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CAVES AND KARST

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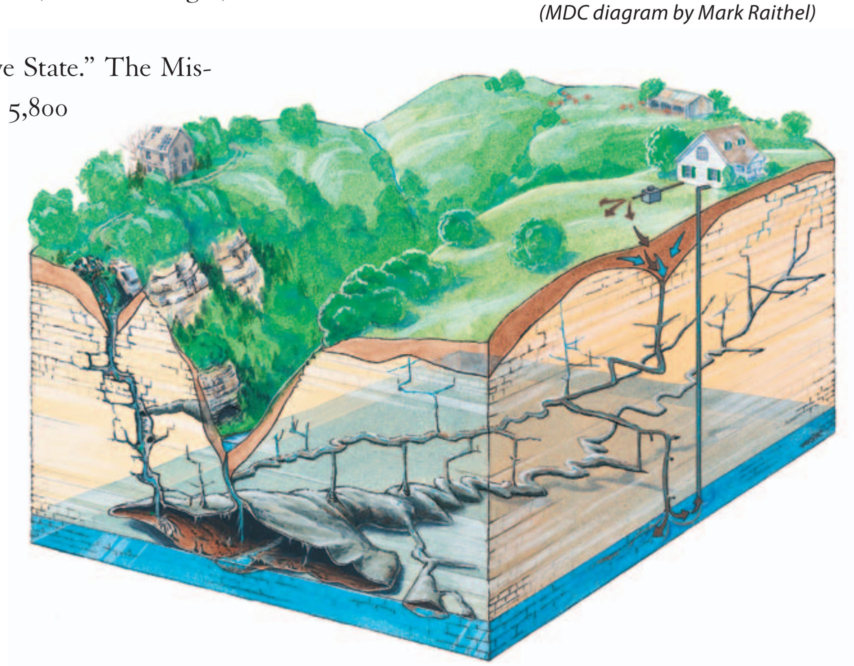
CAVES are an important part of the Missouri landscape. Caves are defined as natural openings in the surface of the earth large enough for a person to explore beyond the reach of daylight (Weaver and Johnson 1980). However, this definition does not diminish the importance of inaccessible microcaverns that harbor a myriad of small animal species. Unlike other terrestrial natural communities, animals dominate caves with more than 900 species recorded.

Cave communities are closely related to soil and groundwater communities, and these types frequently overlap. However, caves harbor distinctive species and communities not found in microcaverns in the soil and rock. Caves also provide important shelter for many common species needing protection from drought, cold and predators.

Missouri caves are solution or collapse features formed in soluble dolomite or limestone rocks, although a few are found in sandstone or igneous rocks (Unklesbay and Vineyard 1992). Missouri caves are most numerous in terrain known as karst (FIGURE 30), where the topography is formed by the dissolution of rock and is characterized by surface solution features. These include subterranean drainages, caves, sinkholes, springs, losing streams, dry valleys and hollows, natural bridges, arches and related features (Rea 1992).

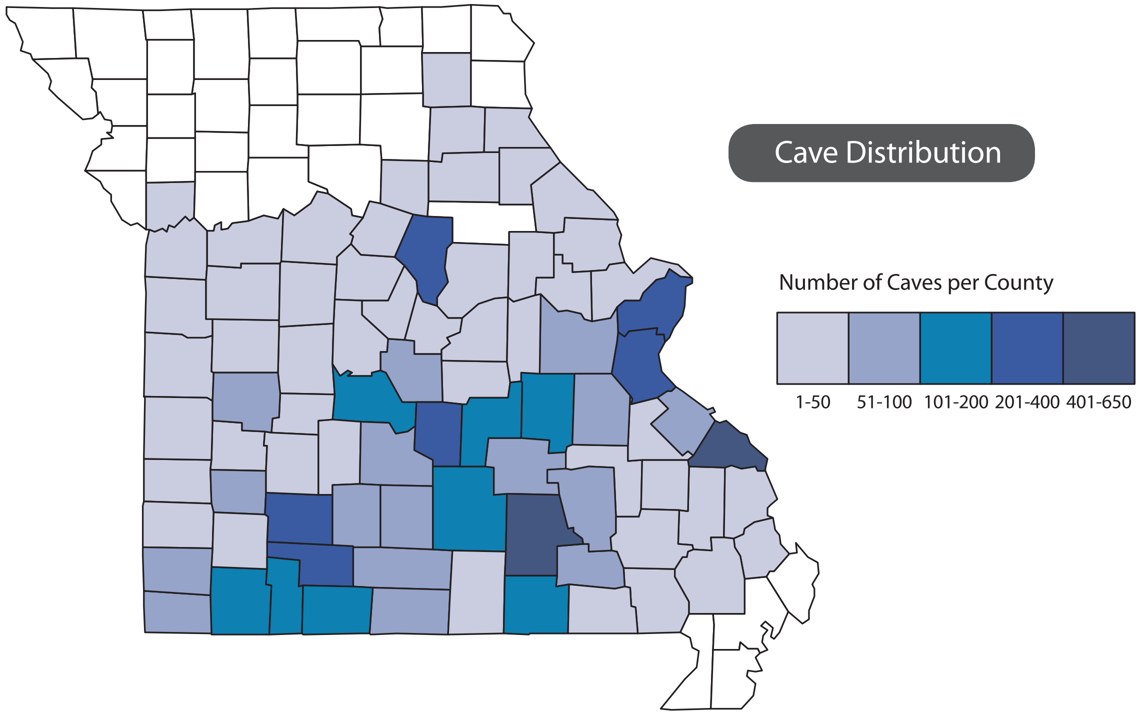
Figure 30. Karst block diagram *(MDC diagram by Mark Raithel)*



