MISSOURI
Natural Areas
NEWSLETTER

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"...identifying, designating, managing and restoring the best remaining examples of natural communities and geological sites encompassing the full spectrum of Missouri's natural heritage"

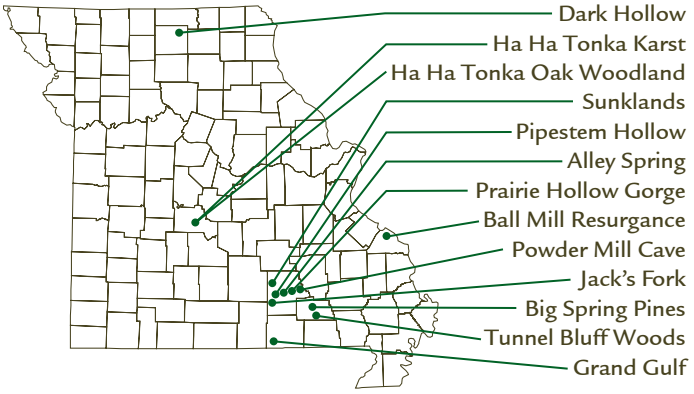
Caves & Karst in Missouri

When the reality of white-nose syndrome began to sink in with the first reports from New York of significant bat die-offs in 2007, biologists across North America started looking for a cure for this deadly disease caused by a previously unknown fungus, *Pseudogymnoascus destructans*. Since that time, the caving community and biologists alike have come together to document, monitor, and protect caves and cave-dwelling fauna. Across the country, thousands of cave gating projects have occurred with funding from government and non-governmental entities. With white-nose syndrome now documented from Missouri, state, federal, non-governmental agencies, grottoes, and the rest of the caving community have worked assiduously to document bat populations and to track the occurrence of the disease in the state.

The feature articles in this issue of the Missouri Natural Areas Newsletter focus on Missouri caves and karst, with an emphasis on our bat populations that are now more than ever in grave peril. The authors of this issue are leaders in the field of cave ecology, and working on the front lines of monitoring, cave protection, and documentation. The Missouri Natural Areas Committee would like to thank the authors for sharing their knowledge and experience. Readers are encouraged to contact them with any questions.

— Allison J. Vaughn, editor

NATURAL AREAS FEATURED IN THIS ISSUE



Edmund Tucker pictured with lighting help from SEMO Grotto

Photo by Chad McCain

White-nose Syndrome in Missouri and the Future of Missouri's Bat Populations

By Anthony G. Elliott

White-nose syndrome is a recently discovered disease in bats that has decimated hibernating populations in many sites of the northeastern United States, causing mortality rates up to 99% at infected sites. White-nose syndrome affects bats while they are hibernating, causing unusual amounts of activity, depletion of necessary fat reserves, and possibly disturbance of water balance. Incidences of the disease have spread out from the state of New York since its discovery there in February, 2007. Strong scientific evidence suggests that the causative agent (a previously unknown fungus, *Pseudogymnoascus destructans*) was introduced into the United States sometime prior to 2006 and began infecting a naïve, highly susceptible bat population. After the disease was described in the U.S., scientists confirmed that European bats can exhibit symptoms of white-nose syndrome, but mortality occurs only rarely, if at all. White-nose syndrome has not been found to affect humans or any other animals.

Over the last three winters, bat and cave biologists from the Missouri Department of Conservation, alongside partner agencies, organizations, and volunteers, have increased our survey efforts in caves and mines throughout the state as a part of the white-nose syndrome surveillance effort, while also improving our knowledge of Missouri's winter bat population. In May 2010, presence of *Pseudogymnoascus destructans* was documented, through genetic identification, in two counties in Missouri. We expected to see clear signs of the disease (visible fungal growth) sometime during our 2010–2011 surveys, and hoping that we would not see mortality that winter. However, surveys of 29 hibernation sites during winter 2010–2011 did not detect any occurrences of the disease or fungus.

During the winter of 2011–2012, we surveyed a total of 36 caves and mines throughout the state and again were expecting to see signs of the disease. As late February approached, while surveying caves in the southeastern portion of Missouri closest to confirmed white-nose syndrome positive sites, we did not find evidence of the disease. I began to hope that we might make it through another winter without mortality.

On March 14, 2012, I was in the lead as we crawled through the small entrance area into a Lincoln County cave. When the cave opened up slightly, it allowed me to sit up on a small ledge where I came face-to-face with a little brown bat (*Myotis lucifugus*). It was only a small spot on the bat's muzzle, but the white, fuzzy, fungal-growth that is the classic presentation (and source of the name) of

Figure 1. Bat White-nose Syndrome (WNS) Occurrence by County/District (or portions thereof) as of 9/17/2013

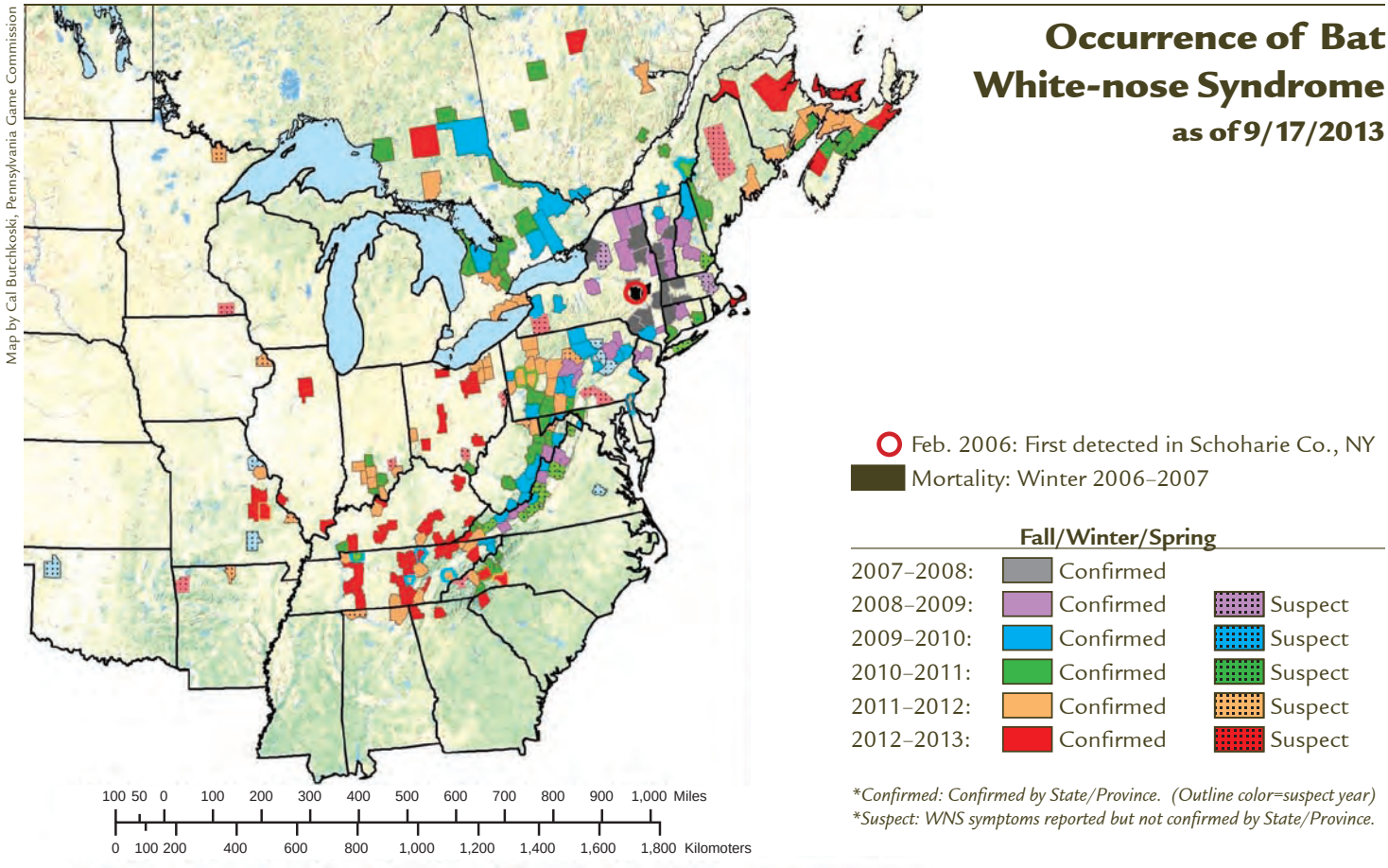


Photo by Shelly Colatskie

The first case of visible white-nose syndrome encountered in Missouri

white-nose syndrome was clearly visible. My stomach sank. We sampled the individual for submission to the laboratory. Two days later, I received pictures of two tri-colored bats (*Perimyotis subflavus*) from a second cave located within a mile of the first one, both bats exhibiting more extensive visible fungal growth. I was certain that these would be confirmed positive cases in two different caves, which meant that my hope of discovering an isolated case of white-nose syndrome was unrealistic. The National Wildlife Health Center in Madison, Wisconsin confirmed that white-nose syndrome was affecting all three of these individuals. These infected bats served as the first confirmed cases of the actual disease in Missouri, and, more significantly, west of the Mississippi River.

In winter 2012–2013, we documented several new cases of white-nose syndrome with visible fungal growth in Crawford, Franklin, and Washington Counties. While the Lincoln County cases were discovered in minor hibernation sites, it was documented that certain major hibernacula used by endangered gray and Indiana bats — as well as most other cave hibernating bat species found in Missouri — harbored the disease. Unfortunately, there is every reason to expect documented cases of this disease to continue spreading throughout our state over the next several winters. At the time of this writing, we have not witnessed mortality due to white-nose syndrome in Missouri, but it is likely just a matter of time.

