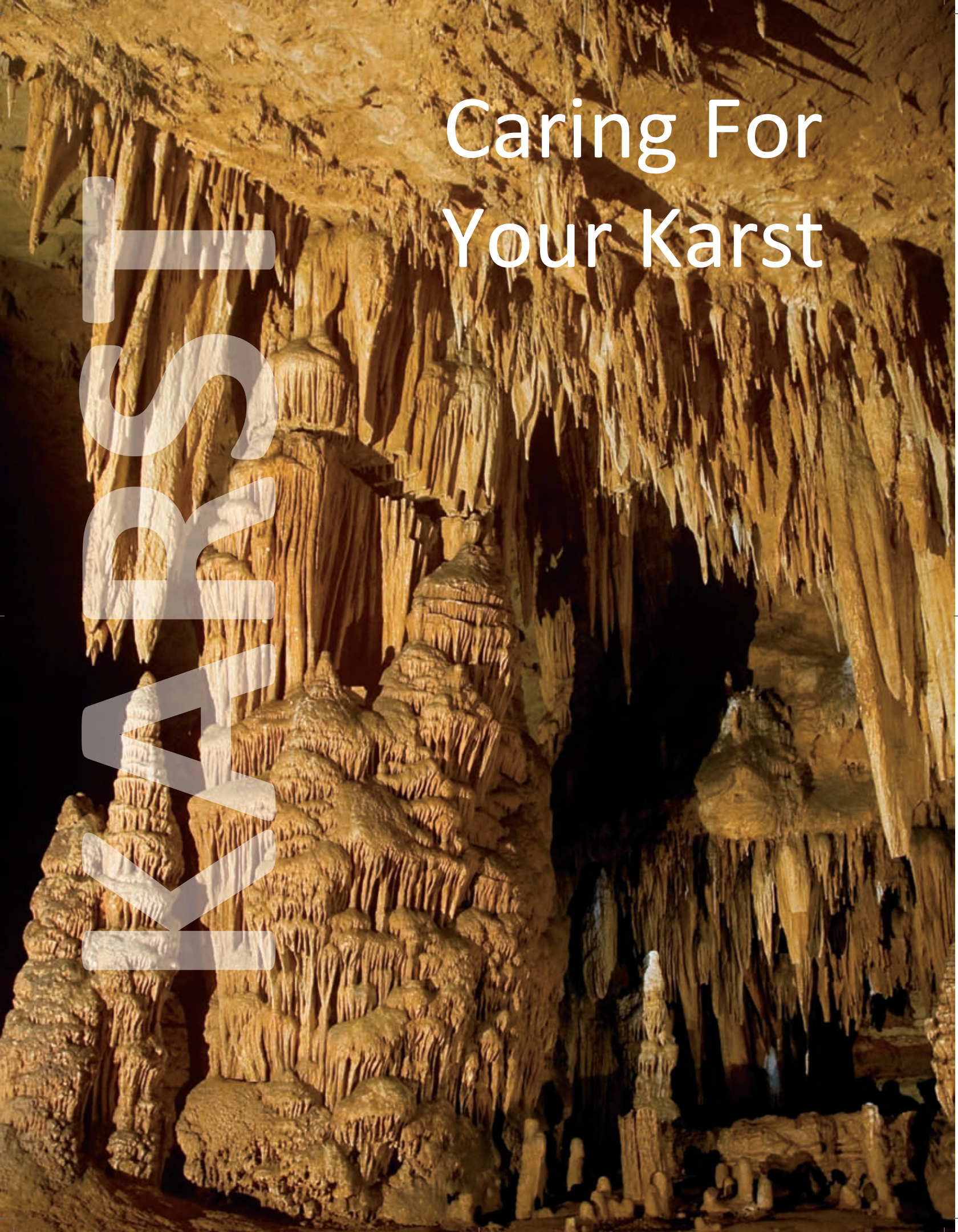
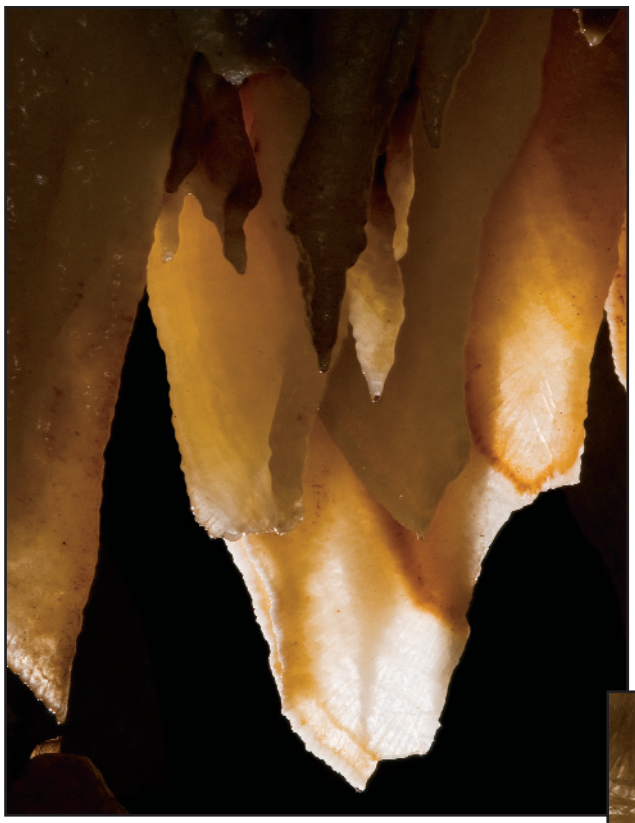


Caring For Your Karst

KARST



Missouri is the Cave State! Living in much of Missouri is like living on the surface of an unopened geode. We get little glimpses of what is underneath if we visit a commercial cave or peruse one of the books about Missouri's karst and caves. And then there are the clues – virtually everywhere – that more undiscovered treasure lies beneath our feet. Streams disappear into the ground. Springs come bubbling to the surface. Depressions funnel rainwater down into the ground. Flights of bats are observed. And occasionally a sinkhole will form after a heavy rain.

There are many unanswered questions about the fantastic hidden world beneath our feet. But one thing we know for sure is that our activities on the surface can greatly impact this special world of underground streams and caves – and that our impacts can appear right in our own drinking water or that of others miles and miles away.