Missouri is sometimes called "The Cave State." The Missouri Speleological Survey lists about 5,800 known caves in Missouri, based on files maintained cooperatively with the Missouri Department of Natural Resources and the Missouri Department of Conservation. The highest density of caves is in Perry County (650 caves) followed by Shannon County (500 caves). There are more than 500 linear miles of Missouri cave passageways, 51 percent of which lie under Perry County. The distribution of caves is shown in Figure 31.

The Lily Pad Room is one of the many interesting features in Onondaga Cave, which has been designated a National Natural Landmark. Onondaga Cave State Park, Crawford County. DNR PHOTO BY EUGENE VALE

Figure 31. Cave distribution in Missouri. *MDC graphic by William R. Elliott*



Most caves share one thing in common — darkness. Beyond this, each cave has its own set of unique and fascinating dimensions. The longest is Crevice Cave in Perry County, with more than 28 miles of mapped passage. Marvel Cave in Stone County is the deepest at 383 feet below the surface. Some entrances are over 100 feet wide and high. One system has been dye-traced for 39.5 miles from the input point in Texas County to a spring in Carter County — the longest known dye trace in the United States. Missouri caves contain a myriad of speleothems (cave formations), meandering streams, waterfalls, lakes as deep as 200 feet, and cave floors mantled with red clay, silt, mud, gravel, breakdown (rocks from the ceiling), talus, organic detritus and guano (animal droppings).

Caves are popular for educational and recreational uses. About 50 Missouri caves have been commercialized as show caves, although fewer than 20 of them are still open to the public (Gurnee and Gurnee 1990).

Cave Classification

There are different geomorphological types of solutional caves, different cave entrances and different cave communities. Cave communities are found in most types of caves and with various entrances. Various cave animals are found in different zones, such as the entrance, twilight and dark zones of the cave. Some writers refer to the constant temperature zone where the temperature may vary less than one degree in a year from the annual mean, which is 53 to 55 degrees Fahrenheit in Missouri. However, cave temperatures can vary considerably.

Geomorphological types of solutional caves include branchwork (dendritic), network (maze), anastomotic (braided) and ramiform or spongework types (Palmer 1991). Most Missouri caves are branchwork or linear remnants of such caves, which formerly were conduits for springs. Some of these springs may no longer exist because of gradual hydrogeologic changes.

Entrance types in Nelson (1987) have been revised to reflect terminology used in karst science and biospeleology (cave biology). These entrance types are:

- Cave spring (formerly effluent cave)
- Swallet (formerly influent cave)
- Wet pit cave
- Dry pit cave
- Dry cave

A cave spring has a stream flowing from the entrance. The Missouri Natural Heritage Database distinguishes "caves," which may be dry or wet, from "cave springs" and "springs." Confusion sometimes occurred previously because some sites were named only as springs, but may also have a large cave behind them. The latter are now termed "cave springs," whereas a "spring" (narrowly defined) has no air-filled cave. A spring could be karstic (in limestone or dolomite), or nonkarstic (sandstone, igneous or other relatively insoluble rock).

Many caves have springs that have sunk into the cave floor before exiting the entrance, and they now flow from rocks or gravel below the entrance; the water may overflow through the entrance at times, thus they can be perennial cave springs or intermittent cave springs. Most caves of this type have dendritic (branched like a tree) passages. Various terms are used for different types of springs: a resurgence spring is supplied primarily by the sinking of surface streams, while an exsurgence spring is fed by diffuse seepage waters from the karst landscape (Jennings 1971). Many intermediate situations occur.

A rising is a deep spring, such as Blue Spring in Shannon County. Many caves are associated with springs located in river valleys in the Ozarks. Often, the communities associated with a cave spring depend on bat guano as the basis for the food chain. Most gray bat (*Myotis grisescens*) caves are cave springs because this species likes to roost and forage over water. An example is Smittle Cave in Wright County.

