Landowner’s Guide to Biological Resources and Biodiversity in Tennessee Caves

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Caves and associated subterranean habitats represent one of the most unforgiving and challenging environments on earth, even though significant and diverse fauna are found in these habitats. More than 25 percent of all known caves in the United States are located in Tennessee, Alabama and Georgia (TAG). More than 1,138 cave-restricted animal species have been described in the United States alone, representing 112 families and 239 genera (Hobbs 2012). Tennessee ranks second behind Texas for the most obligate subterranean species in the United States.

This guide summarizes what it is like to live in a cave, describes the types of life that may be encountered in Tennessee caves, and provides an overview of how understanding more about cave biodiversity can help with conservation and management of caves and karst in the state. Other information about Tennessee caves and sinkholes can be found in the series of publications, W 453-A: Guide to Caves and Sinkholes in Tennessee.pdf

The Cave Habitat

The cave habitat consists of three major ecological zones: the entrance (Figure 1), twilight zone and dark zone. Each zone has specific light and other abiotic conditions. The biology of each zone is adapted to live within those conditions. Although light, temperature, humidity, etc., can change daily in entrance habitats, dark zones are generally more stable, with nearly constant temperatures, water content and continuous darkness. All forms of life can be found throughout a cave, in all zones, from microscopic bacteria to large animals.
Most people are more familiar with the strange and exotic animals found in caves. Cave habitats vary from being dry sediment or rocky surfaces (terrestrial) or underwater (aquatic). Nearly all of the obligate terrestrial cave species, referred to as troglobionts, and obligate aquatic cave species, referred to as stygobionts, have obvious adaptations. These include different shapes and sizes (morphology), physiologies and behaviors associated with life in perpetual darkness and often limited food resources. The sum of these traits are referred to as troglomorphy. Obligate cave animals usually have striking morphological features, like reduced-size or no eyes, no pigmentation, and elongated appendages. Many obligate cave animals also have longer life spans than similar animals living in surface environments.

Because photosynthesis does not occur within the dark zone, fauna living inside caves are dependent on organic matter produced from plants and other animals that comes into the cave. Ways that organic matter can enter a cave range from water flow from sinking streams or dripping water associated with cave formations, as well as from air currents or other animals (such as from bat and cricket guano). Plant and tree branches, roots, and leaves washed into a cave could become food for obligate cave animals. Cave animals can often be seen near or within piles of plant debris or guano (Figure 2).

Depending on the location of a cave within a watershed, water that brings natural organic matter into caves, such as during and after high rainfall events, can also bring trash and pollutants (solid waste or dissolved chemicals) into a cave. High volumes of trash and other contamination can disrupt the natural balance of a cave ecosystem that is dependent on organic matter from outside the cave.

**Tennessee Cave Life**

A variety of organisms can be found in caves, from those that find their way into a cave accidentally or for some part of their life cycle, or who live in the subsurface and never leave.

Some animals, like snakes, raccoons, opossums, dogs or big cats, are accidentally found in caves after wandering, falling or being washed into the subsurface. These species do not possess any adaptations to subterranean life and must return to the surface or perish. Accidentals can be important to a cave ecosystem because they bring in food in the form of guano or, unfortunately, their dead carcass (Figure 3).

Other animals visit caves on a seasonal or occasional basis. They are temporary visitors that utilize cave habitats for some aspect of their life history, such as shelter, hibernation, reproduction or even to find food. These species, called trogloxenes, must also return to surface habitats at some point to complete their life cycle. They are also important in some caves for bringing food and energy into cave habitats in the form of guano. Common examples of trogloxenes in Tennessee caves include the eastern phoebe (*Sayornis phoebe*), raccoon (*Procyon lotor*), Allegheny woodrat (*Neotoma magister*), cave crickets (Figure 4), and several bat species that regularly roost in caves (Figure 5).
Animals that complete their entire life cycle in caves but can also be found in surface habitats are called *troglophiles*. Typically they do not exhibit troglomorphy that is associated with obligate cave animals. Common examples of troglophiles in Tennessee caves include the cave salamander (*Eurycea lucifuga*) (Figure 6), banded sculpin (*Cottus carolinae*), cavespring crayfish (*Cambarus tenebrosus*), and cave orbweaver (*Meta ovalis*).