We urge you to read this guide and think about how you can help protect this fragile living underground world. And, we invite you to spend some time underground. Visit a commercial cave or contact a local cave grotto to learn how you can be involved in cave exploration, discovery, research, and protection.
Bob Harvey

Bristly cave crayfish Eric Hertzler

Ozark cavefish Jim Rathert

Tumbling Creek cavesnail Dr. David Ashley

Covers and inside cover photography by Diane Kelsay and Bob Harvey, *Crystal Caverns and Fisher Cave*; cricket photo on back cover by Jon Beard
Layout and design, Diane Kelsay

CARING FOR YOUR KARST

A Guide For Landowners in the Ozarks

Table of Contents

Bob Harvey and Diane Kelsay

Introduction

This booklet is about defining the landform called karst and describing why it is beneficial to understand what **karst** is, how it works and how to best take care of it. Taking good care of karst is accomplished by maintaining clean **groundwater**. This is not only beneficial to you and your neighbors; it supports ecosystems that are dependent upon healthy karst systems for survival.

As you have already seen in this paragraph, there are highlighted words used in discussing karst. These are defined in the following text and in a glossary in the back of this booklet.

Acknowledgements

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Porter, James, and Thomson, Kenneth, 1975. Geology, Geomorphology and Karst Development in the Nixa Karst Area, Southwestern Missouri. Geoscience Series No. 1, Department of Geography & Geology, Southwest Missouri State University, 46 pages.

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Diane Kelsay

What is Karst?

The term ***karst*** is derived from the Slavic word ***krs*** or ***kras***, the name of a small region in the Dinaric Alps of Slovenia (Europe). The kras region is underlain by soluble ***limestones*** which have been dissolved by water to form a porous ***terrain*** pockmarked with ***sinkholes, losing streams, caves*** and ***springs***. Geologists have used the term karst to describe other soluble landscapes around the world where limestone, marble, ***dolomite***, gypsum, salt and other rocks have been carved and shaped by water. The Ozarks consist mainly of soluble layers of limestones and dolomites.

Limestone and dolomite are sedimentary rocks composed primarily of calcium carbonate (calcite) and calcium-magnesium carbonate (dolomite). These rocks are dissolved by water to form caves, sinkholes and springs. Plain water cannot readily dissolve limestone and dolomite - acidic water is required. The water that forms karst becomes slightly acidic by contact with carbon dioxide, forming carbonic acid (the same acid that makes soda pop “fizz”). Karst is a combination of soluble rocks and acidic water.

Water flows both on the surface of the land and under the surface of the land. In karst areas, there is considerable water flowing into—and through—the subsurface of the land.

Surface drainage is what people are most familiar with. Small streams flow into larger streams that eventually flow toward the oceans. These streams carry dissolved and suspended particles of various sizes. Streams carve the valleys by slowly removing the land. Eroded material is carried downstream to bodies of water such as lakes and the oceans. If the water flows over or around soluble rocks, it can dissolve parts of the rocks to form surface karst, often called ***karren***. Ozarks karren includes rounded, pockmarked rocks, ***cutters*** and ***pinnacles***.

Subsurface flows of water behave much the same as surface streams except that subsurface water has inhibited flow—the conduits carrying subsurface water have roofs overhead. Like surface water, subsurface water transports silt, gravel and other material from higher places to lower places.

Kinds of Karst Features

Sinkholes (sinks) are naturally occurring depressions on the surface of landscapes that are the result of the solution or erosion of rocks below, the collapse or subsidence of voids below the surface or a combination of solution and collapse. Water falls as rain into sinks, or flows into sinks, then moves downward through soil and rock layers, governed by gravitational pull. It finds the ***water table*** or a subsurface water conduit where it can then flow laterally to eventually return to the surface as a spring, also known as a resurgence.

Collapse sink Doug Gouzie

Losing streams are surface streams that "leak" into the subsurface. A large percentage of "hollers", creeks and rivers in the Ozarks contain sections in streambeds that lose water into the subsurface. That is why so many cobble strewn creek beds are dry except after rainfall. Some surface creek beds remain dry except after the heaviest of storms. Some losing streams leak through minute cracks while others leak through major openings that send large quantities of water into the groundwater and spring systems below.