A swallet or swallow hole is characterized by an intermittent or perennial flow of water, usually a stream that enters a cave system through an upstream entrance. The swallet can be a horizontal entrance, a sinkhole or a crack in a streambed. Subterranean piracy takes place when a surface stream is diverted underground via a sinkhole or cave within its valley. In contrast to cave springs, large quantities of organic debris are typically "flushed" into the cave system (often through a swallow hole) forming a food base for cave life. Examples of swallets include River Cave at Ha Ha Tonka State Park in Camden County, and Grand Gulf Cave at Grand Gulf State Park in Oregon County (Beveridge and Vineyard 1990). Boone (Rocheport) Cave in Boone County is a flash-flooding swallet and resurgence.

Pit caves contain vertical entrances. The entrance shaft or pit is usually associated with sinkhole solution features or crevices on bluffs. Few pits exceed 100 feet deep in Missouri. The entrance of Marvel Cave at Silver Dollar City in Stone County is a deep pit. A sinkhole is a closed depression on the land surface. It may be a free-fall pit, a depression with a cave entrance or may lack an entrance but still serve as a water collector. The distribution of sinkholes in Missouri is shown in Figure 29.

Wet pit caves contain permanent water occurring as subterranean streams or lakes. One of Missouri's most spectacular wet pit caves is Devil's Well in Shannon County. The cave opening is in the basin of a large sinkhole, a crevice that opens in the ceiling of a large underground cavern. The cave room is 400 feet long and 100 feet wide with water 93 feet below the entrance. The water forms a lake 90 feet deep. The outlet for the system is Cave Spring on the Current River (Weaver and Johnson 1980, Beveridge and Vineyard 1990).

Dry pit caves feature sinkhole shafts or open joint fissures descending to relatively dry cave floors. The floor is often littered with leaves, twigs, eroded soil, windblown dust and even animal bones. Many such pit caves create traps that various animals accidentally fall into, dying of injury or starvation. Paleontological excavations of cave floors in fissure and pit caves have turned up the remains of black bear, beaver, bobcat, woodchuck, mountain lion, box turtle and human (Mehl 1962). One of Missouri's most awesome dry pit caves is The Mammoth Fissure in Pike County. It is an open joint crevice a few feet wide, 1,000 feet long and 100 feet deep. Some pits, like Coffin Cave in Laclede County, are important cold-air-trap caves for hibernating bats.

Dry caves may be rock shelters formed by erosion of cave segments or cave springs that were left high and dry by the downcutting of river valleys and the lowering of the water table. The cave passageway is elevated high enough above the water table that the cave floor is usually not ponded, but the cave may be quite damp. Intermediate situations occur. A variety of moisture and humidity levels can occur throughout the cave depending on rainwater infiltration and airflow characteristics. Most dry cave entrances occur on elevated hillsides, on high cliffs or in crevices.

Geography

There are few caves in the northwestern one half of the Central Dissected Till Plains Section and in the Mississippi River Alluvial Basin Section. Caves are most numerous in the Ozark Highlands Section and the Mississippi River Hills Subsection of the Central Dissected Till Plains Section where there is more karst terrain. There are at least five distinct karst regions. These regions do not necessarily coincide with conventional physiographic or biogeographic regions, but are related to rock type, hydrology and cave biogeography (Elliott 2000b, Elliott et al. 2002). Karstic rocks include dolomites and limestones of Cambrian to Mississippian age, 530–330 million years old. These regions are outlined in Figure 32.