Over a year has passed since I saw that first little white spot in the glare of my headlamp and I am still trying to come to grips with what this may mean for the future of Missouri's bat population. I try to maintain hope that the resilience of nature will allow some of our cave hibernating bats to survive, but I know that we have some very vulnerable populations. Most of the Indiana bat population in Missouri hibernates in a small number of important sites, and if white-nose syndrome impacts those sites heavily, the Indiana bat population is in grave danger of extirpation.

If white-nose syndrome impacts Missouri's cave-hibernating bat species at levels similar to those seen in the northeastern United States, it could have significant ecological and economic impacts. Bats are the primary predators of night-flying insects and are therefore important to Missouri's economy and environment. Many of the insects that bats eat are either agricultural or forest pests. For example, corn earworm moths are consumed by several species of bats and some species of bats may consume substantial numbers of mosquitoes. Missouri is home to over 775,000 gray bats during the summer, and that number of this species alone could eat over 540 tons of insects (that is over 223 billion insects) per year. Bats are also an important part of the ecosystem because predators such as snakes, owls, and raccoons prey upon them. In some caves bats are a major source of nutrients that develop through their droppings, or guano. But it is their intrinsic value to biodiversity in Missouri that drives biologists to seek a way to protect and maintain our thriving bat populations throughout the state and North America.

The primary management action that has been implemented to slow the spread of white-nose syndrome is to reduce the possibility that humans are disturbing hibernating bats, which can exacerbate the disease or inadvertently spread *Pseudogymnoascus destructans*. Conservation partners throughout Missouri have taken proactive steps to address this vector of disturbance. Partners with a need to enter caves or handle bats have learned the new reality of decontamination associated with these activities. Typically, as cave biologists, we wear disposable coveralls when entering caves, even though these coveralls are not designed to withstand crawling and climbing that is often necessary for cave exploration. Gating of important caves to reduce unauthorized entry into these sites is another step taken to address this threat. Major cave gating projects have occurred on lands owned or managed by the US Forest Service, National Park Service, Missouri Department of Conservation, The Nature Conservancy, Missouri Department of Natural Resources as well as privately owned lands. In addition to serving as important contributions to the battle against white-nose syndrome as an effort to protect bats from human disturbance, these gates protect additional cave resources that are often damaged by unauthorized visitors to caves.

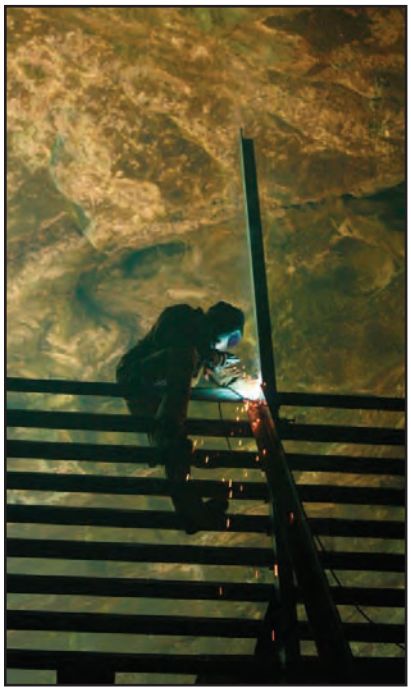


Photo by Shelly Colatskie

Cave gate construction in spring 2012 at an important bat hibernaculum

We continue working with an impressive array of federal, state and international partners to protect bat populations from white-nose syndrome. The cooperation is rewarding, but the reward we are all hoping for is successful implementation of mitigation or control measures that will reduce the impact of this disease. Currently, there is no known cure for white-nose syndrome, but we hope that by closely documenting the timing of spread and the severity of cases, in addition to contributing to various studies of this potentially devastating disease, Missouri's biologists will be able to assist with developing effective control measures.

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Karst Features of Ha Ha Tonka State Park

by Larry Webb

Ha Ha Tonka State Park is a showcase of karst topography with 18 caves, a natural bridge, losing streams, several large, deep sinkholes, and Missouri's 12TH largest spring. Several of these features can be found within the boundaries of the 70 acre Ha Ha Tonka Karst Natural Area.

The centerpiece of the Ha Ha Tonka Karst Natural Area is Ha Ha Tonka Spring. Ha Ha Tonka Spring is Missouri's twelfth largest spring with an average discharge of 48 million gallons of water per day. The recharge area of the spring has been traced to areas as far as 18 miles away and encompasses more than 100 square miles. The spring is a great place to observe wildlife; birds, including belted kingfishers, wood ducks, mallards, green herons, and great blue herons are regulars in the spring area. Mammals including mink, muskrat, beaver, and otters can be seen swimming in the 58 degree water. Red-eared slider turtles are often seen basking on logs, while sculpin, darters, and suckers swim in the water below. Plants like coontail, bur-reeds, watercress, and duck weed provide food and shelter to the spring's inhabitants. The spring has also been responsible for much of the park's cultural history, attracting settlers for centuries, from Native Americans, to early settlers operating a grist mill, to a wealthy Kansas City businessman who built a "castle" on the bluff overlooking the spring chasm.

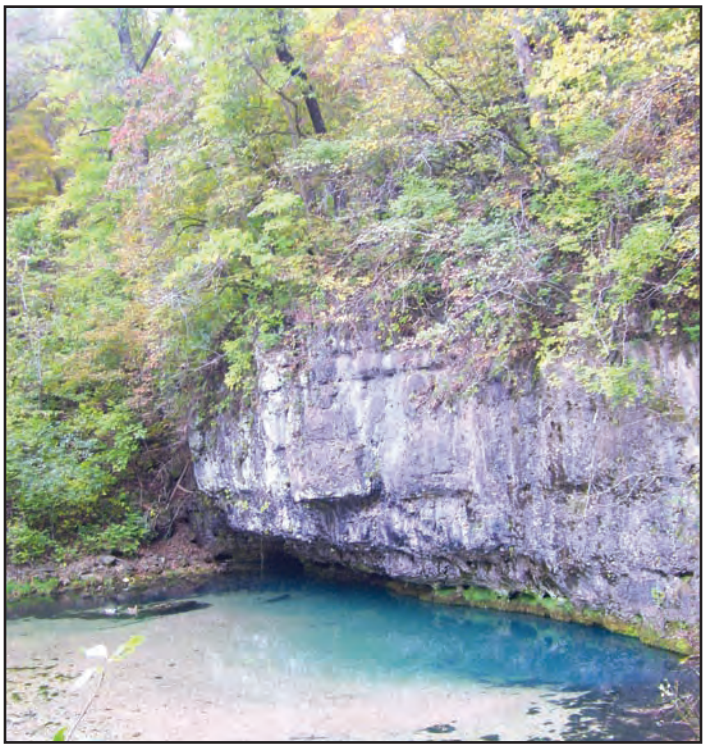

Photo by Allison J. Vaughn

Ha Ha Tonka Spring

Southern Cavefish in River Cave

Photo by Eric Hertzler

Another highlight of the Ha Ha Tonka Karst Natural Area is River Cave. While River Cave traverses only a quarter-mile of passage, 41 species of cave life inhabit River Cave. Seven of these animals are state listed species of conservation concern, including two state and federally endangered bat species. In a 2007 report by Dr. William Elliott, entitled *Zoogeography and Biodiversity of Missouri Caves and Karst*, River Cave was rated the fifth most biodiverse cave in Missouri. The cave's biological diversity is owed to material brought in from a wet weather swallow hole and guano from the cave's bat population. In the growing season, the cave houses a maternity colony of gray bats. According to Missouri Department of Conservation infrared camera counts, approximately 129,000 gray bats were using the cave in the spring, 2012. A small colony of Indiana bats move in after the migration of the gray bats and use the cave as a hibernaculum. Southern cave fish and grotto salamanders are abundant in the cave with several species of aquatic macroinvertebrates thriving in the cave stream and in the guano piles left behind by the gray bats.

Many other karst features are found in the Ha Ha Tonka Karst Natural Area including a large natural bridge that spans 70 feet across a sinkhole. The bridge is composed of 15 ft. of Gunter sandstone on top of 30 feet of Eminence dolomite. Several caves and sinkholes surrounding the spring expose more of the ancient dolomite rock that is responsible for the park's karst features. The dolomite bedrock responsible for all of these karst features extends far beyond the karst natural area boundaries. The influence of dolomite on karst is also evident in the recently expanded Ha Ha Tonka Oak Woodland Natural Area.

While primarily recognized for its high quality complex of woodland and glade communities, the Ha Ha Tonka Oak Woodland Natural Area also harbors some remarkable karst features. Large sinkholes and caves have been prominent features in the natural area since its first designation as Red Sink Natural Area in 1980. With a diameter of 400 ft. and more than 200 ft. of elevation change on its deepest side, Red Sink is one of the most impressive geologic features in the park. It houses rare ferns, towering red oaks, black walnuts and basswood. Since 1980, the natural area

boundaries have expanded twice. In 1990, the Red Sink Natural Area and the Lodge Glade Natural Area were combined with the surrounding woodland and glade landscape to form the 953 acre Ha Ha Tonka Oak Woodland Natural Area. In 2012, the Ha Ha Tonka Oak Woodland Natural Area was expanded by more than 2,000 acres after 20 years of fire management in areas around the natural area. This expansion included the addition of five caves to the natural area's inventory.