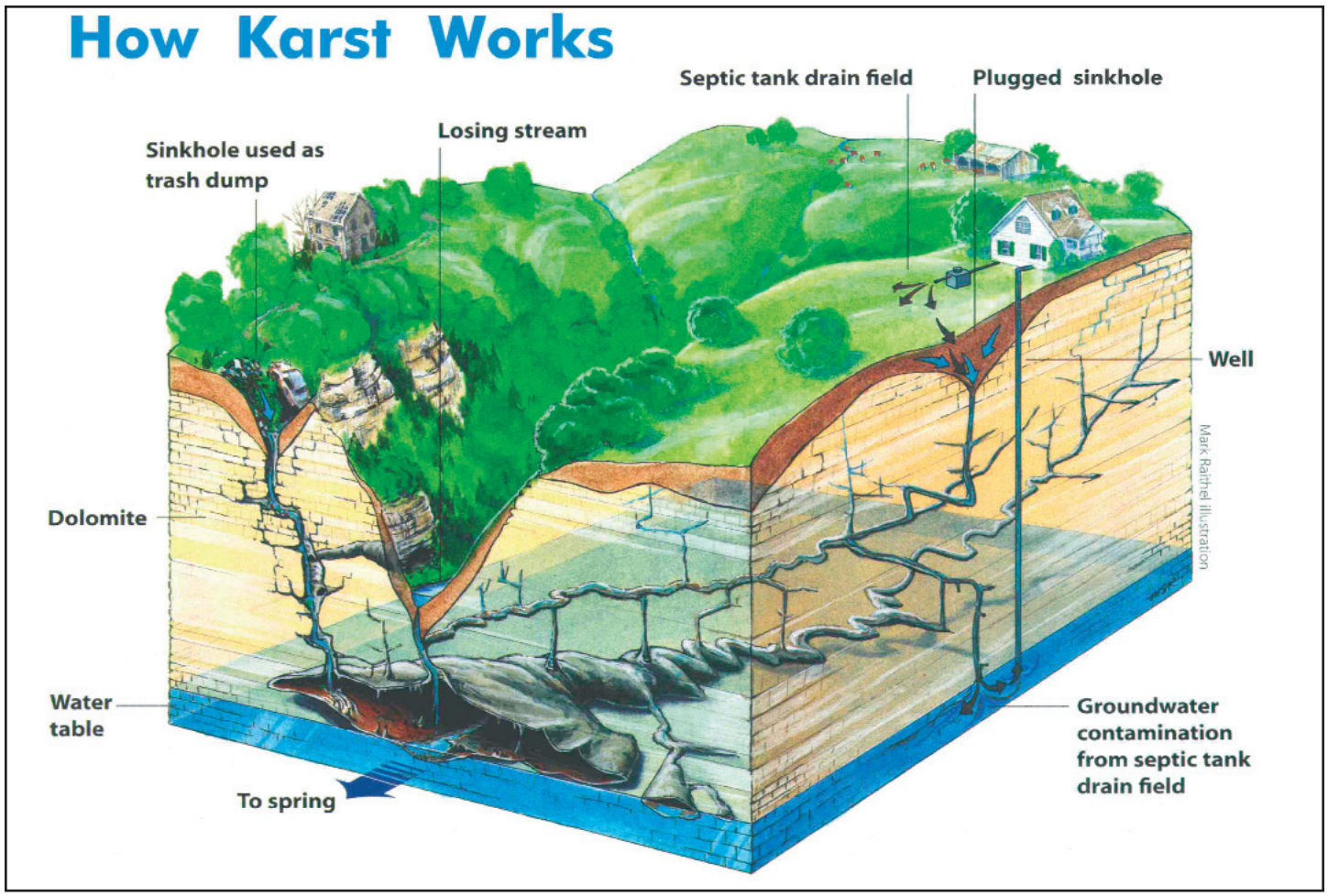
Losing stream Eric Hertzler

Ozarks caves are the product of water moving through limestone and dolostone. The water becomes acidic by mixing with carbon dioxide, and then dissolves rock when moving through cracks and fissures. The cracks are slowly enlarged into water conduits. Caves are voids in rock large enough to permit entry by people.

Cave Diane Kelsay

A spring is the emergence (resurgence) of water from the ground. The Ozarks contain some of the largest springs in the United States. Many of these giant springs are located within the Ozark National Scenic Riverways along the Current River. The largest of these is Big Spring, which averages a daily flow over 280 million gallons. Large springs in central Missouri include Boiling Spring on the Gasconade River and Ha Ha Tonka Spring. Two of the largest springs in southwest Missouri are Bennett Spring and Roaring River Spring, located in state parks bearing their names. Large springs are large "caves in the making", water-filled conduits, that when eventually abandoned by water, will become air-filled caves much like many of the caves we see today.

Spring Zach Copeland



This diagram shows most of the ways surface water contributes to the groundwater systems that supply us with water for our wells as well as contributes to cave and spring systems. It also shows some of the ways pollution from improper surface land uses may find its way into the groundwater. Diagram by Mark Raithel, courtesy of the Missouri Department of Conservation.

Karst is about Groundwater

Groundwater is purely defined as any water below the surface of the ground, but many publications might give this term only to the water within the zone of saturation. Beneath most land surfaces, there are two distinct zones. The ***vadose zone*** consists of a zone where the water has not saturated the zone and generally moves downward, governed by gravity. The ***phreatic zone*** is the zone where water has filled every available pore or space in the rock or soil, where no air space exists. Many of the conduits that feed large springs are located in the saturated zone, but the saturated zone is fed by descending water within the vadose zone. The vadose zone is fed by water on the surface, which is fed by rain and snow. Thus, the water on the surface and subsurface is really a part of one interrelated hydrologic system. Anything affecting water on the surface will also affect water below the surface.

Groundwater is most readily and efficiently transported laterally (horizontally) through porous rock units known as ***aquifers***. The best aquifers in most of the Ozarks are sandstones such as those found in the Cotter Formation's Swan Creek sandstone members, Roubidoux Formation's sandstones and Gasconade Formation's Gunter sandstone member and sandstones even deeper than those. Many caves form adjacent to these sandstone layers due to the readily available water flows.

Who needs groundwater? Everyone in the Ozarks needs groundwater. Groundwater feeds water wells and springs, the latter of which feed rivers and lakes. Our private and municipal water supplies derive all or part of their water from the groundwater. Much of Missouri's livestock depends on water wells or spring-fed rivers for drinking water. There are hundreds of species of animals in the Ozarks that are dependent on clean groundwater, including many species that live in caves and springs.

Groundwater Protection

Maintaining the quality of the groundwater is vital. Water captured by sinkholes and losing streams is not filtered when it flows downward through the cracks in soluble rock. Instead water is a very effective media in transporting surface materials underground, including sand, particles of soil, leaf litter, chemicals, garbage and trash deposited by people into sinkholes, hollows or anywhere else on the ground. Anything small or soluble on the surface of karst landforms can be transported into the groundwater systems. Therefore, land users must be careful how they use the land and how they dispose of waste. Unwise land use can cause excess silt, fertilizers, pesticides, herbicides, septic effluent or other harmful chemicals in groundwater.

Urban groundwater problems are caused by petroleum leaks and spills from paved roads, sewage leaks, trash washing into sinkholes and changes in surface water drainage patterns due to construction of roads and buildings.

Rural groundwater problems are caused by agricultural chemicals, sinkholes used as garbage dumps, improper land grading and leakage from failing septic systems.

Land development and uses in both urban and rural areas can cause changes in surface and subsurface drainage patterns. These changes may increase flow in some drainages, reduce it in others. Sudden sinkhole collapses such as that which occurred in 2006 in the City of Nixa are often the result of changes in drainage patterns due to urbanization.

What we do to the land affects groundwater

If you bulldoze the land surface, how will it affect how rain water drains from the land? If you build houses and paved roads, how will the water flow from these developments?

Typically, water falling on a vegetated surface will soak into the soil where some of it will be absorbed by plants. Bulldozing land often creates changes in the slope of the surface, changing the way water flows. When houses and streets are built, they reduce land surface and concentrate flows of water to gutters and ditches. This causes increased surface flow in areas that were formerly receiving much less flow. Wise planning in the development of the land is essential to minimize negative impacts on surface drainage which ultimately affects subsurface drainage.

What is Pollution?

Pollution is any substance that negatively changes the quality of the air, water and land. Pollution is a negative impact on air, water and land caused by the introduction of a foreign substance, or an excess amount of a natural substance to a given area. Pollution includes septic runoff from sewage; household, industrial or agricultural chemicals; excess surface runoff; excess silt from unmanaged erosion; or excess organic material.