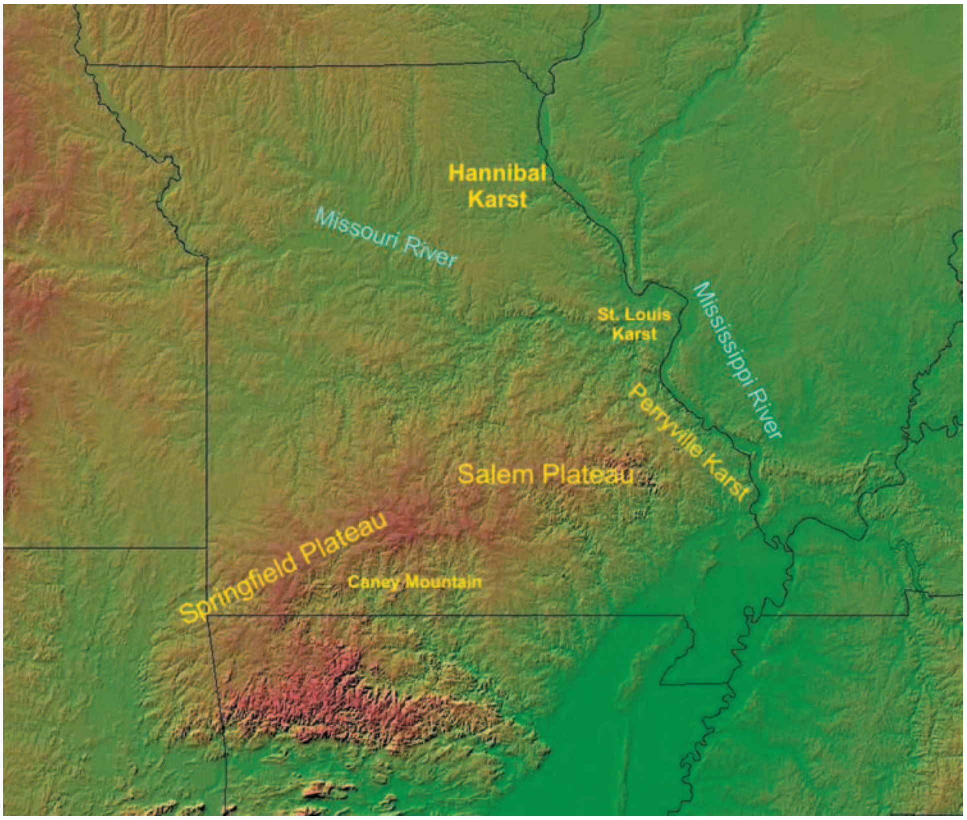
Karst Regions

Hannibal Karst: This region is also called the Mark Twain Karst (near Hannibal in Marion County) and contains Mississippian-age limestones. Network (maze) caves, such as Mark Twain and Cameron caves, are formed along joints and may have originated beneath an earlier version of the Mississippi River. Some caves occur in the Mississippi River Hills (Lincoln Hills) Subsection nearby. Biodiversity is low.

Perryville Karst: In Perry and adjacent counties, the Ordovician Joachim Dolomite and other formations contain the highest density of caves and karst features in Missouri. Many large stream caves with sinkhole entrances, karst windows and swallets underlie farmland. Biodiversity is high in less polluted caves such as Mystery, Berome Moore and Tom Moore caves.

Salem Plateau: The largest contiguous karst region is in south-central Missouri and is considered a cave factory with the oldest and most spectacular caves in the Gasconade (Ordovician) and Eminence (Cambrian) dolomites. Many large springs, cave springs and caves of all sizes abound. Outstanding examples are Round Spring Cavern near Eminence (operated by the National Park Service) and Onondaga Cave in Crawford County (operated by the Missouri Department of Natural Resources). Many important roosts for federally listed gray bats (*Myotis grisescens*)* and Indiana bats (*Myotis sodalis**)

Figure 32. Karst regions of Missouri. *MDC graphic by William R. Elliott*



* indicates species of conservation concern (Missouri Natural Heritage Program 2004)

occur in river valleys. Representative species are Salem cave crayfish (*Cambarus hubrichti*) and southern cavefish (*Typhlichthys subterraneus*).

Springfield Plateau: An arc of Burlington and Keokuk limestones (Mississippian-age) runs from central Missouri to Springfield and into northern Arkansas. Caves in this area are relatively younger and of simpler structure. A fine example is Fantastic Caverns near Springfield. Representative stygobites include the bristly cave crayfish (*Cambarus setosus*) and the endangered Ozark cavefish (*Amblyopsis rosae**), which range into Arkansas and Oklahoma.

St. Louis Karst: This Mississippian karst region is all but obliterated by urban development. Some caves remain under downtown buildings and in parks and conservation areas. Biodiversity is relatively low except in a few instances.

Cave Animals

Beyond the entrance, caves are totally dark and lack enough light for plants to grow; therefore they are "food-poor" environments involving decomposer communities. The food chain is dependent on organic detritus, dung and the corpses of cave crickets, bats and other creatures. The base of the food chain starts with fungi and bacteria. The terrestrial cave community is based upon invertebrates such as springtail insects, millipedes, certain beetles and flies that feed upon guano, corpses, fungi and bacteria. Spiders, pseudoscorpions, cave webworms, beetles and salamanders prey on them. In aquatic cave communities, the grazers are amphipods, isopods and cave snails, which are fed upon by grotto salamanders, cave fishes and cave crayfishes. Raccoons, which can travel long distances in the dark, may be the top predator. In Missouri, aquatic and terrestrial cave communities are interdependent.

Figure 33. *Typhlotriton spelaeus*, the grotto salamander is the trademark cave species of the Ozarks. The larvae live in cave streams and springs and the adult is equally at home in water or on a damp cave floor. Note the skin growing over the eyes and the absence of gills in the adult. *MDC photo by William R. Elliott*

Cave organisms are categorized into groups based on the organism's use of the cave habitat (Elliott 1992, 2003a, Ashley and Elliott 2000). One group restricted to cave life is called troglobites or troglobionts. A stygobite is an aquatic troglobite. Phreatobites inhabit groundwater but not necessarily caves. The grotto salamander (*Typhlotriton spelaeus**) (FIGURE 33) is a unique stygobite adapted to life in darkness. The larval stages are darkly pigmented and have functional eyes. As they mature, they lose their pigmentation and tissue grows over their eyes so that the adults are pinkish and partly or completely blind. White and blind cavefishes, millipedes, crustaceans (crayfish, isopods and amphipods) and planarians are found in some Missouri caves. Grotto sculpins (*Cottus carolinae**) inhabit some caves in Perry County and they appear to be somewhat cave adapted.