Heimbeaugh Cave is one of the caves recently added to the Ha Ha Tonka Oak Woodland Natural Area's long list of features. Heimbeaugh Cave was added to the Missouri Cave Files in 2006 following a cave monitoring and inventory project at Ha Ha Tonka State Park completed by Eric Hertzler. Hertzler and others mapped, photographed, and described the cave in detail, including notation of animal life in the cave. The cave only contains 100 feet of passage, but Hertzler noted a number of speleothems including soda straws, stalactites, stalagmites, draperies, columns, and flowstone. Hertzler also observed tri-colored bats, cave salamanders, dark sided salamanders, and cave crickets.

Another cave included in the expansion of the Ha Ha Tonka Oak Woodland Natural Area is White Cave #1. This is a small cave with only 330 feet of passage. A cave stream runs the length of the cave which harbors large numbers of salamander larvae. In recent surveys of the cave, more than seventy larvae have been counted in a single visit, but no adults have been present. This was also noted in a 1959 report on the cave by Elbert Leigh, who later supposed the larvae were probably long-tailed salamanders (*Eurycea l. longicauda*). In February 2007, a faunal survey of White Cave #1, conducted by park staff and volunteers from the Lake of the Ozarks Grotto, netted 124 tri-colored bats, 73 salamander larvae, over 100 isopods, 16 millipedes, 4 crayfish, and a number of other invertebrates. A small guano pile and ceiling stains were present in the cave, likely from gray bats using the cave during the previous growing season.

White Cave #2 is located near White Cave #1. The cave is very small with only 25 feet of total passage. A small stream runs through the cave, and Hertzler speculated that it surfaces about a 100 feet away at a spring near the bed of White Cave #1. Hertzler also noted slimy salamanders, long-tailed salamanders, and cave salamanders in the cave during his survey.

Racetrack Hollow Cave, a large shelter cave formed in Gunter sandstone, and Bank Branch Cave, a small cave in Eminence dolomite were also added to the natural area with the boundary expansion. Racetrack Hollow may be among the longer caves in Gunter sandstone in Missouri.

Ha Ha Tonka State Park is a remarkable example of karst topography. The Ha Ha Tonka Oak Woodland Natural Area while recognized primarily for its outstanding examples of woodland and glade communities is a great example of the extent of karst topography at Ha Ha Tonka State Park. With many miles of trails through both natural areas, the park is a great place to enjoy some of the best examples of several of Missouri's natural landscapes.

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Formations along the right wall of Heimbeaugh Cave

Photo by Charity Hertzler

The Gating of Bat Cave Shannon

An Exemplary Partnership in Action

by Dr. Paul McKenzie

Sometimes challenges associated with a project are so large that it takes multiple partners to complete the task. This was certainly the case for the gating of Bat Cave in Shannon County, Missouri between 2010 and 2012. This cave is a priority 1 hibernaculum for the federally listed gray bat *(Myotis grisescens)* and also for a small number of Indiana bats *(Myotis sodalis)*. This site is owned by the Nature Conservancy and is a registered state historic landmark. Due to illegal trespass through a fence placed around the entrance and the increasing threat of the spread of white-nose syndrome in Missouri, it was necessary to gate the cave. Challenges associated with gating the project were enormous due to lack of funds, location, designation as a registered historic landmark, seasonal presence of endangered species, and requirements to write an environmental assessment under the National Environmental Policy Act (NEPA).

The project required extensive coordination and cooperation among the Missouri Department of Conservation, the U.S. Fish and Wildlife Service, The Nature Conservancy, the Missouri Department of Natural Resources and State Historic Preservation Office, National Park Service, and Karst Solutions. Each entity provided expertise, service or funding for the project without which the project could not have been accomplished.

In 2010, MDC cave biologist Bill Elliott initiated the development of a proposal to gate the cave and contacted Paul McKenzie of the USFWS for possible funding. The USFWS provided $60,000 to MDC to fund the project. Project planning and design, securing funding, acquiring NEPA approval, and developing necessary cooperative agreements required extensive participation from multiple individuals. Bill Elliott drafted the memorandum of understanding between MDC, DNR and TNC, located and contracted Karst Solutions to construct the gate, provided information for the draft environmental assessment, assisted in gate construction and coordinated closely with the USFWS, and other MDC personnel and partners regarding funding and logistics. Preston Mabry with TNC (and later MDC) assisted with logistics, worked with MDC and NPS in finalizing the interagency MOU, and assisted the USFWS and NPS in completing the environmental assessment. McKenzie (USFWS) assisted in coordination of all aspects of the project, especially project funding, coordinating the archaeological survey, and drafting the environmental assessment for TNC. Joe Strenfel of the NPS coordinated the completion of the assessment to satisfy NEPA requirements. Ken McCarty of DNR assisted in completion of the interagency agreement. Lisa Davis, Tracy Tomson and Doyle Brown of MDC all assisted in administration of the USFWS grants. Jim Newberry of DNR provided

Photo by William R. Elliott

Breached fence at entrance to Bat Cave Shannon, Feb. 2007

access to the cave, a landing area for steel and lodging for crews. Susan Farrington (MDC) provided an Americorps crew to clear an access trail and to move equipment and steel to the site. Judith Deel of DNR-SHPO and James Myster of the USFWS surveyed the site for cultural resources. Robbie Smith of MDC assisted in transport of steel and Raenhard Wesselschmidt of MDC arranged pre-construction fabrication. Jim Newberry (DNR) provided logistic assistance, lodging and a staging area for materials and equipment.

Due to the complexity of the project associated with the location of the cave, cave gating costs, and paperwork required (grant and cooperative agreements and an environmental assessment under NEPA), the project design and planning phase took two years and construction was completed on April 20, 2012. Cooperating entities worked in close coordination to ensure that the gate was constructed within a narrow window when potential disturbance to hibernating bats would be minimized. The cave gate is the second largest standing cave gate in the nation. At 64' wide and 20' tall, this project required the movement of 13 tons of steel plus equipment and supplies 150 feet up a vertical bluff and then down into the cave entrance via a cable hoist powered by an electric motor.

Cave Gating Partners (left to right): Jerry Fant (Karst Solutions), Kim Houf and Joe Strenfel (NPS), Preston Mabry (MDC), Cynthia Pessoni (TNC), Tony Elliott (MDC), Shauna Marquardt and Paul McKenzie (USFWS) and Jim Newberry (DNR)

Photo by Norman Murray

While the protection of the cave fauna residing here has been of interest for many years, the threat of WNS increased the urgency to restrict trespass into this cave facilitated by its proximity to the popular Current River. Replacing the chain-link and razor wire fence with a modern designed cave gate will better prevent trespass, but will accommodate the needs of gray and Indiana bats and other species to move freely into and out of the cave. The half-gate design allows large numbers of gray bats to freely enter and exit the cave and allows for airflow so the cave's natural temperature and humidity fluctuations still occur. Additionally, it will prevent disturbance and/or vandalism of a registered historic landmark. Conservation of our natural and cultural resources requires commitment and collaboration from a variety of stakeholders.

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Surveying for Bats: Recent Discoveries in the Race to Document Populations

by Shelly Colatskie

As the assistant cave ecologist for the Missouri Department of Conservation, I am fortunate to work alongside a variety of partners including private land owners, various governmental agencies, universities and several non-governmental organizations. While conducting bat surveys remains a primary job duty, resource scientist Tony Elliott and I are responsible for surveying other cave fauna including pink planaria and cave fish, while also helping to protect cave resources through cave gating projects and cave cleanups. With over 6,500 caves in Missouri, we rely heavily on other agencies, universities, and volunteers to assist with surveys and data collection. These partners often provide important information, especially regarding previously unsurveyed sites.

Missouri is home to 16 bat species, many of which can be difficult for even the most seasoned biologist to identify. Several – but not all – of Missouri's bat species inhabit caves during some portion of the year. The remaining species utilize trees, rock faces, and rock slabs in a variety of Missouri's natural communities. Among the more uncommon species in Missouri, the southeastern myotis (*Myotis austroriparius*) and Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) persist in Missouri but are restricted to bottomland forests and the swamplands of southeastern Missouri region where caves are limited. In other states where these two species exist in larger populations, the southeastern myotis and Rafinesque's big-eared bat may inhabit caves throughout the year. In June of 2013, both of these rare-to-Missouri species were captured at Big Oak Tree Natural Area.

Only two bat species utilize caves year round in Missouri, the federally endangered Ozark big-eared bat (last documented in Missouri in the early 1970s) and the federally endangered gray bat. However, even these two species can occasionally make use of other natural and man-made features. Ozark big-eared bats can be found in talus cracks and mines, and gray bats are known to inhabit mines, quarries, storm sewers, buildings and under bridges.

With the onslaught of white-nose syndrome in Missouri, monitoring bat populations and associated cave fauna has risen in significance. Not only are endangered species dying from white-nose syndrome, but today, once-common species are declining dramatically in population numbers and may be considered for listing under the Endangered Species Act.