Too much of a natural thing:

Erosion and Sediment Control

Erosion occurs when water moves loose soil unconstrained by adequate ground cover. Soil in a horizontal drainage is less likely to be eroded than the soil on a steeply sloping land surface.

Stormwater Runoff

Groundwater and cave systems are fragile ecosystems that depend on consistent conditions in order to survive. Fragile fauna that live in the groundwater and cave streams need specific water temperature ranges and water quality conditions to survive. Uncontrolled runoff contains excess silt and organic material that can drastically change the temperature, pH and dissolved oxygen levels in the groundwater. Excess silt can also damage the gills of aquatic fauna and change flow patterns of the groundwater.

The Unthinkable: The Unnatural in well water

Reducing Runoff Pollution in Karst Areas—Damaged or altered sinkholes can be repaired or restored. Repair can reduce or prevent additional silt or pollutants from entering the groundwater or caves below.

Pasture Land or Grassland Management—For thousands of years, specific conditions on the surface were relatively consistent, helping to create and foster delicate ecosystems in the groundwater and caves below. Changes on the surface can alter water flow or change water quality in the groundwater or caves. Land management on the surface can be done in such a way as to maintain the ecosystems below.

Pesticides on the Home and Farm—Pesticides are used wisely and very effectively in certain situations in controlling unwanted pests. When they are used in the wrong places, or used in excess, they can leach into the groundwater systems damaging delicate ecosystems below and endangering drinking water supplies.

Charlie Young

Fertilizers and Nutrients—Improperly applied chemicals can pollute the groundwater. Fertilizers should always be applied according to soil test recommendations and application guidelines. Following soil test recommendations can save money by reducing the amount of chemicals applied. Care should always be taken to ensure that the soil has adequate time and opportunity to absorb nutrients. Fertilizers should not be applied immediately before a precipitation event that could wash the nutrients to streams. Ecosystems dependent on natural nutrients can change quickly and dramatically if excess nutrients are introduced.

Septic Systems—Septic systems are installed to “clean” waste water from homes. In ideal places, there is plenty of soil and organic matter in the soil to filter out and decompose harmful septic effluent. But septic systems, like any filtration system, don’t last forever. Septic systems will stop working properly sooner or later, depending on the slope of the land, the quality and quantity of the soil, the quality of the septic system itself, and the quality and quantity of waste water moving through the system. Septic systems should be checked periodically by qualified experts, and repaired or replaced as needed.

Many septic systems have been installed in places that cannot support even the best designed systems. Often the quality of the soil is poor and/or there is too much waste water for the septic system to handle. There may be only a thin layer of soil between the surface and the bedrock and waste water is able move through cracks directly into groundwater systems below. That wastewater can end up in groundwater, caves, springs and surface streams – and to drinking water supplies.

Household Wastes

Proper disposal of household wastes is vital to the well being of karst lands. Improper disposal can be catastrophic to spring and cave ecosystems and to well water quality.

The Wise Use of Water

Due to increased demand, groundwater is being used faster than it is being replaced. This causes the lowering of groundwater levels, which can cause the sudden formation of subsidence sinkholes. Lowering groundwater levels can also cause changes in subterranean drainage patterns, sometimes causing flow of springs to diminish or “dry up”.

What Happens when we Use the Groundwater

The drilling and installation of water wells is an important subject in karst areas in the Ozarks. Shallow groundwater supplies are subject to high fluctuations depending on the recent precipitation levels, and are especially prone to pollution from unwise land use or accidental spills or leaks. Most cave streams are fed by shallow groundwater systems, but some derive water from deep spring systems. Welch Spring along the Current River, Ha Ha Tonka Spring, Roaring River Spring and Bennett Spring are all deep spring systems. Even these deep spring systems are fed by water that originally fell as rain or snow and entered the shallow groundwater first before descending into the deep phreatic zone.

Bob Harvey

When a water well is built, it intercepts some of the water flowing through an aquifer. Generally speaking, the deeper the aquifer, the less likely it will be rapidly influenced by recent precipitation or pollution events, but they can be influenced.

Water wells to be used for human consumption should be drilled into deep aquifers, and should be cased and sealed their entire depth. This helps to prevent shallow, potentially polluted water, from entering drinking water or descending down the well shaft to mix with and pollute the water within the aquifer.

As good as any aquifer might be, it can only transport so much water in a given period of time. If too many wells are drilled into a given aquifer, it can deplete the water in that aquifer faster than the water supply can replenish it. When that happens, wells can go “dry”. In areas of urban or industrial development or agricultural irrigation, this can be a very real problem. The more wells there are in a localized area, or the greater the quantity of water extracted (such as a municipal or industrial well), the larger and deeper the ***cone of depression***. In the immediate area around a well, a “cone of depression” can be created where the top of the zone of saturation is lowered—the closer to the well, the lower the top of the zone.

Abandoned water wells can represent a direct connection between the surface and a deep aquifer. To prevent an abandoned well from carrying pollutants to the groundwater, the well should be sealed and landowners should be especially careful about land use near the well.

Old, abandoned dug wells can also provide a path for pollutants to enter the groundwater. These wells were commonly used decades ago to collect drinking water and are usually 10-30 feet deep and 2-5 feet in diameter. They provide a window into the subterranean environment and often cave-adapted ***fauna*** are seen in them. To protect groundwater and cave life within the water, these wells should be properly decommissioned. The size of the openings also makes these wells a safety concern if not properly covered or decommissioned.

Karst is about Sinkholes

Sinkholes are also called sinks, depressions, recessions, basins, pits and natural wells. Sinkholes are naturally occurring enclosed drainages where water entering them descends into the ground and contributes to the groundwater. Sizes of depressions in the Ozarks can range from literally inches in diameter and a few feet deep to the giant sinks over 1,000 feet wide and over 100 feet deep. Sinkholes can be created either by a slow migration downward of soil materials through a small crack as water widens the crack (known as a solutional sink), or by a sudden collapse or subsidence of a subterranean cavity (known as a collapse sink) or a combination of the two. One study in the Ozarks found that about 95% of all the mapped sinkholes were solutional and less than 5% were collapse sinks (Porter and Thomson, 1975).