* indicates species of conservation concern (Missouri Natural Heritage Program 2004)

Organisms that favor caves but that are not restricted to them are called troglophiles. These organisms are also found in forest leaf litter, under rocks and logs and in similar habitats. Most species of cave-dwelling salamander (except the grotto salamander) in Missouri are troglophiles. Other troglophiles include pigmented amphipods and isopods found in cave streams and cave pools. Fish (like sculpins) will often move up streams into caves.

Trogloxenes are animals that spend considerable time in caves but cannot complete their entire life cycle there. They must regularly move in and out of caves for a variety of reasons. They might be in a cave to hibernate (for example, bears, pickerel frogs and certain moths), or they might roost in caves during the day and then exit the cave at night to feed, as do bats and cave crickets.

Important environmental conditions affecting cave communities include the size and shape of the cave entrance, number of entrances, size and shape of cave passages, water conditions and the availability of organic matter. Temperature is critical for bat roosts of different types. For example, hibernating Indiana bats and gray bats prefer "cold-air-trap caves" where cold air sinks into larger or deeper entrances and remains in low areas throughout the year. Maternity colonies of gray bats prefer "warm-air-trap caves" with high domes that accumulate warm air from air movements and the body heat of bat clusters. Although the typical Missouri cave may have a dark zone temperature of about 55 degrees Fahrenheit, a bat hibernaculum may be at 40 to 50 degrees Fahrenheit, while a bat maternity roost may be at 60 to 90 degrees Fahrenheit.

The accidental category refers to those organisms that find their way into caves but are very unlikely to survive in a cave. They may not be very efficient at finding food in the nutrient poor environment and will probably perish if they do not find their way out of the cave. Animals that fall down sinkholes (as evidenced by some of the skulls and bones of prehistoric animals) often die. Snakes that have moved too deep within the cave system are cooled down to the point that their body movements are slowed considerably. Occasionally, the floor of a surface pond or stream will collapse and all inhabitants will fall into a sinkhole or cave below. Surface fish will normally perish in the deep cave environment if they cannot exit the cave.

Caves are important conduits for groundwater and shelter for wildlife. The great antiquity of caves and the protected cave environment make our caves storehouses of natural history. Paleontologists have studied significant bone deposits, bear beds and cat tracks in Missouri caves dating back to the ice ages of the Pleistocene epoch (Schubert 2003, Schubert and Kaufmann 2003, Weaver 1992). Some troglobite and stygobite species may be ancient, such as a recently discovered species of cave crayfish, the Caney Mountain cave crayfish (*Orconectes stygocaneyi**). This cave crayfish is known from only one cave in Ozark County.

* indicates species of conservation concern (Missouri Natural Heritage Program 2004)

Biodiversity

Missouri and the Ozark region rank as important in North American cave biodiversity. Missouri is sixth in the United States in the number of troglobites (Culver et al. 2000, 2003; Elliott 2003).

The Missouri Cave Life Database is used to track and analyze Missouri's rich cave fauna. The database currently has 975 species, 1,266 caves and springs, and more than 10,000 observations and collections. About 973 (17 percent) of Missouri's known 5,800 caves have biological records, but only 408 caves (7 percent) meet minimum criteria for biological evaluation. There are about 84 troglobites, with 68 described species, including 32 aquatic species or stygobites, 15 phreatobites and 21 terrestrial troglobites. Sixteen of the 84 troglobites are undescribed or are possibly troglophiles. One hundred forty seven troglophiles (14 aquatic), 217 trogloxenes (20 aquatic) and 478 species of uncertain status (41 aquatic) are known. Many of the flatworms, mollusks, arachnids, crustaceans and millipedes appearing on the Missouri species of conservation concern checklist are restricted to caves and springs (Missouri Natural Heritage Program 2004).

Karst biogeographic regions coincide with the karst regions mentioned above, but distinct, small isolated areas such as Caney Mountain in Ozark County do occur.

The discovery of the Caney Mountain cave crayfish in Ozark County in 1999 revealed the possibility of new endemic species yet to be found.