From an ecological perspective, bats serve as the foundation for many of Missouri's cave ecosystems. Guano accumulations are an important link in the food chain of certain caves, with

Photo by Shelly Colatskie

Juvenile southeastern myotis captured at Big Oak Tree Natural Area

Photo by Ron Colatskie

A lactating female Rafinesque's Big Eared Bat captured at Big Oak Tree Natural Area

Photo by Shelly Colatskie

An Ozark Big Eared Bat from Oklahoma

Photo by Shelly Colatskie

A northern long eared bat photographed with a telephoto lens high up on the cave ceiling

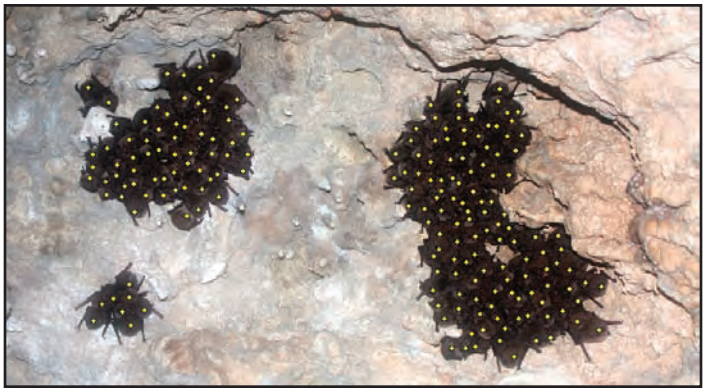

Photo by Shelly Colatskie

Indiana bat clusters from Powder Mill Creek Cave Natural Area counted with the ArcMap method

guano piles often harboring endemic millipedes, isopods and other invertebrates. Bats also serve as the primary predator of a variety of nocturnal flying invertebrates; they are responsible for keeping crop pests in check, which reduces the need for insecticides that can negatively impact the multitude of beneficial invertebrates and other fauna.

Biologists across Missouri employ several methods to monitor cave bat populations. Winter hibernation surveys occur between December and March when hibernating bats can be observed in a variety of hibernacula including caves, mines and quarries. White-nose syndrome has increased the importance of gathering data on bat populations, and winter bat surveys provide a glimpse into winter bat population trends across the state. In recent years, winter bat surveys have helped to document occurrences of the deadly disease.

During winter bat surveys, limited numbers of biologists traverse the cave quickly and carefully to minimize disturbance to the hibernating bats. Counting and identifying bats requires a great deal of experience and generally requires a digital camera, outfitted with a zoom lens, which is used to photograph roosting bats high on the ceiling or congregating in large clusters. Biologists use the images to assist in identification and counting. A cluster of hibernating bats may include thousands of individuals. To achieve an accurate estimate of clustering bats, we employ ArcMap. In a time consuming process, the biologist will place dots on the nose of each bat in the photograph. ArcMap tracks the number of dots, which provides a count for each compact cluster of bats. Occasionally, we encounter a bat

A mist net set up in front of a cave entrance

Photo by Ron Colatskie

with a wing band among the bat clusters; these band numbers are recorded to potentially track their origin and migration patterns, both of which are poorly understood. Recently, a bat that I had banded in the fields of northern Missouri was found in a newly discovered major Indiana hibernaculum four years later and 180 miles away. Exciting finds like this one makes the work rewarding.

Biennially, MDC conducts surveys of the major or historic Indiana bat hibernacula. This statewide effort helps to estimate the population of Indiana bats. Annually, MDC crews survey caves that have not been surveyed in several years or have never had an official survey.

For the eager biologist ready for the 'hands-on' approach, a mist net survey will provide a variety of data. A mist net resembles a volley ball net with two poles and a thin nylon mesh net stretched between them. Good netting locations include creeks, roads, or cave mouths. A great deal of skill is needed to remove the squirming, biting, but delicate bats from the fishing-line-thin net.

For cave bats, biologists take advantage of fall swarming and spring emergence periods when large numbers of bats congregate near the entrances of caves. Captured bats are identified to species, weighed, sexed, measured, banded and swabbed for *Pseudogymnoascus destructans (Pd)*, the fungus responsible for white-nose syndrome. Swabbing the bats in the fall, winter, and as they come out of hibernation in the spring gives us more information about the spread of *Pd* as well as how long the fungus takes to develop.

Less labor-intensive methods for monitoring cave bat populations are thermal infrared and near infrared videography. These specialized video cameras utilize light wavelengths undetectable to the human eye to record bats as they exit caves in the dark of night. Specialized software is then used to estimate the number of bats exiting during the recording period. These methods work well to monitor gray bat populations where maternity colonies can host over 100,000 bats in one cave.

The past two years have been quite exciting for Missouri bat biologists in the way of bat hibernacula discovery. A previously unknown (to biologists) Priority 1 Indiana bat hibernaculum was discovered in Missouri during the winter of 2012. Not only is it the largest known bat hibernaculum in Missouri, it contains the largest currently known concentration of Indiana bats throughout their range at over 120,000 individuals. This discovery significantly increases the known population of the rapidly declining Indiana bat. The Indiana bat hibernation site is also home to gray bats during the summer. Thousands of gray bats use this as a summer maternity colony, making it the most northern maternity site of the species in the state. Band recoveries from this site include bats captured during the summer in northern Missouri, Iowa and Illinois. While this is a great discovery, in the times of white-nose syndrome, it is quite scary to see such a large population of multiple species in one place.

Another significant discovery in 2012 was that of a gray bat colony located in abandoned lead mines in eastern Missouri. While it is known that bats use abandoned mines throughout the United States, bat use of mines in Missouri is understudied. Abandoned mines are common throughout the state, and they should be surveyed regularly for bats. This particular colony of gray bats was discovered when a landowner discovered bats in mines that were slated to be filled in. We conducted a thermal infrared video count of the mineshaft weeks later when we counted at least 3,000 bats exiting the site, confirming that this mineshaft was likely a hibernation site.

With a variety of threats to our cave bats, including white-nose syndrome, habitat fragmentation, cave disturbance, and wind energy farms, it is imperative to continue our efforts to monitor bat populations.. These threats come at a time when biologists are still learning about migration patterns, life history, and other ecological facets of these species. Many of these species which were considered 'common' in recent years may be pushed to the verge of extinction as white-nose syndrome continues to devastate cave dwelling bats across North America.

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Hibernating Little brown bats

Photo by Shelly Colatskie

Hibernating Gray bats

Photo by Shelly Colatskie

PERRYVILLE KARST

A UNIQUE RESOURCE

by Brad Pobst

Missouri contains over 6200 caves in several karst zoogeographic regions. These regions include the Springfield and Salem plateaus; the Boone, Hannibal, St. Louis, Jefferson-Ste. Genevieve, and Perryville karsts, and an isolated Caney Mountain area. The Perryville Karst encompasses most of the eastern portion of Perry County, Missouri and is underlain by Ordovician dolostone and limestone. The St. Peter Sandstone formation borders the sinkhole plain to the west and these soluble rocks underlay the sinkhole plain in the Perryville karst.

Perry County leads the state in the number of known caves, with more than 670; Perry Co. also harbors some of the longest caves such as Crevice Cave (28.2 miles), Moore Cave System (19.36 miles), Mystery Cave (16.98 miles), and Rimstone River Cave (14.03 miles). The Perryville Karst contains thousands of sinkholes ranging from a few feet to several hundred feet in diameter and can be up to 100 feet deep. In addition to several caves of considerable length, caves in the Perryville Karst possess fairly rich cave fauna. Dr. Bill Elliott (MDC, retired) ranked the diversity of cave life in Missouri using the Cave Biodiversity Ranking system developed in 2007. Several caves within the Perryville Karst are ranked in the top 50 caves for biodiversity: Mystery (#3), Berome Moore (#4), Tom Moore (#8), Running Bull (#36), and Crevice Cave (#48).

Photo by Brad Pobst

Mertz Cave entrance in Perry County

Five major cave systems in the Perryville Karst contain an endemic cave-dwelling fish called the grotto sculpin, (*Cottus specus*). Members of this species live in cave streams, springs, and surface streams and migrate between underground and aboveground habitats to complete their life cycle. The U.S. Fish and Wildlife Service identified the grotto sculpin as a candidate for listing under the Endangered Species Act in 2002 and proposed to list the grotto sculpin as an endangered species in September 2012. The final listing determination was published in the Federal Register in late September 2013.

Even though there has been significant caving activity in Perry Co. since the 1960s, very little research on the biological and water quality aspects of this unique karst system has been conducted. To evaluate the existing conditions of the Perryville Karst, the Missouri Department of Conservation began several

Photo by Brad Pobst

Grotto Sculpin from Mystery Cave: eyes are absent in the specimen above but present in the sculpin below

Photo by Brad Pobst

Grotto Sculpin *(Cottus specus)*

The grotto sculpin is a small, cave-dwelling fish that exhibits physical adaptations to living in total darkness, such as pale skin pigmentation. The grotto sculpin is genetically distinct from epigean (above ground) banded sculpin found in adjacent streams and is morphologically distinct because of reduced, sometimes absent, eyes, and differences in brain structures responsible for optic and olfactory functions. At this time the grotto sculpin is found in five cave systems and two surface streams in Perry County. Grotto sculpin can live in cave streams, springs and corresponding surface streams. Individuals can migrate between underground and surface habitats.

Grotto sculpin are carnivores that eat invertebrates, including isopods and amphipods. These fish use stream pools as well as areas under rocks that offer more protection. Both pool and riffle areas with a variety of substrates are used, including silt, gravel, cobble, and bedrock.

The grotto sculpin has been of interest to State and Federal agencies since 2002 when it was listed as a candidate for listing under the Endangered Species Act. At that time it was still considered a subspecies of the banded sculpin complex. In February 2013 it was officially named as a unique species. The grotto sculpin was listed as an endangered species by the U.S. Fish and Wildlife Service in late September 2013.