Sinkholes represent direct, unfiltered paths from the surface to the groundwater systems below. These direct routes are called discrete recharges (the opposite—the slow percolation through soil and solid rock is known as diffuse recharge). Material and water that enters sinks is transported through the groundwater and on to caves, wells and springs. Therefore, it is very important that sinks are not used as places to dispose of garbage. In many parts of Missouri, it is illegal to use sinkholes for dumping trash, garbage or any castoff equipment. Sinkholes, simply, should be left in their natural state as much as possible. Altering a sinkhole can alter the groundwater drainage patterns to springs and caves. It is a good idea to consult with a professional geologist before considering any changes to any sink.

Sinkholes occur in hilltops, hillsides and valley bottoms. Many of the sinks in valley bottoms are filled with alluvial material (gravel, boulders, organic material and soil) and may not be apparent except that surface water flows along a creek bed and "disappears" into the gravel. These are known as losing streams. Many surface ravines, creeks and rivers flowing in the Ozarks have losing sections where the stream is "pirated" in whole or in part by a gravel-filled sink or vertical crack.

This sink was used as an illegal dump for tires and trash. Jonathan Beard

If you have an old-fashion hourglass timer, you can create a representation of a sinkhole and how it works to transport material into the ground. Simply begin the timer and watch the grains fall through the small opening between chambers. The small hole represents a crack in the bedrock that allows small rocks, soil and anything dumped into the sinkhole to fall to a chamber below. Eventually, a small depression will form on the surface of the sand in the upper chamber of the hourglass timer. This depression represents the typical solutional sink you might find on the surface of the Ozarks. The lower chamber represents the groundwater and spring systems that we drink from.

Caring for your Sinkhole

A sinkhole that is plugged or filled with garbage, castoff equipment, old appliances, bulldozed soil or rocks will lose some of its ability to drain the water as fast as the water enters it. It can pond, flood or overflow onto adjacent areas. In an urban area, this lack of adequate drainage can flood a neighborhood after rain events, causing water damage to homes and businesses and lowering property values. This was a chronic problem in a neighborhood in southern Springfield for years until the sink was cleaned of the trash that had washed into it, and other improvements were made to prevent future problems. Leachate (the liquid draining from trash or chemicals dumped into a sink or ravine) will be carried by water into the groundwater system and caves below.

Avoid locating a development where it is adjacent to or might drain into a sinkhole if it might add excess water, excess soil or pollutants into the sink. In rural areas, feedlots and septic systems should be located away from sinkholes and losing streams. In urban areas, avoid runoff from paved roads, parking lots or any surface that could add oil, gasoline or asphalt chemicals into a sink.

When building rural and urban structures, careful siting is tantamount to conserving groundwater resources, springs and caves. When siting of developments must involve placement near sinkholes and losing streams, surface drainage should be designed to bypass the sink. Protective earthen berms can sometimes be built around the sink to divert septic or chemical-laden water away from sinks.

Some counties and municipalities have laws that regulate development in sinkhole areas. Greene County has a sinkhole ordinance that has been used as a model by other counties and towns in developing sinkhole regulations of their own. Be sure to consult with local and state authorities before attempting to build near or altering sinkholes. When developing near a sinkhole or altering a sinkhole, be sure to consult with a professional geologist.

If you purchase land containing sinks filled with trash or other karst problems, contact a local agency. The Missouri Department of Natural Resources, for example, may be able to advise you on proper cleanup or improvement techniques including planting vegetative cover around the sink to prevent erosion. It might also be possible to obtain government grants to fund the cleanup of sinks. Volunteers from a local caving club, civic group or other groups may be available to help clean up a sinkhole.

Good Sinkhole Management is good for you, your neighbors and cave and spring critters

Wise management of sinkhole areas will contribute to good quality well water for you and others, and it protects nearby spring and cave ecosystems. It can also contribute to property values for your land and lands nearby. No real estate buyer wants to pay for sinkholes filled with trash, nor does anyone wish to buy a home with polluted well water or erosion problems around sinks.

Sinkholes containing trash should be cleaned. Trash is not only a visual eyesore, but it can contribute to groundwater pollution or plug natural drainage patterns.

Surface erosion can be prevented or controlled by making sure trees, hedges and grasses are planted in and around sinks. Roots from vegetation will hold the soil in place and prevent the sides of sinkholes from expanding due to headward erosion of unprotected soils.

Karst is about Losing Streams

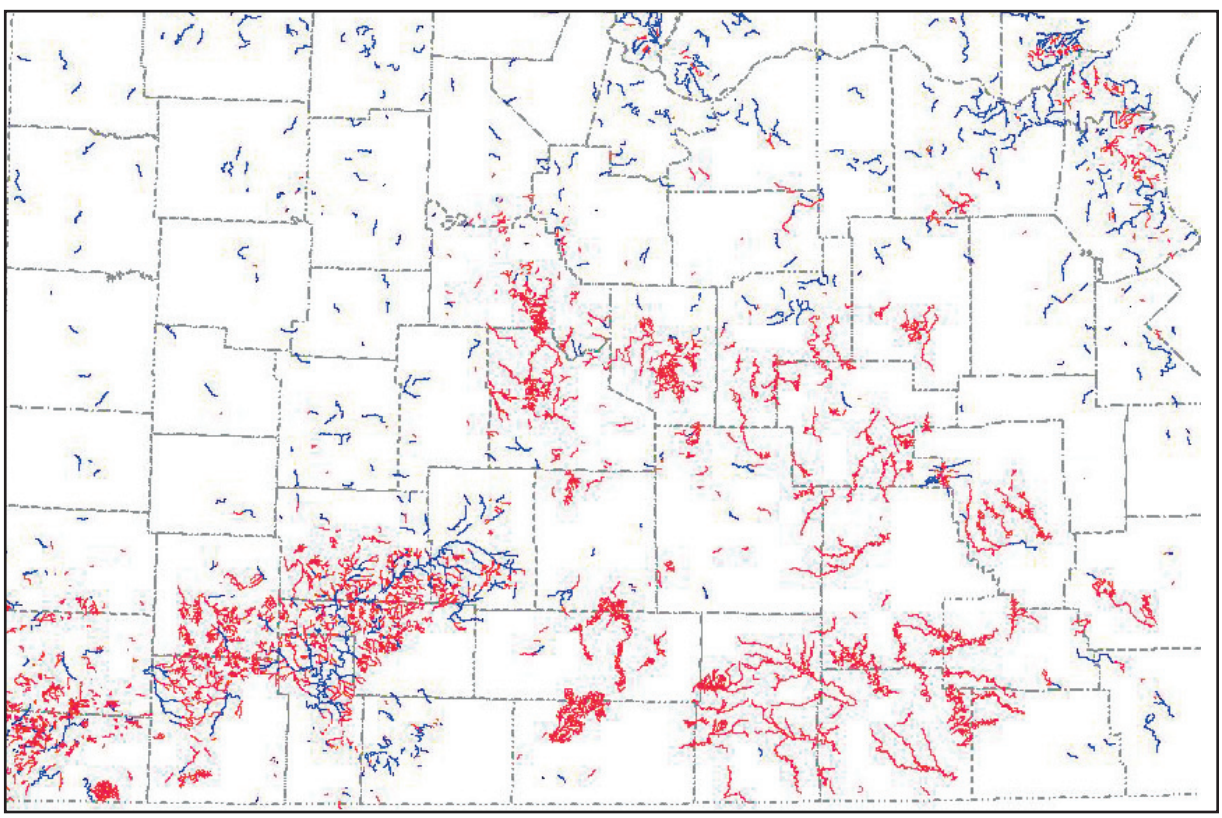
Losing streams are found in most parts of the Ozarks. Long valleys can leak into the groundwater over their entire lengths.