Natural Communities

The former five cave natural communities (Nelson 1987) are now grouped into two primary cave communities (terrestrial and aquatic) with eight subtypes, although there are many overlapping examples. Similar community schemes may be found in Poulson (1992) and Sutton (1997). Most caves have both terrestrial and aquatic communities, and many have all eight subtypes but with different species in different karst regions. The two primary cave natural communities may have some or all of the subtypes listed below:

Terrestrial cave community

- Parietal subtype
- Bat subtype
- Rocks and crevices subtype
- Dung subtype
- Organic detritus subtype

Aquatic cave community

- Deep phreatic subtype
- Streams and pools subtype
- Shallow phreatic/drip pool subtype

Terrestrial Cave

Physical Characterization

A cave, especially a larger one, can have more than one entrance type and many different subtype communities. Cave communities are overlapping and are based on water (or lack of it), zonation, microhabitat, nutrient sources and suites of species concentrated there. Cave communities are not limited to an entrance type and entrances may be intermediate between the classical types.

Cave entrances may be outlets at the base of cliffs or bluffs along streams (much of the Ozarks), or may be sinkholes on ridge tops (Salem and Springfield plateaus) or sinkhole plains (Perryville Karst). Many sinkholes are plugged or mantled with chert soils and are not visible, but they may function as water collectors for extensive cave systems below. Many caves have no entrance at any particular time and may be discovered in road cuts, mining or well drilling.

Natural Processes

Slightly acidic groundwater dissolves rock and enlarges groundwater flow paths. After a cave becomes air-filled, breakdown results in collapse features such as sinkholes, dome pits and chasms, which can be further modified by water. Flooding results in shifting streambed material, abrasion by gravel or boulders, formation of pools and cascades or deposits of sediments. Many Ozark caves show evidence of past lives in which the caves were choked with red clay and gravels and then re-excavated (Bretz 1956). Water transports organic matter consisting of eroded soil, branches and leaves flushed into the cave, or carried in by wildlife. Wind can carry loess material and detritus into cave entrances. Cold fronts carry masses of relatively heavy, cold air into large entrances or sinkholes, creating suitable microhabitats for some hibernating bats. High domes may trap warm air and body heat from bats in the summer, creating microhabitats suitable for bat maternity colonies.

Crevices, bedding planes, rocks, wood, guano and ceiling pockets within the cave provide hiding places and various temperature, light and humidity conditions.

Figure 34. A *Ceuthophilus* cricket on a cave wall is a typical component of the terrestrial/parietal cave subcommunity. *MDC photo by William R. Elliott*

Community Variation and Subtypes

a. Parietal subtype (FIGURE 34):

The parietal subtype occurs primarily on the walls and ceiling in the entrance and twilight zones. Characteristic animals include camel crickets (*Ceuthophilus* species), daddy longlegs (*Leiobunum* species), a spider (*Meta ova-*

Figure 35. Many cave animals hide under rocks and in crevices where the humidity is higher. Some salamanders are part of this subcommunity during drought and particular seasons. *Photo by David C. Ashley*

Figure 36. The organic detritus subcommunity is typified by springtails and millipedes. *MDC photo by William R. Elliott*

Figure 37. A summer cluster of gray bats, *Myotis grisescens*, exemplifies the bat subcommunity. *MDC photo by William R. Elliott*

lis), flies of several families, webworms of the mycetophilid fly (*Macrocera nobilis*), cave salamander (*Eurycea lucifuga*), and long-tailed salamander (*E. longicauda*). Some bats such as eastern pipistrelle (*Pipistrellus subflavus*) may be found scattered here in the winter.

b. Rocks and crevices subtype (FIGURE 35):

Animals that are thigmotactic (like to hide in tight places) may be found in tight holes and under rocks. Some species retreat into caves during drought or winter to avoid drying or freezing, or to avoid predators. Characteristic animals include slimy salamander (*Plethodon glutinosus*), southern redback salamander (*P. serratus*), springtails, diplurans (*Litocampa* species), beetles, small spiders and pseudoscorpions. Restricted animals include such troglobites as a rare troglobitic pseudoscorpion (*Mundochthonius cavernicolus**), a cave millipede (*Scoterpes dendropus**) and diplurans.

c. Organic detritus subtype (FIGURE 36):

Wind and water may sweep leaf litter and twigs into cave entrances. Streams or beaver may deposit wood in caves. Roots may grow into the cave through ceilings or through plugged sinkholes. Wood rats may deposit hackberry fruit hulls. Thin biofilms may be deposited on clay banks and flowstone. Characteristic animals include such troglophiles and troglobites as springtails, diplurans, millipedes, rove beetles, terrestrial isopods, spiders and salamanders. Some restricted animals include troglobitic millipedes (*Tingupa pallida** and *Causeyella dendropus*), diplurans (*Litocampa* species) and others.

d. Bat subtype (FIGURE 37):

Female gray bats may roost in warm dome rooms during the summer to give birth and raise young. Maternity colonies of many thousands may deposit guano mounds several feet across and several feet high. The oil of the bats' feet stains and etches the cave ceiling over centuries of activity. Scattered guano is found along flyways and beneath roosting bats.