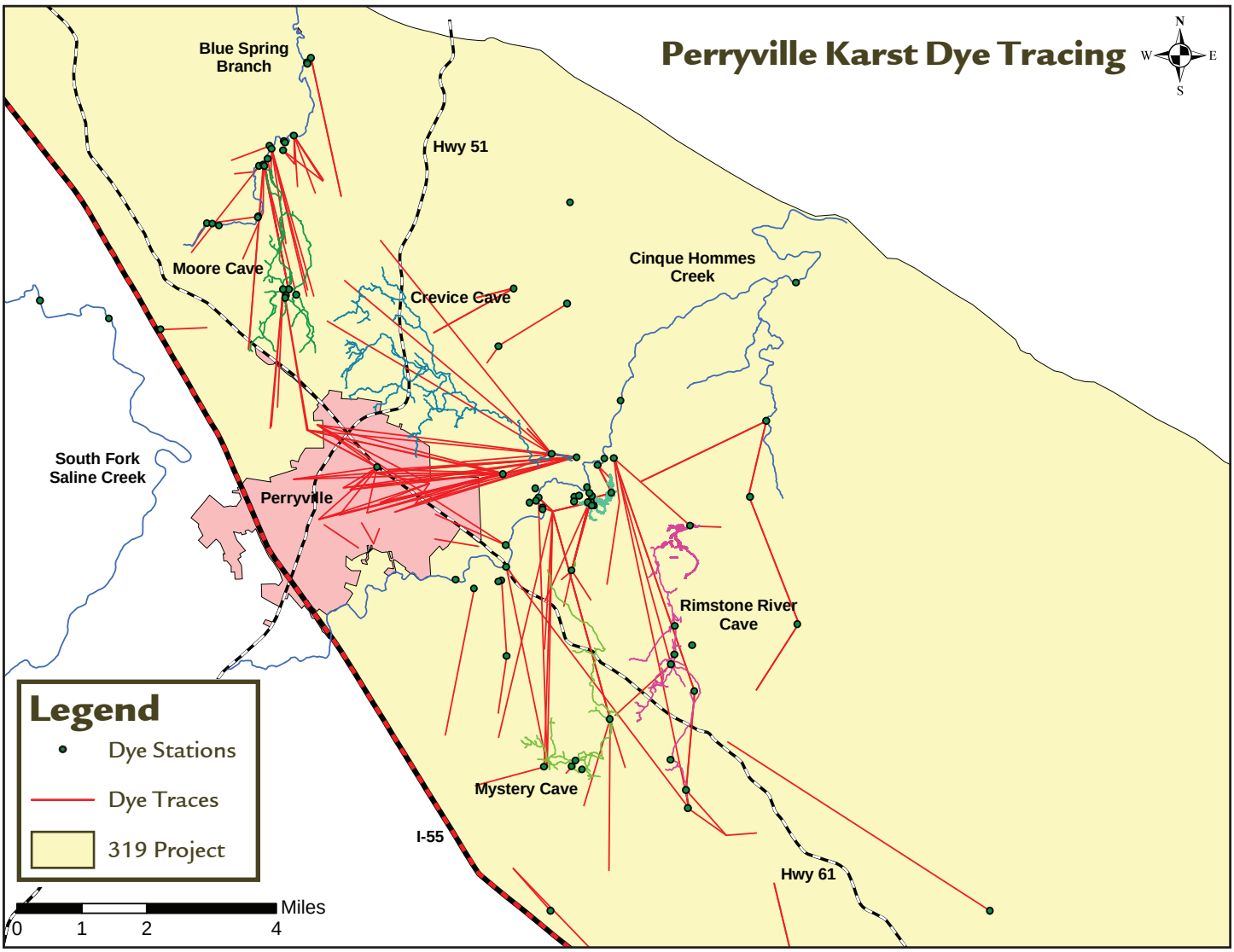
water quality projects to identify areas of concern and impairments as well as the general conditions of the karst region. The evaluations included dye tracing to determine cave stream recharge areas, GIS cave mapping, grotto sculpin sampling, water quality testing, and an assessment of vulnerable conditions within the cave systems.

Since the Perryville Karst is situated above the Ozark aquifer, a shallow groundwater system exists here that is directly connected to the surface water system via multiple conduits. Dye tracing studies are the best way to gain an understanding of the connectivity, movement, and recharge areas of the shallower groundwater system. Four dye tracing studies were conducted to determine the recharge areas for the major cave systems in the Perryville Karst that contain a population of grotto sculpin and to examine storm water runoff issues in the City of Perryville: Vandike (1985), Sides (as reported by Schooler, 1996), Aley and Moss (2007), and Crawford (2006). These studies were funded through MDC, the Missouri Department of Natural Resources, U.S. Fish and Wildlife Service, City of Perryville, and grotto (caving) clubs. The latest dye tracing efforts (Moss and Pobst, 2010) built upon earlier studies, repeated inconclusive traces, and summarized the data of earlier and current traces in order to determine the most complete picture of the recharge areas. The Environmental Protection Agency funded this recent survey through a 319 grant.

To date, 87 dye introductions have been conducted in the Perryville Karst. These introductions were used to delineate eight recharge areas that include approximately 36.3 square miles. These eight recharge areas include Moore Cave (Blue Springs), Keyhole Spring, Ball Mill Spring, Crevice Cave (Mertz Resurgence), Mystery Cave (Mystery Resurgence), Rimestone River Cave (Cedar Spring), Running Bull Cave (Thunderhole Resurgence) and Thunderhole Resurgence. Some of the introductions went to other springs that need additional tracing to delineate their recharge areas.

In conjunction with the dye tracing project, MDC collaborated with the Cave Research Foundation to produce GIS maps that combined existing cave maps with the observable surface topography. These maps defined the accurate location of these caves in relation to a variety of available surface maps, including topographic and aerial imagery. Radio telemetry was also conducted in Mystery, Crevice, Rimstone River and the Moore Cave systems to enhance the accurate locations of these caves. At the time of this writing, over 60 caves have been geo-referenced.

Figure 1. Dye traces and sampling stations to determine recharge area for the major cave systems in Perry County



Since 2001, two major fish kills have occurred in two different cave systems that impacted the grotto sculpin. These fish kills provided the impetus to acquire funding to conduct several water quality projects that spanned several years (Pobst and Taylor, 2007–2011). These projects included monthly grab samples that tested for water quality parameters, herbicides, nutrients, and bacteria. Researchers collected samples from 20 sites that included cave streams, springs, resurgences, and surface streams. Significant findings from these samples included the following:

- The water quality standard for classified streams is for a minimum dissolved oxygen concentration of 5.0 mg/L. A water body is judged to be impaired if more than 10% of the samples exceed this criterion. Five out of 20 sites exceeded this criterion.
- The water quality standard for pH is between 6.5 and 9.0. A water body is judged to be impaired if more than 10% of the samples exceed this criterion. Six out of 20 sites exceeded this criterion.
- Atrazine samples were taken biweekly from April through July. The water quality criterion for Atrazine is 3 µg/L. Atrazine is typically applied to cornfields in the spring. Ten out of 12 sampling sites exceeded this criterion. Five sites exceeded this criterion more than 10% of the time. The highest reading was 35.81 µg/L.
- The water quality standard for bacteria (*E. coli*) for classified streams is for a geometric mean of 206 colonies/100mL during the recreational season, April1 to October 31. Thirteen sampling sites exceeded this standard. Seven sites had a geometric mean above 1000 colonies/100mL.
- Nitrate and total phosphorus samples also showed consistently higher levels compared to the MoDNR reference station, indicating impacts to the water quality.
- Total suspended solids were consistently high, especially from springs and resurgences.

Modification of natural sinkholes can have negative consequences on a karst system. In a karst plain, sinkholes serve as the natural drainage system much like surface streams in non-karst landscapes. Disrupted hydrological functions can cause a cascading effect from the surface to underlying waterways and include changes in sediment movement, water filtration, water quality, and destruction of habitat for karst-dependent species, as well as terrestrial wildlife, such as quail and other small game.

Photo by Brad Pobst

Vertical drains in field without adequate vegetative buffer

Management practices have been developed to control soil erosion in altered karst landscapes. One such practice used frequently in the Perryville Karst is installation of vertical drains. A vertical drain is defined as "a well, pipe, pit, or bore in porous, underground strata into which drainage water can be discharged" (Natural Resources Conservation Service 2006). Vertical drains can be recognized in the field as vertical metal standpipes visible above the ground. The intention is to decrease erosion and, often, to make more of the land surface useable to the landowner. In the counties that participate in these practices, landowners are eligible for state and federal cost-share programs through the County Soil and Water Conservation District and the Natural Resources Conservation Service and can receive up to 75% cost-share to install vertical drains to mitigate erosion. Participating landowners agree to implement appropriate best management practices as outlined in the Conservation Practice Standard. However, in addition to erosion control, other factors should be

The L-A-D Foundation and Perryville Karst

The L-A-D Foundation is a private operating foundation dedicated to sustainable forest management, protection of exemplary natural and cultural areas in Missouri, and providing support and advocacy for projects and policies that have a positive influence in Missouri. In Perry County, the Foundation has purchased several tracts of land to protect and restore the natural communities of the karst area. These tracts of land include Ball Mill Resurgence Natural Area (1978), Shafer Farm Tract (2007) and the Riney Farm Tract (2012). The Missouri Department of Conservation manages these lands for the L-A-D Foundation.

Ball Mill Resurgence Natural Area is a 19.7 acre designated natural area that possesses several karst windows scattered along a hiking trail that ends up at one of the largest sinkholes in Perry County. This sinkhole, known as the Ball Mill Resurgence, fills up during periods of heavy rainfall and water and rocks are then forced up and out of the surface entrance of Ball Mill Resurgence.