There is a ten-mile long surface valley in Christian County, Missouri that remains completely dry most of the year. After exceptional rains, the lower half of the valley may run water from wet-weather springs that flow into it, but the upper half of the valley is always dry. The valley is a literal sieve, with so many hidden cracks and holes below the surface that rain is immediately pirated underground. Dye tracing by qualified professionals has shown that the rainwater falling into this valley goes in several directions—north, south and west to various springs in valleys, some several miles away. One of the spring systems fed by this dry valley contains the delicate ecosystem that supports the largest known habitat for the white, blind, bristly cave crayfish. Some springs fed by this valley are used for water supplies for cattle ranches and other businesses.

Making sure this valley does not introduce excess silt or pollutants to groundwater is not only important for the survival of delicate ecosystems that live in the groundwater, but also important for cattle ranchers in the area and other businesses that depend on good quality water.

Caring for your Losing Stream

When you recognize you have a losing stream, you can help the groundwater ecosystems as well as your neighbors by managing developments to avoid negative impacts on the subsurface. Earth moving tasks should be controlled to prevent excess erosion or silt runoff into the losing stream. The boundaries of the losing stream should be vegetated with trees, shrubs and grasses to prevent erosion or siltation downstream. Cattle should be excluded from losing streams and adjacent areas. They can adversely impact protective vegetation and contribute large quantities of organic debris.



Map courtesy of the Missouri Department of Natural Resources

The red lines on this map show the sections of losing streams found in most of the Missouri Ozarks. The blue lines show the sections of gaining streams. Losing streams “leak” into the groundwater whereas gaining streams are being fed by springs. The Ozarks containing so many losing streams illustrates why it is important to prevent pollutants and excessive silt from entering surface streams that contribute to our groundwater.

Diane Kelsay

Karst is about Springs

Springs are the doors through which groundwater exits the subsurface. Larger springs are water-filled caves, and many air-filled caves contain small or large cave streams that surface at or near cave entrances. The smallest springs are called seep springs, and the largest are so large they form rivers on the surface. Examples include Greer Spring in Oregon County and Roaring River Spring in Barry County. Some smaller springs flow only after high periods of rainfall while other springs flow all year round. Springs served as sites for grist mills years ago, and some provided early settlements with drinking water. Many of those springs are now too polluted to safety serve as drinking water sources, while others are unchanged from pre-settlement times.

Many springs gush out water at a constant temperature year round - the water in some spring branches never freezes in winter and never gets warm in summer. This has supported the development of small ecosystems comprised of plants and animals that thrive in spring branches and could not survive in other nearby streams. Watercress perhaps is a well known plant in such environments. These spring habitats are beautiful and some contain endangered species.

There are many species of aquatic wildlife that live in the dark water conduits that feed those spring branches. A clean healthy spring is good for underground ecosystems, and also supports farms and cities with safe and dependable water.

When you see a spring branch with lots of green gooey algal growths, or with an obvious bad odor, it is a sign that pollutants have entered the groundwater.

Caring for your Spring

Springs need tender loving care. Many landowners keep fences around spring branches to keep cattle and people from trampling the delicate plant life and animal habitats in the branches. Visitors should respect that fencing as part of the conservation of that area. When fencing is not practical or affordable, posting a sign or two at a spring advising visitors to keep out of the spring and to not throw trash in it may be helpful. You can see good examples of good spring management at Ha Ha Tonka Spring in Ha Ha Tonka State Park in Camden County and Greer Spring near state highway 19 in Mark Twain National Forest in Oregon County.

Karst is about Caves

Caves are protected in Missouri by federal, state and local laws. Federally owned caves are covered by the Federal Cave Resources Protection Act. In Missouri, these caves are located on the Mark Twain National Forest, Ozark National Scenic Riverways, Eleven Point National River, wildlife refuges governed by the U.S. Fish & Wildlife Service and other federal lands. All other caves in Missouri are protected by the Missouri Cave Protection Act of 1980. That includes caves on state-owned lands, local public lands controlled by county or municipal governments and lands under private ownership. Cave wildlife is protected through the Federal Endangered Species Acts and other laws. These laws protect cave ecosystems, life forms, and cave features, and they also protect the landowners by defining criminal trespass and vandalism by unauthorized visitors. As a landowner, you have laws and agencies to help you protect natural resources on your property.

Why should your cave be protected? Missouri caves are past and/or present courses for water flow. Caves are records of natural history where past history can be studied, both natural history (geology, paleontology, biology) and human history (archaeology, anthropology). Caves can be beautiful with a variety of speleothems. They are relatively safe havens for hundreds of species of animals dependent on caves for survival, some threatened or endangered. There are three endangered species of bats in the Ozarks—the Ozark big-eared bat, the gray bat and the Indiana bat. Some cave critters are found in just one cave—the Tumbling Creek cavesnail is a translucent aquatic snail the size of a pinhead that may be limited to only one cave stream and nowhere else.

In Missouri, it is ILLEGAL to remove ANY cave animal, mineral deposit or other cave feature from a cave without permission of the landowner. Period. As a landowner, you can press charges against anyone who has taken something out of your cave without permission.

Karst is about Cave Life

Why do we care about what lives underground? We can't eat the bats, cavefish and tiny animals that live in the caves, so what good are they? One answer is, "To have a healthy environment we must think about what lives around us, how it helps us live and what it teaches us about our environmental quality."