Bats are trogloxenes. Gray bats are the only bats depositing large amounts of guano in Missouri caves. The Indiana bat, eastern pipistrelle, little brown bat (*Myotis lucifugus*), big brown bat (*Eptesicus fuscus*) and others may leave scattered guano. Little guano is deposited during hibernation.

e. Dung subtype (FIGURE 38):

The bat guano on the cave floor is decomposed by bacteria and fungi, which provide a food chain. Animal scats and bat guano are two kinds of dung subtypes. Raccoons, eastern woodrats, crickets and other species may travel far into the dark zone and deposit dung (scats).

Characteristic animals are mostly trogloxenes and troglophiles. Food webs involve springtails, millipedes, mites, spiders, beetles (*Ptomaphagus cavernicola)*, carabid beetles, rove beetles, pseudoscorpions, flies, webworms of the mycetophilid fly (*Macrocera nobi-*

* indicates species of conservation concern (Missouri Natural Heritage Program 2004)

Figure 38. Dung subcommunities may consist of gray bat guano, (pictured here) or scats of raccoon, wood rat, beaver or other mammals. The freshest guano has fungal growths and various "guanophiles." *Photo by Steve Samoray*

lis) and pseudoscorpions (*Hesperochernes* species). Restricted animals include many species of springtails, rove beetles, scarab beetles, mites, and flies. Some of these are probably restricted to bat guano or other types of dung.

Presettlement Distribution and Size

This cave natural community occurs in all karst regions and the Ozark Highlands Section and Mississippi River Hills Subsection in the Central Dissected Till Plains Section. Bat and dung subtypes containing gray bat guano occurred primarily in the lower portion of the Ozark Highlands Section.

Representative Sites

Dung subtype: Scats may be found in most caves. Bat guano: Boone (Rocheport) Cave and Devil's Icebox Cave (Boone Co.), Smittle Cave (Wright Co.), Bat Cave (Shannon Co.), Great Scott Cave (Washington Co.); **Organic detritus subtype:** Boone (Rocheport) Cave, Little Scott Cave (Washington Co.) and most other caves.

Status

S4. Most accessible caves have suffered various degrees of vandalism, especially plundering and removing of cave speleothems. Endangered gray bats are now at 57 percent of their numbers 20 to 30 years ago. Endangered Indiana bats are at 11 to 15 percent of their numbers 20 to 30 years ago.

Threats

People illegally trespass into caves and either unintentionally or intentionally damage or destroy cave features, and disturb bats roosting or hibernating. Surface land development, road building, land clearing, agriculture and heavy grazing affect groundwater quality in caves by increasing siltation and chemical pollutants. Untreated sewage, pipeline spills and pesticide contamination can occur as point-source pollution in caves.

Aquatic Cave

Physical Characterization

Aquatic cave communities are found in most caves, but more often in cave springs and other springs, swallets and wet pit caves. Features include wells, springs, drip pools, rimstone pools and base-level pools in caves connecting to submerged passageways. The shallow groundwater layer may extend for great distances even into nonkarst areas. The dry pit cave and dry cave may contain some of these aquatic elements. Cave entrances and subterranean springs primarily occur at the base of cliffs or bluffs along streams. Rock substrates for all cave types include limestone, dolomite and rarely sandstone and shale.

Natural Processes

Slightly acidic groundwater dissolves rock and enlarges groundwater flow paths. After a cave becomes air-filled, breakdown results in collapse features such as sinkholes, dome pits and chasms, which can be further modified by water. Flooding results in shifting streambed material, abrasion by gravel or boulders, formation of pools and cascades, or deposits of sediments. Water transports organic matter consisting of eroded soil, branches and leaves flushed into the cave or carried in by wildlife. Oozing or dripping water and small flowing streams create calcite and aragonite deposits including stalactites, stalagmites, helictites, rimstone dams and flowstone.

Community Variation and Subtypes

a. Deep phreatic subtype (FIGURE 39):

Springs, submerged caves and interconnected, porous water-filled passageways make up deep phreatic subtypes. These include groundwater aquifers tapped for drinking water through wells. Characteristic animals include such well and spring phreatobitic amphipods as Hubricht's long-tailed groundwater amphipod (*Allocrangonyx hubrichti**), the subtle cave amphipod (*Stygobromus subtilis**), Clanton's groundwater amphipod (*S.*

* indicates species of conservation concern (Missouri Natural Heritage Program 2004)

Figure 39. The Ozark cavefish, *Amblyopsis rosae,* is an inhabitant of both the deep phreatic and streams-and-pools subcommunities of the aquatic cave community. *MDC photo by Jim Rathert*

*clantoni**), Barr's groundwater amphipod (*S. barri**), cave (stygobitic) amphipods (*Stygobromus* species), isopods (*Caecidotea* species), crayfishes (*Cambarus hubrichti**), and cavefishes (*Typhlichthys subterraneus* and *Amblyopsis rosae*).

b. Shallow phreatic/drip pool subtype (FIGURE 40):

