 miles of passages, Devil's Icebox Cave is ranked as second in biodiversity among Missouri's 6,300 caves. The cave that is number one in Missouri is also the highest in cave biodiversity among caves west of the Mississippi River - Tumbling Creek Cave in Taney County. Missouri ranks about seventh in the United States in troglobite biodiversity. Overall, Devil's Icebox Cave

would rank highly among western US caves, while many Eastern US caves would have higher biodiversity. (Elliott, 2007).

The biological records for Devil's Icebox Cave include about 200 observations and collections. These records have been entered into the Missouri Cave Life Database, a project of the Missouri Department of Conservation and its partners. Devil's Icebox Cave now has about 80 species, 9 of which are cave-restricted. About 23 species are not completely identified yet, but this is not unusual for a large cave with a rich fauna. The cave-restricted species include a spider, an amphipod, the Tingupa cave millipede and the Missus cave springtail. Their identity is about all we know about them.

On the other hand, a lot of research has been conducted with bats. In 2002, it was reported that the U.S. Navy was studying bats because the Navy's sonar systems are not as sophisticated as those of bats (Simmons, 1998). Bats are able to differentiate between sounds that are only 12 millionths of a second apart, and between objects separated by only the width of a human hair (Simmons, 1998). Research for medical benefits has focused on hibernation and reproduction. Sperm is stored alive inside the female bat's body all winter prior to fertilization (Schwartz, 1981). Bats of the genus Myotis (includes gray and Indiana bats) caught 500 to 1000 mosquitos in one hour in a laboratory study (Griffin, 1960). Each female corn earworm moth lays about 2,500 eggs that become caterpillars and damage our corn crops, but bats eat these moths and disrupt their reproductive behavior (Gillam, 2002).

Devil's Icebox Cave is important as habitat for both gray and Indiana bats, both of which are federally listed endangered species. Female gray bats establish a nursery colony for raising their young each year, using Devil's Icebox Cave April through August. The gray bat colony currently numbers about 13,000. One mystery that remains is how the bats, who fly here in the spring from caves about 325 miles away, find the small cave entrance. Another mystery scientists are frantically trying to solve is why Indiana bat numbers continue to drop drastically, while gray bat numbers have been steadily increasing. A few hundred Indiana bats are hibernating inside Devil's Icebox Cave despite the fact that the temperature there is warmer than what scientists thought they prefer.

Hundreds, if not thousands, of other bats hibernate in the 55 degree F temperatures of Devil's Icebox Cave, including the little brown, big brown, long-eared and Eastern pipistrelle species. In addition, a variety of land animals use caves from time to time to escape from predators, drought, heat and cold. They include the pickerel frog that congregates in the water passage of Devil's Icebox cave, sometimes in the hundreds.

One question that may come to mind is why Devil's Icebox Cave has such a high biodiversity level. The answer has to do with its location within the natural divisions of Missouri and with its watershed. Most Missouri caves are located south of the Missouri River and were not affected by glaciers. Some of the glaciers covered northern Missouri and stopped their southern push in the general area of what is now central Boone County. These glaciers deposited deep soils. Their melting washed silt into the Missouri River valley. That silt was picked up by winds and deposited over much of Boone County. It is theorized that the deep mud deposits inside Devil's Icebox Cave may have washed in when the glaciers melted (Weaver 1980). Definitely, water that flows through the Devil's Icebox Cave now carries with it nutrients from the deep soils of the upper Bonne Femme Creek. In addition, leaves, sticks and other debris enter the cave through the many

sinkholes of the Pierpont Karst. These inputs provide more nutrients for cave life than what is typically seen with caves of Southern Missouri. These nutrient levels are still much lower than those of surface streams and much lower than what could easily occur if poor land management occurs in the cave's watershed. To generalize, Northern Missouri doesn't have caves and Southern Missouri's caves are lower in nutrient inputs, making caves of Boone County rather unique. The caves of Boone County do not contain the cave-restricted species of fishes and crayfishes found in Southern Missouri, but contain cave life not found in Southern Missouri caves.

Large caves of Boone County, other than Devil's Icebox Cave, include Hunter's Cave (located within Three Creeks Conservation Area within the Bonne Femme watershed) and Rocheport (Boone) Cave (not in the Bonne Femme watershed). They have few cave-restricted animal species and no endemic species, so their biodiversity scores are low. The watersheds that feed water through most of the length of Hunter's Cave and through Rocheport Cave are small in size. Some water diverts from Bass Creek to flow through a short lower section of Hunter's Cave, but the land drained by Bass Creek has soils that are not as rich and deep as those of the upper Bonne Femme Creek (that feeds Devil's Icebox Cave). Hunter's Cave has 33 species, four of which are cave-restricted. It is a minor roosting site for male gray bats during the summer months. For some maybe not-so-mysterious reason, they don't hang out with the females at the nursery site in Devil's Icebox Cave! Probably more species will be found in Hunter's Cave, but it is smaller than Devil's Icebox Cave, has fewer microhabitats and less flowing water. Consequently, it will likely not have as much biodiversity as Devil's Icebox Cave. Rocheport Cave is a relatively short cave that floods violently. Although Rocheport Cave has 32 species, it has no cave-restricted species. It does, however, provide an important roosting area for Indiana and gray bats because of the height and shape of cave passages and their temperatures. (Elliott, 2007)

Devil's Icebox Cave and some of its life are unique. The rich soils of the cave's watershed and numerous sinkholes input more nutrients than what most caves receive and thus support a rich diversity of life. Devil's Icebox Cave is ranked second in biodiversity among Missouri's 6,300 caves. Slowly, as funds are available, scientists are revealing more about the mysterious life that resides only in caves. Since many mysteries remain, some of which may benefit people, and since you can't fix something unless you keep all of the parts, it's an important goal to protect these cave-restricted animals. The endemic cave-restricted pink planarian lives in the stream that flows through Devil's Icebox Cave. It and other aquatic cave animals are very vulnerable to chemicals, dirt and extra nutrients that could easily wash in from the watershed.