To the average person the two most important aspects of caves are bats and groundwater. Bats provide a free service to us in consuming night-flying insects, some of which are agricultural or health pests. Groundwater is important to millions of people who drink from wells, springs and spring-fed surface streams.

In Missouri there are over 6,800 known caves, many with bats. Arkansas has 3,000 caves, Oklahoma 2,500 and Kansas 1,000. In Missouri, about six species of bats use our caves, and another six or more bat species live in forests at least part of the year.

The eastern pipistrelle *(Perimyotis subflavus)* is the smallest of bats that normally use caves for shelter. It is a solitary bat that is found in most Ozarks caves. Photo by Charley Young

The most colorful of salamanders typically found in Ozarks caves is the cave salamander *(Eurycea lucifuga)*. As with other salamanders found in caves, it requires a cool, damp environment to survive. Photo by Roy Gold

The endangered Gray bat is completely dependent on caves for roost sites all year round. Conservation work has returned Gray bats to about 40% (784,000) of the population we had decades ago in Missouri. The average colony of 10,000 Gray bats consumes about 100 pounds of insects each night, between March and October (they hibernate the rest of the year). That translates to about 11 tons per colony per year, about 4.3 billion insects! A medium-sized maternity colony of 35,000 Gray bats, where they raise their young each summer, consumes 48 tons of insects per year, about 19 billion bugs. Some colonies are twice that size. Statewide, Gray bats are eating ***540 tons (223 billion)*** of insects per year. That translates to over one million pounds of bugs! They eat a variety of bugs like aquatic insects, especially mayflies, caddisflies and stoneflies, but also beetles, mosquitos and moths.

The endangered Indiana bat, and the common Little Brown, Northern, Big Brown, Eastern Pipistrelle and other bats hibernate in caves for up to six months. They need those places to survive. They each eat a different diet of insects, including disease-spreading mosquitoes, moths that consume and damage our crops, and other pests.

Missouri caves shelter about 900 different species of wildlife. We have over 80 species that are specialized for subterranean life, lacking eyes and pigment, called “troglobites.” Some cave species are rare and found only in a few caves such as the grotto sculpin in Perry County. Caves also provide refuge to many common species of animals from the surrounding forests, like salamanders, pickerel frogs, raccoons and others. Even deer have been seen to seek shelter in a cave entrance. Some birds nest in cave entrances, including Rough-winged Swallows, Eastern Phoebes, owls and vultures.

Much of our groundwater flows through caves and underground plumbing to large springs. We tap into the groundwater through our wells. Some of the tiny cavesnails, amphipods and isopods that live in the groundwater are sensitive to chemicals, sediments and nitrogen waste products. Those pollutants are dangerous to people too, so those little animals are good water quality monitors for us. If polluted water causes them to die off, then we know there is a problem.

A case in point is the Tumbling Creek Cavesnail, known from only one cave. Sediments got into the groundwater from a farm that had been cleared off and converted to a barren feedlot. The sediments choked the cave stream, and the cavesnail nearly went extinct. The good news is that neighbors working together have restored that land, and a local school even got a new septic system as a result of concern for this endangered species. Now the water quality is better for everyone in that part of Taney County, Missouri.

Subterranean creatures have value apart from what they mean to us practically. They have scientific and educational value. They are part of the web of life, and we respect that.

As a landowner, you can help protect the species of life that depend on your groundwater and cave for survival by

- making sure that anyone visits your cave will respect those animals and their cave habitat, and
- managing what goes on with the surface of the land above and upstream of caves to avoid creating negative impacts on the groundwater or cave streams.

This springtail is the length of two grains of sand. It and other small insects are a part of an elaborate, but very fragile, cave ecosystem. Photo by Bob Harvey

Diane Kelsay

Caring for your Cave

Helpful Hints for the Cave Landowner

Fencing can protect your land and its karst features. Constructing a fence around sinkholes prevents livestock from falling in or otherwise becoming trapped in them.

Signing involves erecting signs around the perimeter of your property, or at the entrance to caves. The signs should be prominent (easily visible) but located where they, themselves, cannot easily be defaced or damaged.

Cave Gating involves installing a steel barricade to prevent trespassers from entering a cave. The gate should be designed to enable free flow of air, water and biota in and out of the cave. For help in the design and construction of a gate, contact the Missouri Department of Conservation.

Know your cave (you can't protect what you don't know). There are caving clubs who can document your cave, map the cave and inventory its biology and other resources. Some will even manage it with you or for you.

Cave Protection Options Available to Landowners

Contact a local caving club or other conservation organizations or agencies and make sure your cave is registered in the Missouri cave database. The database contains data on more than 6,800 caves in the state (there are over 3,000 registered in Arkansas's cave database). By registering your cave, conservation groups can help to protect your cave. No one can help you protect your cave if they don't know about it.

Documentation of a cave may include one or more of the following:

- An exact location for the cave entrance(s) which can be plotted on an area map or marked with GPS
- a detailed map of the interior of the cave to show its length, direction and its features
- inventories of the cave's geological and biological contents

Management options to protect your cave may include one of the following:

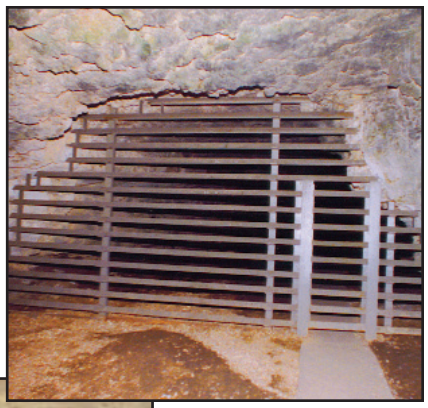
- Leasing a portion of the property to conservation organizations is one way to protect the cave temporarily.
- Allowing a conservation organization to help manage the cave is another way to have the cave protected for the short term.
- A conservation easement written into the deed of your property will forever limit undesirable developments that might be made by future landowners. Written Conservation Easements can be tailored to fit your needs and wishes.
- Selling a portion of your land to a cave conservation group such as the Missouri Caves & Karst Conservancy, other 501(c)(3) charitable conservation organization or a state agency can be a way to protect the cave in perpetuity. Donation of the land to such an organization is fully tax deductible. The deed of such a land transfer can be tailor written such as allowing you lifetime access to the property, should you desire that option.