Troglobionts found in Tennessee caves are obligate and permanent residents of subterranean habitats. These animals possess troglomorphic characteristics. A recent study compiled more than 2,200 records for 200 described obligate subterranean animal species from 661 caves in Tennessee (160 terrestrial species and 40 aquatic species) (Niemiller and Zigler 2013). This diversity includes four phyla, 10 classes and 22 orders of invertebrates, and two classes and two orders of vertebrates. All but three of the 200 troglobionts known from Tennessee are invertebrates, with the greatest diversity comprising beetles (79 species), millipedes (29 species), pseudoscorpions (18 species) and spiders (14 species). About 25 percent of troglobionts and 20 percent of stygobionts are known from just a single cave (referred to as being single-cave endemics), and nearly two-thirds of all species (130 species) are known from just five or fewer caves.

Common examples of troglobionts found in Tennessee caves include pseudoscorpions (Figure 7), cave spiders, cave beetles (Figure 8), cave millipedes, cave isopods, cave crayfish (Figure 9), southern cavefish (*Typhlichthys subterraneus*) (Figure 10), and Tennessee cave salamander (*Gyrinophilus palleucus*), the state amphibian of Tennessee (Figure 11).
Lastly, colonies of microorganisms, including bacteria and fungi, are obvious in caves but often overlooked, particularly on walls as white, yellow, orange, pink, blue, gray or black splotches. Most visible colonies are usually smaller than the width of a pencil eraser, although some colonies can also cover large areas of a cave passage (Figure 12). Old sediment and mud can become completely covered by microbial colonies that are easily disturbed by foot traffic and can often have graffiti.

Microorganisms living in caves, on rocky surfaces, in sediments, and in the water are important to cave ecosystems by converting organic matter into usable compounds for other microbes and animals, and some can even generate energy using chemicals instead of sunlight. Obligate cave animals are adapted to limited food resources, and some cave ecosystems around the world are dependent only on microbial chemical energy rather than from sunlight and plants. To date, no caves like this have been discovered in Tennessee. That is, all cave ecosystems currently known in Tennessee are dependent on the input of surface-derived organic matter.

Regional Distribution of Cave Life

Two major karst biogeographic regions occur in Tennessee: the Appalachians and Interior Plateau.

Three major karst terranes occur in the Interior Plateau of Tennessee: the Highland Rim karst, Nashville Basin karst and Cumberland Plateau karst. The latter is sometimes considered a separate karst biogeographic region. In the Appalachians karst region, karst is developed in the Appalachian Valley and Ridge (AVR) and small sections of the Blue Ridge Mountains ecoregions.

Nearly half (91 species) of Tennessee’s obligate cave diversity occurs in a hotspot of diversity along the escarpment of the Cumberland Plateau and adjacent Eastern Highland Rim in south-central Tennessee (and extending into northeastern Alabama), where several cave systems contain 10 or more obligate cave species, including one cave with 23 species. In general, the distribution of obligate cave communities across the state is linked to natural watershed boundaries and geological barriers. In fact, only 15 species (7.5 percent of all troglobionts currently described) occur in the Interior Plateau, Cumberland Plateau, and Appalachian Valley and Ridge.

We briefly highlight the troglobiotic species in each major karst region in Tennessee.
Interior Plateau (Highland Rim and Nashville Basin Karst)

Much of the troglobiotic species diversity in the Interior Plateau, which includes 116 species (19 single-cave endemics), occurs in the Eastern Highland Rim, particularly in DeKalb, Putnam, Warren and White counties. Caves in the western Interior Plateau have not been well studied biologically. Cave beetles (the genus *Pseudanophthalmus*) and millipedes (*Pseudotremia* and *Scoterpes*) are particularly diverse in the Interior Plateau. Several caves in the region are important summer maternity roosts of the federally endangered gray bat (*Myotis grisescens*) in this karst region.

Several cave-adapted species are quite common in this karst region, including the two-toothed cave isopod (*Caecidotea bicrenata*), southeastern cave pseudoscorpion (*Hesperochernes mirabilis*), subterranean sheet-web spider (*Phanetta subterranea*), cave dung fly (*Spelobia tenebrarum*), and the southern cavefish. Some of these species are widespread and may actually represent several species that are morphologically similar but genetically very distinct populations.