The Shafer and Riney Farm Tracts were purchased to protect the land around Ball Mill Resurgence Natural Area and along Blue Spring Branch, and the karst systems in the area. Altogether an additional 276 acres will be managed and restored to represent the historic character of the Perry Oak Savanna/Woodland Dissected Plain and/or the barrens communities that were described by the General Land Office surveyors in the 1800s. Management and restoration of natural communities on the property also will protect the karst resourcesand provide an area that is well suited for conducting demonstrations, field days, and workshops focused on awareness of the value of Perry County karst resources.

Unique features one can find on these tracts of land include Keyhole Spring, Keyhole Resurgence, Blue Spring Branch, Ball Mill Resurgence, several unnamed springs and caves, and more than 30 sinkholes. The Moore Cave System extends underneath the Shafer Tract but there is no access to this cave system. In the near future, these properties will be open for public use.

considered before vertical drains are installed because the practice might not be appropriate for all locations and applications. For example, in situations where a vertical drain is inadequate to handle the volume of water that is intended to pass through, water inflow quickly bypasses the drain system and leads to destabilization of the sinkhole. Further complications leading to negative impacts to water quality occur in the absence of an adequate filter system, such as a vegetative buffer. Vertical drains installed without additional filtration facilitate the migration of nutrients and pesticides into the groundwater system.

Remediating damage from historical practices can also present challenges to conserving and managing a unique karst resource. While uncommon today, past uses for many sinkholes include trash dumps. Material including household waste and tires were used to fill sinkholes with the intent of reducing erosion, preventing livestock from falling into sinkholes, and general disposal of unwanted refuse. Today, these impaired sinkholes contain household items that can eventually end up in cave streams. Recent studies have shown the detection of chlordane and heptachlor in cave streams, two pesticides that were banned over twenty years ago and are not in use today. There is a high probability that these pesticides are leaking from old containers that were discarded in sinkholes. Negative implications of such land use practices have included the obstruction or closing of cave openings, eliminating access by organisms dependent on the cave environment, and degradation of water quality from sediment and pesticides. For these reasons, federal and state agencies are hoping to develop cost-share programs to help willing landowners clean out their trash-laden sinkholes. To date, there have been twelve sinkhole cleanouts using funds from this program. Several cleanups revealed significant openings to caves. Additional sinkhole cleanouts will be completed in the future.

The Perryville Karst is unique and diverse. With a multitude of sinkholes and large cave systems, proactive management to protect the water quality and cave environment will necessitate a collaborative effort between citizens of Perry County, agencies, and conservation partners. Recently the Perry Co. Community Economic and Environment Committee developed the Perry Co. Community Conservation Plan. The U.S. Fish and Wildlife Service included the plan in their analysis of potential critical habitat exclusions for the grotto sculpin. The plan summarizes current stewardship practices and defines focused conservation practices that will be implemented to improve water quality to the benefit of wildlife and people that live in the Perryville Karst.

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Photo by Scott House

Volunteer counts bats in Branson Cave, Alley Spring NA

Identifying a Theme Gap: Cave and Karst Natural Areas

By Scott House

Pigeons sometimes use caves; large cave entrances, with small holes in their walls near the entrance, may provide habitat in the form of what humans refer to as "pigeon holes." And humans have developed the term "pigeonholing" to describe our attempts to classify seemingly everything in the world. Caves resist this human tendency toward easy classification, and few natural features are more difficult to classify than caves. Attempts to classify caves usually fail at one or more levels because caves are incredibly different and diverse. With over 6,800 caves currently known in Missouri, one could literally subdivide them into about 6,800 different categories.

Natural areas are defined to include biological communities or geologic sites, which include high quality examples of natural communities. While there is a cave natural community type as outlined in the *Terrestrial Natural Communities of Missouri* (Nelson, 2010), our classifications have tended toward biological communities rather than systems of hydrology or inert systems relying primarily on host rock for definition.

Absence of species, a dearth of a biological community, does not make a cave unimportant or common. A large cave with low diversity is, in itself, highly unusual, which makes it unique by its own right. A very short cave may be a world-class archaeological site. A cave that is only 100 feet long may harbor endangered species, but it may also be home to a rare type of cave formation or display hydrologic complexities that serve as examples of karst hydrology in the Ozarks.

Cave Research is Different

Over the years, Cave Research Foundation (CRF) and its partners within the Missouri Speleological Survey (MSS) have been actively engaged in documenting and studying various components of the Missouri karst landscape. The MSS was founded in 1956 for the intent of gathering cave and karst data throughout Missouri. The CRF came to life the following year, first in Kentucky and then spreading across the country. The CRF is not a membership organization nor is it limited in scope; the real niche of CRF is its ability to work with agencies in identifying, studying, and managing karst and cave resources. The Missouri Cave Database, managed by both organizations and supported by several agencies, contains locational and descriptive information on caves across the state. Volunteer cave enthusiasts, commonly known as "cavers," contributed most of the information in the database (and paper files). Without cavers, we would know very little about caves in Missouri.

Fieldwork in caves is multi-disciplinary. Usually when we map

a cave, we also try to conduct a reasonable biological inventory, subject to agency guidelines. In certain funded projects, we collect invertebrates that need further identification. We also monitor caves as an ongoing activity, checking caves for human use (or misuse) as well as conducting basic biological counts. In the current atmosphere of cave closures, only authorized visitors can report on findings; unauthorized visitors come and go but are careful not to tell agencies of their visits.

Fieldwork can be technical, requiring specialized equipment and skills: vertical gear, wetsuits, nylon cave suits, specialized packs, and dependable lighting sources are all necessary. Detailed and useful cave work cannot be done by "the original amateur hour." Knowing what is rare or different in a cave environment requires years of experience in caves. Understanding cave resources is not easy, and most caves definitely resist pigeonholing. Fortunately, experienced help is available.

Serious cave inventory work is accomplished through a variety of means: some projects are accomplished through contracts, others through challenge cost-share agreements, and others through research grants. All inventory projects involve a great deal of volunteer time. One researcher, working alone, does not make a team and field support must be recruited. Despite the advent of WNS in Missouri, most agencies have recognized the value of inventory work and have written WNS response plans that allow scientifically valid geologic, geographic and biologic work to continue.

The Salem Plateau Karst

As a partial result of these years of ongoing work, the Missouri Natural Areas Committee has designated several natural areas with a strong cave or karst component. The Salem Plateau in the Ozark Highlands is typified by geologic formations of Ordovician age and older. In the Salem Plateau, there exists good representation of caves and karst processes, and cavers have long been active in identifying and mapping these resources. The karst systems of the Salem Plateau are well represented in the Natural Areas Program. The following select examples are mostly from the region in the Salem Plateau known as the Lower Ozarks.

Powder Mill Creek Cave survey, August 1989

Photo by Scott House

Powder Mill Creek Cave Natural Area

The CRF began mapping Powder Mill Creek Cave in the 1980's. The cave had been recognized under various names for many years, but its resources had not been fully documented. Mapping in this long, wet cave took years of effort. Necessary equipment, other than typical survey instruments, included Neoprene wetsuits and sturdy rubber knee pads. Trips to the cave grew lengthier as time progressed, and it was not unusual to spend 12 to 18 hours a day working in Powder Mill Creek Cave. Despite the warmth afforded by Neoprene, it was not unusual for surveyors to lose feeling in their feet; sometimes they did not warm up until we reached the entrance to the cave. Throughout the survey, we made new discoveries. A small side passage opened up into several miles of complex streams and canyons, an area so difficult to traverse that it became known as the Hellhole Section. Trips moving far upstream involved crawling in the stream over large cobbles; to reach the navigable end of the cave required crawling for the better part, coming and going, of two miles. Eventually, we completed the cave survey. The upstream end of the cave continues past our mapping abilities but with no air available for explorers. Today the map sheets are being completed after several years of drafting. The cave had long been known for being longer than a mile, the final surveys showed a cave nearly eight miles long. The cave is the second-longest within the Salem Plateau.

Sunklands Natural Area

A totally different type of "Hellhole" lurks in the bottom of a hollow near the large sinkholes that give this area its name. This cave, on MDC lands, gives us a window into the karst drainage system of the Salem Plateau. We know that much of the water is "lost" underground, only to resurge perhaps miles away at large springs. But here we can actually see the process. The entrance directly captures the water of a deep hollow which falls into a 20 foot deep pit. Not a place to be in the rain, the cave was surveyed in the 1980's for a length of 200 feet and a total depth of more than 40 feet below the hollow bottom.

Other caves within the natural area, on Ozark National Scenic Riverways land across from Pulltite campground, demonstrate a

Helictites and spathites in Powder Mill Creek Cave

Photo by Scott House

variety of cave types including dry remnant caves and yet another window into a spring system. Here, a small depression in the ground leads down into a chamber with an active stream that comes to the surface a few hundred feet away as Fire Hydrant Spring. The water for the spring goes under a side hollow and probably exists as another outlet for the main conduit that feeds Pulltite Spring.

Pipestem Hollow Natural Area

This area on MDC land was inventoried and mapped by CRF some years ago. We helped with the designation of the area which includes a number of small, but varied cave types. The area includes such diverse features as: small upland spring caves, shelter caves, dry tubes, sinkhole-entranced rooms, and a large paleo-trunk cave. None of these caves would, by themselves, necessarily qualify as unique, but the total assemblage makes the area worth noting and protecting.