This subtype includes drip pools and rimstone pools, usually near the cave entrance. The shallow groundwater layer may extend for great distances even into nonkarstic areas. These pools may hold amphipods that fall from and drip out of the ceiling. Some are restricted to cave drip pools only while others may be regionally widespread life forms. Characteristic animals include phreatobitic amphipods found in wells, springs, seeps and caves, such as the short-tailed groundwater amphipod (*Bactrurus brachycaudus**), and stygobites such as the false sword-tailed cave amphipod (*B. pseudomucronatus**).

c. Streams and pools subtype (FIGURE 41):

This subtype includes cave streams with air space above (vadose) and pools that may have both diffuse and discrete recharge origins. They are usually slow moving streams with silt or clay bottoms. A subcommunity may be found in riffles where moderate to rapid, free flowing, shallow streams may provide more aeration and higher oxygen levels than quiet streams and pools. Gravel or cobble substrates usually provide microhabitats for benthic organisms. Characteristic animals include pickerel frogs (*Rana palustris*), salamander larvae, stygophilic amphipods (*Crangonyx forbesi*), isopods (*Lirceus* species), epigean crayfishes and sculpins. Restricted animals include stygobitic planarians (*Macrocotyla glandulosa**, *Sphalloplana* species), amphipods (*Stygobromus* species), isopods

* indicates species of conservation concern (Missouri Natural Heritage Program 2004)

Figure 40. Certain amphipods are found mainly in the shallow phreatic/drip pool subcommunity. (Scale is in millimeters.) *MDC photo by William R. Elliott*

(*Caecidotea* species), Salem cave crayfish (*Cambarus hubrichii**), bristly cave cavefish (*C. setosus**), cave crayfish (*C. aculabrum**), Caney Mountain cave crayfish (*Orconectes stygocaneyi**), cavefishes (*Typhlichthys subterraneus** and *Amblyopsis rosae**) and the grotto salamander (*Typhlotriton spelaeus**). Riffles contain the cavesnail (*Antrobia culveri**) in Tumbling Creek Cave, Taney County and some amphipods (*Stygobromus* species).

Presettlement Distribution and Size

Aquatic cave communities occurred in all karst regions and throughout the Ozark Highlands Section, Mississippi River Hills Subsection of the Central Dissected Till Plains Section and into adjacent states and nonkarstic areas.

Representative Sites

Deep phreatic subtypes: Large springs such as Alley Spring, Big Spring and Blue Spring (Shannon Co.), Greer Spring (Oregon Co.); **Shallow phreatic/drip pools:** Bear Cave (Crawford Co.), Devils Icebox Cave (Boone Co.); **Streams and pools subtype:** Many wet caves, but especially caves along the Current, Eleven Point and Meramec rivers.

Status

S4. Most wet caves and underground aquifers are physically intact, but have suffered various degrees of vandalism, especially plundering and removal of cave speleothems and artifacts, and occasional chemical spills.

* indicates species of conservation concern (Missouri Natural Heritage Program 2004)

Figure 41. Biology students from Missouri Western State College in St. Joseph conduct a cave stream inventory. *MDC photo by William R. Elliott*

Threats

Surface land development, road building, land clearing, agriculture and heavy grazing affect groundwater quality in caves by increasing sedimentation and chemical contaminants. Point-source pollutants include untreated sewage, pipeline spills and pesticide contamination. Knowledge of the spring inhabitants is minimal because of the inability to sample them, but occasionally groundwater contamination may force them to the surface. For example, an ammonia pipeline spill in 1981 killed thousands of southern cavefish, Salem cave crayfish and grotto salamanders in the Maramec Spring system.

A conservation problem exists in the overuse of caves by the untrained, those who litter, mark graffiti on walls, disturb or kill bats and loot archaeological sites. Other threats come from land development, water projects, roads, chemical spills, dumping into caves and sinkholes and some agricultural practices (Elliott 2000a, 2004b).

Protection and Management of Caves

The Missouri Cave Resources Act and other laws protect caves. Hundreds of Missourians are cavers, trained in the proper exploration and conservation of caves. Most cavers are members of organizations such as the National Speleological Survey, the Cave Research Foundation, the Missouri Cave and Karst Conservancy, the Missouri Speleological Survey, the American Cave Conservation Association and Bat Conservation International.

Land protection agencies responsible for managing caves face many challenges. Most agencies have adopted cave ranking systems for protecting resources and permitting public use. Generally, caves containing rare cave formations, hazardous passageways (flooding), endangered species and/or archaeological significance are closed to public use except by special permit. Agencies and conservationists sometimes construct cave gates specially designed to allow endangered bats access while restricting would-be vandals from disturbing them or destroying cave resources.

It is increasingly necessary to protect caves from degradation. Because some cave systems are directly affected by surface drainage, some land protection agencies are acquiring sinkholes and recharge zones to ensure their protection from groundwater contamination.

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