Cumberland Plateau

This karst region includes over 50 percent of the 10,000 plus caves in the state and also is the most intensively studied in terms of number of caves inventoried biologically. The southern section of this karst region is a hotspot of troglobiotic diversity. In total, 102 troglobionts (15 single-cave endemics) have been documented in caves from the Cumberland Plateau. Species diversity decreases from south to north along the western escarpment of the Cumberland Plateau, despite a large number of caves in northern counties.

As in the Interior Plateau, cave beetles (*Pseudanophthalmus* spp.) and millipedes (*Tetricion, Pseudotremia*, and *Scoterpes*) are diverse in the Cumberland Plateau. Pseudoscorpions (*Kleptochthonius*) also are diverse, and the southeastern cave pseudoscorpion is relatively common. Several other species are also relatively common, including the two-toothed cave isopod, southern crayfish (*Orconectes australis*), Barr's cave spider (*Nesticus barri*), subterranean sheet-web spider, cave dung fly, southern cavefish, and Tennessee cave salamander. Several caves in this karst region are important summer maternity roosts of the federally endangered gray bat, with two caves being major hibernacula for this species.

Appalachian Valley and Ridge

Cave biodiversity in the Tennessee Appalachian Valley and Ridge (AVR) has been undersampled compared to the other karst areas in the state and also compared to neighboring states in the Valley and Ridge, such as Alabama and Virginia. Fifty troglobionts (10 single-cave endemics) are known from the AVR. Several caves, two being major hibernacula, are important summer maternity roosts of the gray bat in this karst region. The Berry Cave salamander (*Gyrinophilus gulolineatus*) (Figure 13), an aquatic species that is a candidate for federal listing, is known from a few caves in the AVR, including caves within metropolitan Knoxville in Knox County.

An ongoing study by the authors and their colleagues has increased the number of caves with troglobionts, particularly from caves throughout the AVR. Our goal is to have more bioinventories in caves that will fill previously identified sampling gaps (Niemiller and Zigler 2013). So far, we have significantly expanded the known distribution of several species in the AVR, including for the Appalachian cave amphipod (*Crangonyx antennatus*), cave spiders, including *Porrhoma cavernicola* and *Phanetta subterranea*, and the southeastern cave pseudoscorpion. Also included are the narrowly distributed species, such as the Tennessee cave beetle (*Pseudanophthalmus tennesseensis*) and the cave millipede *Scoterpes* cf. *blountensis*. New species previously not known to science have also been discovered, including populations of pseudoscorpions, a harvestman, and at least two undescribed species of aquatic hydrobiid cave snails, which represent the first records of aquatic cave snails in Tennessee.

Figure 13. The Berry Cave salamander (*Gyrinophilus gulolineatus*) is the only obligate cave-dwelling vertebrate in eastern Tennessee and is listed as endangered. Populations are only known from a few caves, including some in urban watersheds (photo by A.S. Engel).
Cave Conservation

The distribution, population size and other information on the ecology and life history of most cave fauna has not been well studied in Tennessee. Many species are hard to study but may be present at low densities, making it very difficult to detect trends in populations over time. Regardless, it is becoming clear that many cave animals are vulnerable to a variety of anthropogenic threats, including groundwater pollution, habitat degradation and loss (e.g., from quarrying, road construction, and dam building and inundation), disturbance, over-collection and emergent diseases.

Several cave-dwelling species in Tennessee are of conservation concern, including three species of federally listed bats: gray bat, Indiana bat and the northern long-eared bat (*Myotis septentrionalis*). The Berry Cave salamander and six species of cave beetles belonging to the genus *Pseudanophthlmus* spp. are candidates for federal listing. However, the conservation status of the vast majority of cave invertebrates is not well known. Because many of these species have highly restricted distributions and are known from just a few caves, or only a single cave system in some cases, they are thought to be at a particularly high risk of extinction because of environmental threats.

Most caves in Tennessee are privately owned and afforded little protection. As such, there is a great need to document cave biodiversity to assist in setting conservation priorities and guiding management decisions for cave fauna. Given the potential for increasing threats that may impact populations of cave animals, particularly in urban areas, regular monitoring protocols should be initiated. There is a critical need for updated assessments regarding the conservation status of individual species.

Finding new obligate cave species could assist regional land managers and conservation efforts. Unfortunately, the pace of finding new species and of describing them scientifically is slow. This negatively affects our understanding of how species are distributed in the state and impedes our ability to protect cave systems from potential anthropogenic impact, such as in growing metropolitan areas (e.g., Nashville, Knoxville and Bristol).

References