Alley Spring Natural Area

Expanded to include more of the surrounding terrain, this natural area includes three interesting caves on Ozark National Scenic Riverways land. One is Alley Spring itself, classified as a cave even though it contains only water-filled passage. But it is a cave and has been mapped for over 3,000 feet. Branson Cave, one of the most biologically diverse caves in the state, is another. Located in younger rock, but much older in origin than Alley Spring, this high and nominally dry (it is muddy) cave supports a wide variety of cave life. CRF has undertaken both a biological survey and a new cartographic survey of the cave in recent years. It is the type locality for a new species of trechine beetle that CRF researcher Mick Sutton initially identified. The cave also is known for more species of bats than any other Missouri cave. But in addition to these biological oddities, the cave and Alley Spring provide a good contrast and comparison for cave formation; Alley Spring is developed just below a sandstone layer in the upper Eminence formation of Cambrian age, while Branson is developed 250 feet higher in elevation below a sandstone layer in the upper Gasconade formation of Ordovician age. These two zones account for most of the cave formation in the Salem Plateau. Another cave, less than 200 feet long occurs at the same level as Branson Cave. Why do these caves occur at these particular levels? Briefly, most caves within the Salem Plateau form just below relatively impermeable sandstone units or formations. The processes by which this occurs are not well understood, but it may be that under deep phreatic circulation, where groundwater is trying to move upwards, sandstone layers could act as confining units which put the groundwater immediately below them under greater pressure. This additional pressure causes greater dissolution in layers just below the confining units. Therefore, cave development is much greater in these geologic horizons.

Grand Gulf Natural Area

This spectacular chasm, formed by the collapse of a cave, offers a textbook look at sinkhole development. Here one can see cave entrances, including a natural bridge that is a surviving remnant of the collapses that took place. CRF and the MSS mapped this system in the 1980's. The land, owned by L-A-D Foundation is leased by the Missouri Department of Natural Resources as a state park.

Photo by Cave Resources Foundation

A small cave feature in Tunnel Bluff Natural Area

Tunnel Bluff Woods Natural Area

Mapping and inventorying of this area on lands administered by Ozark National Scenic Riverways and Mark Twain National Forest continues today. A pair of steep draws contains a cluster of small caves and a natural arch. While a small number of bats utilize the caves, the interest here is primarily in the high concentration of caves within a little more than a hundred yards distance. When visited, you may wonder what is holding the hill up.

Big Spring Pines Natural Area

Within this natural area on Ozark National Scenic Riverways, near Missouri's largest spring, is a hidden cave that goes down through the boulders to a pool of still water that perhaps connects to the spring conduit. We mapped the cave many years ago, but it was not safe then and it is not safe now. The giant boulders that make up the hill talus, perhaps part of a collapsed cave, continue to move. The cave is now gated for safety to unwary visitors who might stumble on it. It does offer a tantalizing view of the underground behind the spring. And it demonstrates yet another cave type, the talus cave.

Jacks Fork Natural Area

Part of the Ozark National Scenic Riverways, this extensive natural area includes the spectacular Jam-Up Cave system, where a cave system pirates a surface stream. But the system also demonstrates a pit entrance, steep sinkhole entrance, and the huge resurgent entrance, where the stream makes its way to the Jacks Fork River. The MSS mapped this system in the 1980's but field work by CRF is still ongoing within the natural area; new caves continue to be found and aptly demonstrate a variety of cave formation types.

A new cave being mapped in Jacks Fork Natural Area

Photo by Cave Resources Foundation

Prairie Hollow Gorge Natural Area

Because they are insoluble, igneous rocks host few caves in the state. This natural area, on Ozark National Scenic Riverways, includes a couple of small features developed in Precambrian rhyolite. One is a simple shelter without a dark zone, but the other is a two-entranced cave developed along a joint in the rock at stream level.

Outside the Salem Plateau Box

Despite all of these examples the representation of caves and karst within Missouri's Natural Areas System is far from complete. The Salem Plateau is well-represented, from Tunnel Bluff to Ha Ha Tonka. But what of the other karst areas in the state? Well, not so much. View this gap as an opportunity for expansion.

The Springfield Plateau area, a geographically distinct region, has vast numbers of caves, including geologically and biologically significant sites. Many caves are found along the flanks of the Eureka Springs Escarpment where the Springfield Plateau borders the lower Salem Plateau level. Tumbling Creek Cave, the state's most biologically diverse cave is on the lower slopes of the escarpment. Yet only a couple natural areas have a cave or karst element.

The Southeast Missouri Karst includes Perry County, home to the greatest cave development in the state. And yet only one small natural area has a karst element. What would be appropriate here is to designate a smaller, intact karst system with a protected watershed.

The Central Missouri Karst includes areas on either side of the Missouri River, developed mostly in Mississippian age rocks. The Devils Icebox, one of the longer caves in the state, is in this karst area. Yet, we have no karst natural areas designated.

The Northeast Missouri Karst is hosted by newer rocks, including the Louisiana formation of Devonian age and several Mississippian-age formations. The area includes long and intricate maze caves (Cameron Cave is more than four miles long) as well as sinkhole plain caves with high biologic values. Only one natural area, a creek, includes the entrance of a cave.

The St. Francois Mountains is a largely non-karstic subset of the Salem Plateau. And yet there are caves within this area. Some of these are developed in initial-deposition dip rocks, which may have steeply dipping beds that greatly affect the development of the caves. These are highly unique caves, developed as water drained off of igneous highs and into the sedimentary slopes beside them. There are probably less than twenty caves of this type that we know of; some also have rare species within them. A representative of this type should be added to the system.

The Natural Areas System contains wonderful examples of Missouri karst. We just need to finish the work of identifying and protecting type localities throughout the state.

Scott House is the Ozark Operations Manager with the Cave Resources Foundation

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Photo by William R. Elliott

Great Spirit Cave

Protection of Great Spirit Cave Natural Area

by Mike Leahy

Nestled in the Ozark ridges and valleys of Pulaski County, Missouri, is the biological and geological treasure that is Great Spirit Cave Natural Area. Formed from millennia of dissolution of dolomite rock of the Gasconade Formation (Ordovician System), the cave system here contains a perennial spring-fed stream that flows through the cave system and exists at the cave entrance. This constant source of groundwater flow provides for a very biologically active cave system. Nearly two miles of cave passage provide a wide variety of cave community types. Many speleothems including stalactites and stalagmites grace the passageways.

Forty-six animal species have been documented in the cave, including four troglobites, species restricted to the cave environment. While forty-six species does not seem like a significant number to biologists who deal routinely with above ground natural communities, for a cave system this represents biological richness. Elliott (2007) ranked this cave as 37th in cave biological diversity, from a pool of 6,200 caves and cave springs known in the state. One of the fascinating troglobite species found here is the grotto salamander (*Eurycea spelaea*), a Missouri species of conservation concern. This salamander is endemic to the Ozark plateau and has an interesting life history. Grotto salamander larvae have gills and functional eyes; as adults their eyes become reduced and are covered or partially covered by a fusion of the eyelids – they are blind and they have reduced pigmentation ranging from beige to pink in color. Because these salamanders spend their life in total darkness, vision and skin pigmentation serve no adaptive purpose.

In all, five Missouri species of conservation concern utilize the cave, including the gray bat (*Myotis grisescens*) and Indiana bat (*Myotis sodalis*), both of which are listed endangered under the U.S. Endangered Species Act. Recently, the cave has been documented to serve as a hibernaculum for Indiana bats, a use that had not been noted in several intervening years. Large guano deposits indicate that the cave historically supported a large gray bat maternity roost, with tens of thousands of bats. Human disturbance, especially the use of the cave as a show cave during the 1950-1960s, likely resulted in the gray bats discontinuing their use of this cave as a maternity roost. Currently, the cave is used by gray bats as a summer roost but not for raising young. All told, eight species of bat utilize the cave throughout the year — a bat diversity equaled by just three other Missouri

caves. It remains to be seen what impact white-nose syndrome will have on the bat populations of this cave.

In addition to the living creatures, the cave has served science as a site for paleontological and archaeological remains. Bones of the extinct Pleistocene era flat-headed peccary (*Platygonus compressus*) have been documented from the cave. Native Americans inhabited the cave for centuries.

To protect the cave's resources the Missouri Department of Conservation purchased the cave from a willing seller in 1980. In 2002, to better protect the fragile cave resources from trespass, MDC constructed a bat-friendly cave gate across the entrance. In 2011, the Missouri Natural Areas Committee designated Great Spirit Cave as natural area, the most recent natural area to be designated primarily for its cave features. Today, Great Spirit Cave Natural Area is closed to the public to protect the fragile cave resources found there. Most natural areas are open to public use, but for some cave systems, public use would rapidly diminish their biological resources. Great Spirit Cave Natural Area protects endangered species and provides for ongoing scientific research into cave life.

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Recent Natural Area Nominations

by Mike Leahy

In the spring of 2013 the inter-agency Missouri Natural Areas Committee (MoNAC) approved the nominations for a 22-acre addition to Dark Hollow Natural Area and a new 184-acre Prairie View Farm Natural Area. MoNAC seeks final approval by the directors of the Department of Conservation and the Department of Natural Resources.

Prairie View Farm Natural Area is a remnant prairie in Vernon County owned by the Teel family. This remnant prairie is one of only 18 other sites (900 acres total) left in Missouri to support dry-mesic limestone/dolomite prairie; the Teel family's prairie is one of the largest of this prairie type to remain. The prairie supports three species of conservation concern, including the federally listed Mead's milkweed (*Asclepias meadii*), as well as a number of uncommon prairie plant species such as prairie turnip (*Pediomelum esculentum*) and biscuit root (*Lomatium foeniculaceum*). Over 200 native plant species, the Regal Fritillary butterfly (*Speyeria idalia*) and a dozen grassland bird species occur here. The Teel family has owned this property for decades and has worked closely with MDC staff to manage this prairie. Ms. Bonnie Teel is currently a board member of the Missouri Prairie Foundation and is extremely proud of the family's prairie.