Contributors: Roxie Campbell, Interpretive Resource Specialist, Missouri Department of Natural Resources at Rock Bridge Memorial State Park; William R. Elliott, Cave Biologist, Missouri Department of Conservation, Resource Science Division.

Bibliography:

Elliott, W.R. 2000a. Below Missouri karst. Missouri Conservationist, 61(3):4-7.
Reprinted *in* Conserving Missouri's Caves and Karst, 2002, Missouri Department of Conservation.

Elliott, W.R. 2000b. Conservation of the North American cave and karst biota. Chap. 34, pp. 665-689 *in* Wilkens, H., D.C. Culver, and W.F. Humphreys (eds.), *Subterranean Ecosystems. Ecosystems of the World*, 30. Elsevier, Amsterdam. xiv + 791 pp. [Electronic reprint on Biospeleology web site].

Elliott, W.R. 2003. A Guide to Missouri's cave life. Missouri Department of Conservation. 40 p.

Elliott, W.R. 2004. Protecting Caves and Cave Life. p. 458-467 *in* Culver, D.C. and W.B. White (eds.), *Encyclopedia of Caves*, Elsevier Science.

Elliott, W.R. 2006a. *Biospeleology: The Biology of Caves, Karst, and Groundwater*. University of Texas at Austin, http://www.utexas.edu/tmm/sponsored_sites/biospeleology

Elliott, W.R.. 2006b. Biological Dos and Don'ts of Cave Restoration and Conservation. pp. 33-46 IN Hildreth-Werker, V., and J. Werker (eds.), *Cave Conservation and Restoration*, National Speleological Society. 600 pp.

Elliott, W.R. 2007. Zoogeography and biodiversity of Missouri caves and karst. Journal of Cave and Karst Studies. *In press.*

Elliott, W.R., and David C. Ashley. 2005. Caves and Karst. pp. 474-491 i*n* Nelson, Paul, *The Terrestrial Natural Communities of Missouri*, third ed. Missouri Natural Areas Committee. 550 pp.

Elliott, W.R, Stephen T. Samoray, Sara E. Gardner and Thomas Aley. 2005. Tumbling Creek Cave: An ongoing conservation and restoration partnership. American Caves, March, 2005:8-13.

EPA. 1981. Environmental Impact Statement, Mammoth Cave Area, Kentucky. U.S. Environmental Protection Agency, EPA 094/9-81-071, pp. i-V1.

Griffin, D.G., Webster, R. A. and C.R. Michael. 1960. The echolocation of bats. Animal Behavior, 8:141-154.

Gillam, E.H., McCracken G.F. and J.K. Westbrook and P.G. Schleider. 2002. Virtual bats and real insects: effects of echolocation on the reproductive behavior of the corn earworm moth, Helicoverpa zea. Bat Research News, 43 (4): 148-149.

Jacobson, A.L., Clifford F. and S.D. Horowitz. 1966. Planarians and memory. Nature, 209:599-601.

Kenk R. 1975. Fresh-water Triclads (Turbellaria) of North American. VII. The Genus Macrocotyla. Trans. Amer. Micros. Soc., 94(3): 324-339.

Lewis, J.J. and T.M. Lewis, 1980. The Distribution of Two Species of Subterranean Caecidotea in Mammoth Cave National Park. Cave Research Foundation Annual Report, 1980, p.23-26.

Lewis, Julian J. 1987. Aquatic communities in the Cathedral Domes section of Mammoth Cave. Cave Research Foundation 1987 Annual Report, p. 35-39.

Lewis, Julian J. 1989. The Outlook for Reclamation of Hidden River Cave, Hart County, Kentucky. Cave Research Foundation 1989 Annual Report, p. 59-61.

Lewis, Julian J. 1996. The Devastation and Recovery of Caves and Karst Affected by Industrialization. Proceedings of the 1995 National Cave Management Symposium, Spring Mill State Park, Mitchell, IN, p. 214-227.

MDC. 2006. Missouri Species and Communities of Conservation Concern Checklist. Missouri Department of Conservation. Nat. 329.

Poulson, T.L. 1996. Research Aimed at Management Problems Should be Hypothesis Driven: Case Studies in the Mammoth Cave Region. In: G.T. Rea (editor), Proc. 1995 Natl. Cave Management Symposium, Spring Mill, Indiana, p. 267-273.

Quinlan, J.F. and D.R. Rowe, 1977. Hydrology and water quality in the central Kentucky karst, phase 1. University of Kentucky Water Resources Inst. Research Report 101.

Schwartz, C.W. and E.R. Schwartz. 1981. The Wild Mammals of Missouri. University of Missouri Press, 356 pgs.

Simmons, J.A., Ferragamo M.J. and Moss C.F. 1998. Echo-delay resolution in sonar images of the big brown bat, Eptesicus fuscus. Proc. Nat. Acad. Sci. 95, 12647 -12652.

Sutton, M.J. 2004, The Pink Planarians of Devil's Icebox Cave–Census protocols. Cave Research Foundation report to Missouri Department of Natural Resources and Missouri Department of Conservation, 35 p.

Weaver H. D. and P.A. Johnson. 1980. Missouri The Cave State. Discovery Enterprises. 336 pgs.