Secrecy—The first line of defense against unauthorized visitation and cave vandalism is secrecy. A newly found cave can be a target for vandals. Secrecy means keeping the existence of the cave or its location a secret to the public or news media.

Signage—Placement of signs at or near the entrance can inform the visitor of cave conditions and access policy. If endangered species occupy the cave, the Missouri Department of Conservation can provide you with signs to place inside the cave to inform visitors that the cave contains species of concern and landowner/manager contact information. All signs should be sturdy and weather resistant, and should be readily visible yet out of reach of vandals.

Gating—When secrecy and signage are not adequate to keep unwanted visitors and vandals out of the cave, it may be necessary to gate the cave to keep people out. The cave should be assessed by an expert to determine if the cave is suitable for a gating, and if so, where the gate should be placed and what design is most suitable for the cave and its fauna.

Visitation Policy—Each cave should have a detailed policy that can be used by the landowner or cave manager to control visitation and make sure visitors do not damage the cave or harm the wildlife. Before granting permission to enter your cave, you should be able to tell potential visitors the rules of visitation. Tell them to not leave trash, to not handle or break formations, to not write or carve graffiti and to not harm cave wildlife.



Max White

Can vandalized caves be "restored"?

You bet! Increasingly, caving organizations are becoming involved in cave restoration. Trash left by vandals can be collected and taken out of caves. Spray paint graffiti can be removed or masked using brushes and other tools. Broken stalactites and stalagmites can often be reattached. If you have a cave that has been damaged, contact a caving club and ask about restoration opportunities.

Charlie Young

Michael Carter

Helpful Folks

You are not alone! Managing your karst resources is not something you have to do by yourself. There are federal, state and local agencies, and private organizations and individuals who want healthy sinkholes, losing streams, springs and caves and may be able to help you manage your karst lands and restore damaged areas.

The U.S. Fish & Wildlife Service and ***Missouri Department of Conservation*** can help you by identifying and protecting endangered species and their habitats.

The ***Natural Resources Conservation Service*** and ***Missouri Department of Natural Resources*** can assist you in controlling erosion.

Local chapters of the ***National Speleological Society*** and ***Missouri Speleological Survey*** have programs and processes to assist landowners in the study and conservation of karst resources. These organizations may be able to assist in the cleanup of sinks and losing streams as well as the caves themselves. They may also help you vegetate eroding edges, gate caves, and develop management plans.

For More Information

If you have access to the internet, please visit the Springfield Plateau Grotto website at www.spgcavers.org. There is an educational section that consists of illustrated essays on caves and karst conservation. There are also links to other websites where additional information can be accessed.

Help in managing your land can also be reached through your local or regional office of the Missouri Department of Natural Resources and Missouri Department of Conservation. Help may also be available through your county commission or county extension office.

National Speleological Society—2813 Cave Avenue, Huntsville, AL 35810 www.caves.org
Missouri Speleological Survey— www.mospeleo.org
Missouri Caves & Karst Conservancy— www.mocavesandkarst.org

Glossary of Terms

Aquiclude—a rock layer that is impervious to water, that is, it does not allow water to pass through it.
Aquifer—a rock layer that allows water to efficiently pass through it
Aquitard—a rock layer that inhibits water flow
Caves—cavities or voids in the earth large enough to permit entry by humans. In the Ozarks, caves are primarily formed by solution by water.
Chert—rock composed primarily of fine-grained silicon dioxide. It is found as thin layers, lenses and nodules in other forms of bedrock and forms gravels in stream beds.
Cutters and Pinnacles—a common solutional surface feature marked by pinnacles. The areas between pinnacles are called cutters.
Dolostone or dolomite—bedrock consisting primarily of the mineral dolomite (calcium-magnesium carbonate). It is limestone in which much of the calcium has later been replaced by magnesium.
Dripstone—Cave formations (speleothems) formed by deposition by dripping mineral-laden water.
Fauna—Animals. Even small dry caves contain several species of small animals, many of which are delicate, fragile animals dependent on caves for survival.
Flowstone—Cave formations (speleothems) formed by deposition by flowing mineral-laden water.
Fossil-bearing—bedrock containing fossils of animals or plants. In parts of southwest and central Missouri, much of the bedrock contains fossils of marine animals.
Groundwater—Literally, water in the ground. The water beneath the surface, primarily in the zone where the ground is saturated with water.
Karst—The land surface (terrain) that is characterized by solutional or collapse depressions (sinkholes), springs and caves.
Kras—A region in the Dinaric Alps in Slovenia containing sinkholes, springs and caves from which the term karst is derived..
Limestone—Bedrock composed primarily of calcium carbonate (calcite) derived from the decomposition of shellfish.
Losing Streams—a surface stream partially or wholly diverted underground into the groundwater system.
Phreatic Zone—The zone of the subsurface completely saturated with water, the area below the water table.
Piracy—The point or area where a stream is diverted. In karst terrains, many surface streams are pirated into the groundwater system.
Recharge—An area of the surface that contributes water to a spring or cave system.
Resurgence—A spring, the point at which the groundwater exits the subsurface.
Sandstone—Bedrock primarily composed of cemented grains of sand. The cementing agent, matrix, can be composed of any other type of rock (limestone, shale, etc.). Many sandstones are excellent aquifers into which water wells are drilled to provide water for private homes, cities and industry.
Shale—Bedrock primarily composed of clay particles. Most shales are very effective aquitards or aquicludes—water does not easily pass through shales.
Sinkholes—Enclosed depressions that collect surface water and direct the water downward to the groundwater system.
Speleothems—a term derived from the Greek words spelaion and thema, literally translated as “cave” “deposit”, cave formations. This includes all forms of flowstone and dripstone. In the Ozarks, these consist primarily of the mineral calcium carbonate. Speleothems are formed by deposition of minerals from mineral-laden water.
Springs—resurgences, where groundwater issues from the ground to the surface. Large spring systems form caves.
Stalactites—Speleothems that form on ceilings or the underside of ledges and point downward. Minerals form on the bottom tip or outer surfaces by descending water.
Stalagmites—Speleothems that form on floors or the topside of ledges and point upward by water dripping from above or down the outer surfaces of the stalagmites.
Vadose Zone—The area above the water table that is not saturated with water. Water tends to move downward through this zone in search of the water table.
Watershed—The area of land that contributes to a stream system.
Water Table—The boundary between the vadose (unsaturated) zone of the ground and the phreatic (saturated) zone below.