Dark Hollow Natural Area occurs in Sullivan County and is owned by the Conservation Department. The area was first noted in 1954 by botanist Julian Steyermark as having value for its varied plant life. This area was historically a transition zone between savannas and prairies to the south, and woodlands on the hills and bottoms along Spring Creek to the north. In the spring, the lower north facing slopes put on a show of ephemeral spring wildflowers including bellwort (*Uvularia grandiflora*), Jack-in-the-pulpit (*Arisaema triphyllum*), and wild ginger (*Asarum candense*). In contrast to the fern-rich lower slopes, the dry ridges support little bluestem (*Schizachyrium scoparium*), finger coreopsis (*Coreopsis palmata*), wild quinine (*Parthenium integrifolium*) and other fire-adapted species of prairies, svavnnas and open woodlands. On the side slopes, oaks over 150 years old occur. The original 292-acre natural area was designated in 1992 and the 22-acre addition will add more acreage of similar natural communities, bringing the total natural area to 308 acres.

Photo by Mike Leahy

Shooting Star (now *Primula meadii*) and Mead's sedge (*Carex meadii)* at Prairie View Farm Natural Area

Jane Lale retires from Missouri Natural Areas Committee

by Ken McCarty

Jane Lale served on the Missouri Natural Areas Committee from 2005 until her retirement in September, 2013. On behalf of the committee, Ken McCarty, Chair, presented Lale with a letter of appreciation (at right.)

"My experience on the committee has been more of me learning from the talented, diverse group of committee members and experiencing the natural areas throughout the state, first hand with our field visits and discussions. The importance of recognizing, protecting and managing our state's natural areas became more clear while serving on the NA committee. I strived to assure that our state parks' natural areas and natural resources are at the forefront of the decision making processes that we do in the Planning and Development Program. More importantly, I saw that the collective knowledge and dedication of the committee members to the goals of the Natural Areas Program will sustain it and assure that these special natural areas throughout the state are identified, protected and enjoyed by future generations." — Jane Lale

Ken McCarty, Missouri Department of Natural Resources, is Chair of the Missouri Natural Areas Committee.

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MISSOURI NATURAL AREAS COMMITTEE
POST OFFICE BOX 180, JEFFERSON CITY, MO 65102

Presented to Jane Lale
Director, Planning and Development Program
Missouri State Parks

This Letter of Appreciation

Recognizing her time and service as a member of the Missouri Natural Areas Committee, and ambassador for natural area programs and values both within Missouri state parks and on behalf of the committee within the state of Missouri

Dear Jane,

Since its founding in 1976, The Missouri Natural Areas Program has served our partner agencies and the conservation efforts in this state with the way and means to preserve and showcase the very best examples of Missouri's native natural environments. Throughout these years it has set the standards of natural area designation and management, and built a system of Natural Areas that is among the best in the nation.

The strength of Missouri's Natural Areas Program has always reflected the strength and passion of the select group of resource professionals who form the Missouri Natural Areas Committee. These people have joined their visions of perpetuating the best of Missouri's natural heritage, converting the highest levels of technical expertise and administrative capability across the spectrum of Missouri's natural resource agencies, into the ideas and philosophies which guide the program today.

The Missouri Natural Areas Committee has a growing legacy of personalities who have made these things happen. One has been you, and upon your impending retirement your co-committee members with single voice convey our deepest appreciation for the time and talent you brought on behalf of Missouri Natural Areas through your years of service with us. We wish to thank you for your participation, your ideas and your advocacy for natural areas that has helped grow this program. Particularly we regard how you have transformed its ideals into policies, planning and practices to assure that Natural Areas in Missouri's state parks remain both stellar and secure.

So thank you for your many years of service and commitment to the Missouri Natural Areas Committee, and Missouri's Natural Areas Program. We all have enjoyed working with you, and wish you the best in your new endeavors.

Sincerely,

The Missouri Natural Areas Committee
September 12, 2013

Missouri Department of Natural Resources

Friends of Natural Areas Potluck

Allison J. Vaughn

On October 18, a crisp autumnal bluebird morning, members of several constituent groups and private individuals joined Missouri Natural Areas Committee members at Ha Ha Tonka State Park for a guided hike followed by a potluck lunch designed to meet some of the Friends of Natural Areas. The Audubon Society of Missouri, Columbia Audubon Society, the Missouri Native Plant Society, and the Missouri Botanical Garden were all represented at the Friends hike and potluck.

Photo by Allison J. Vaughn

Park Naturalist Larry Webb discusses glade restoration with the Friends of MoNAC at Ha Ha Tonka State Park on October 18, 2013

The morning began with Ha Ha Tonka SP Park Naturalist Larry Webb leading a hike on the Quarry Trail which traverses a series of recently restored glades and encompasses an area that, in January 2012, was accessioned to the Ha Ha Tonka Oak Woodland Natural Area which now includes 2,995 acres.

Following the hike on the Quarry Trail, the group visited a 12 acre glade belt along Spencer Creek that was the focus of a 2010 Missouri Bird Conservation Initiative grant that allowed for cedar removal and prescribed fire implementation. Since cedar removal was completed in early 2011, the glade has responded with a rich grass and forb cover. Fall wildflowers were at their peak that day. Throughout the day, the birders in the group detected 39 species including winter residents such as yellow-bellied sapsuckers. By lunchtime, the group gathered at the Post Office Picnic Shelter for a delicious potluck lunch and camaraderie.

Allison J. Vaughn is a Natural Resource Steward with the Missouri Department of Natural Resources.

Contact: allison.vaughn@dnr.mo.gov

November 1, 2013

Call for Proposals: Botany 2014

Botany 2014: New Frontiers in Botany will be held July 26–30, 2014 in Boise, Idaho. Papers, posters, and workshop proposals are due November 1, 2013. Visit *http://www.botanyconference.org* for more details.

November 5, 2013 • 1pm Central

Reconstructing pre-European fire regimes, forests and wildlife habitats in the eastern United States: Mammoth Cave National Park, Kentucky

Webinar

Presented by Dr. Cecil Frost, Adjunct Faculty at The University of North Carolina at Chapel Hill. This webinar qualifies for Society of American Foresters and The Wildlife Society continuing education credits.

➢ Attend here: *http://forestry.adobeconnect.com/r7h37tu0nhr/*

November 19, 2013 • 5:30-9:00pm

Energy Production Meets Biodiversity

St. Louis, Missouri

The 2013 Whitney and Anna Harris Conservation Forum will feature four speakers addressing the energy industry and impacts to biodiversity. The event is free and open to the public, but registration is required. Light dinner will be served to all attendees. For a complete agenda and registration information, visit *http://icte.umsl.edu/Events.html.*

December 10, 2013 • 1pm Central

Oak, Fire and Mesophication: Past, current and future trends of oak in the eastern United States

Webinar

Dr. Gregory J. Nowacki, Ecologist with the US Forest Service, Eastern Region, will discuss current and future trends of oaks in the eastern United States. This webinar qualifies for Society of American Foresters and The Wildlife Society continuing education credits.

➢ Attend here: *http://forestry.adobeconnect.com/r8oc1tgd6le/*

January 17–18, 2014

The Science, Practice and Art of Restoring Native Ecosystems Conference

East Lansing, Michigan

The Stewardship Network is pleased to bring you two great days of informative talks and workshops that will focus on Field and Place Based Conservation – Applying Techniques That Work at the Community Level. For more details and a conference agenda visit *http://www.stewardshipnetwork.org.*

January 26–29, 2014

74th Midwest Fish & Wildlife Conference

Kansas City, Missouri

The annual conference attracts over 800 biologists and students from state, federal and tribal natural resource agencies across the 12 Midwestern states. Highlights include: over 400 technical talks, poster displays, plenary sessions, networking opportunities and social events. For more details and a conference agenda visit *http://www.midwestfw.org.*

February 5–7, 2014

Missouri Natural Resources Conference

Osage Beach, Missouri

"Battles in Conservation: Politics, Science, and Stewardship." The Missouri Natural Resources Conference (MNRC) is an annual meeting organized and sponsored by the Missouri Chapter of the American Fisheries Society, The Missouri Chapter of the Society of American Foresters, Missouri Chapter of the Wildlife Society and the Show-Me Chapter of the Soil and Water Conservation Society. This unique blend of disciplines, represented by the four societies, promotes wise use and management of Missouri's natural resources. Each year the conference hosts approximately 1,000 established and aspiring natural resource professionals who meet to exchange information and ideas and encourage continued cooperation among resource professionals, agencies, and other natural resource stakeholders. For more details and a conference agenda visit *http://www.mnrc.org.*

The Missouri Natural Areas Newsletter

is an annual journal published by the Missouri Natural Areas Committee, whose mission is identifying, designating, managing and restoring the best remaining examples of natural communities and geological sites encompassing the full spectrum of Missouri's natural heritage. The Missouri Natural Areas Committee consists of the Missouri Department of Natural Resources, the Missouri Department of Conservation, the U.S. Forest Service, the U.S. Fish and Wildlife Service, the National Park Service and the Nature Conservancy.

The Nature Conservancy
Protecting nature. Preserving life.™

Missouri Department of Natural Resources