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**The need for presumptive habitat considerations in working with subterranean aquatic species of concern: Three Ozark region case histories, USA NCKRI Symposium 2: Proceedings of the Thirteenth Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst**

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# THE NEED FOR PRESUMPTIVE HABITAT CONSIDERATIONS IN WORKING WITH SUBTERRANEAN AQUATIC SPECIES OF CONCERN: THREE OZARK REGION CASE HISTORIES, U.S.A.

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## Abstract

Delineating habitats for aquatic species of concern present in groundwater systems, and especially those in karst groundwater systems, presents challenges. It is not reasonable to limit the delineated habitat to those portions of a groundwater system that can be directly observed. How then do we make reasonable delineations? Three case histories in the Ozarks region of the central USA illustrate differing approaches for identifying presumptive habitat in recharge area delineations for subterranean species of concern. The first case study of the Tumbling Creek Cavesnail explores the reasoning for designating presumptive habitat downgradient of observed habitat in a cave stream. The second case study of Ozark Cavefish illustrates reasonable designation of presumptive habitat in a complex distributary spring system that discharges water from a well-developed saturated epikarstic area. The final case history illustrates the case for expanding the presumptive habitat in both upgradient and downgradient areas for a Hell Creek Cave Crayfish site in northern Arkansas.

## Introduction

Delineating habitats for aquatic species of concern present in groundwater systems, and especially those in karst groundwater systems, presents challenges. It is not reasonable to limit the delineated habitat to those portions of a groundwater system that can be directly searched. How then do we make reasonable delineations? This paper presents three case histories of the use of presumptive habitat designations in recharge area delineations.

## Presumptive Habitat

The habitat of a species is most often identified by direct observation or capture. This method is severely limited when dealing with subterranean aquatic species. Even

caves generally provide only a small area of access to a much larger groundwater system. Presumptive habitat is the concept that all groundwater with subsurface hydrological interconnections should be presumed to contain the species of concern that is found in accessible portions of the system (Moss and Aley 2003). Implicit in this concept is the assumption that the conditions (temperature, salinity, pH, etc.) in the interconnected groundwater are compatible with the survival of the species in question. This concept allows for more realistic evaluation of the habitat for subterranean aquatic species of concern.

It is important to distinguish the recharge area from presumptive habitat. In most cases, the entire recharge area should not be included as presumptive habitat for the aquatic species. In many cases characteristics of the species in question indicate that certain portions of the recharge area would not be expected to contain the species of concern. Although the entire recharge area for aquatic species should be managed to maintain good water quality for the benefit of the species of concern, the recognition of the probable extent of species habitat beyond an area of direct observation is important for the effective management of subterranean aquatic species of concern.

## Tumbling Creek Cavesnail, Protom, Missouri, USA

The Tumbling Creek Cavesnail (*Antrobia culveri*) is federally listed as endangered under the provisions of the Endangered Species Act. The only known habitat for this aquatic cavesnail is the stream in Tumbling Creek Cave in southeastern Taney County, Missouri (McKenzie 2003). As a result of litigation, the U.S. Fish and Wildlife Service was required to designate critical habitat for this species. A hydrogeologically based determination of the area that constituted critical habitat for this species was needed.

Tumbling Creek rises in, and flows through, a major portion of Tumbling Creek Cave. Humanly accessible portions of the cave are in the lower members of the dolomitic Cotter Formation of Ordovician age. A locally massive chert unit with a typical thickness of about 1.2 meters (3.9 feet) lies beneath the known cave passages. While dolomite is relatively soluble in groundwater, chert is relatively insoluble. Water passing through a fracture in dolomite will, through time, enlarge the opening by solution. In contrast, the passing water will be much less effective in enlarging a similar fracture in the chert.

The distance from the bed of the cave stream to the top of the chert unit varies from about 0.5 to 3 meters (1.6 to 9.8 feet). At the upstream end of perennial flow in the cave stream the water rises through a solutionally widened joint in the dolomite that almost certainly overlies a major fracture in the underlying chert. The water is rising under pressure up through the chert bed and then flows in the cave stream above the chert. A tributary stream that joins Tumbling Creek in the cave rises through a pool that apparently overlies another fracture in the chert unit.

The weir at the stream gauging station in the cave is about 595 meters (1,952 feet) upstream of the Bear Cave entrance to the Tumbling Creek Cave System. Flow rates of about 0.12 cubic meters per second (cms) at the weir are needed before any flow in the cave stream will discharge through the Bear Cave entrance. Water lost from the channel of Tumbling Creek moves downward through fractures in the chert into dolomitic units that underlie the chert unit. The sinking segments of the cave stream are highly localized and most are within 150 meters of the Bear Cave entrance. The largest single flow loss zone is about 60 meters (197 feet) upstream of this entrance.

With the exception of the Bear Cave entrance to the cave (which is above the chert unit), all of the springs that drain the cave and the accessible portions of the snail habitat derive almost all of their water from flows that have been confined by the chert unit. There are two perennial springs about 730 meters (2,395 feet) apart that drain the cave. Perennial flow is also present in a karst window located between the Bear Cave entrance and most of the springs.

Under high flow conditions the cave is drained by 15 to 20 springs depending upon how one counts springs that are relatively close to one another. These springs are located along 1,585 meters (5,200 feet) of surface stream channels. The range in elevation of these springs is 15.7 meters (51.4 feet). Under high flow conditions tracer dyes introduced into Tumbling Creek in areas near the Big Room will subsequently discharge from all of the 15 to 20 springs. Under high flow conditions groundwater travel rates in excess of 3 meters (9.8 feet) per minute have been documented. The relatively insoluble nature of the chert is the reason for the large number of springs. Under high flow conditions none of the fractures in the chert unit have sufficient capacity to discharge all of the water (up to 4.25 cms) that passes the weir in the Big Room.

Flow beneath the chert unit between the cave and the springs is through a matrix of solutionally widened and interconnected openings localized immediately beneath the chert unit. This distributary flow network explains the large number of springs draining the cave and the rapid groundwater flow rates that have been demonstrated by tracer tests. This area provides presumptive habitat for the cavesnail.

The karst groundwater system beneath the chert unit is not humanly accessible so no survey can be conducted in that area to verify the presence of cavesnails. However, the hydrologic and biologic conditions present for snails beneath the chert unit and hydrologically down gradient of the accessible portions of Tumbling Creek are essentially identical with the conditions found in the areas of Tumbling Creek that are known habitat for the cavesnail. This down-gradient area below the chert unit receives the same water that has flowed through the cave. Bat guano that is an important energy source for the cave ecosystem is flushed into this downgradient area by the stream flow. Flow velocities within the downgradient area are rapid and, like the accessible portions of the cave stream, capable of transporting sediment and organic matter in suspension. As a consequence, during storm events Tumbling Creek and all of the springs are turbid.

The designated critical habitat for the cavesnail (Federal Register 2011) includes all accessible portions of Tumbling Creek within the cave. It also includes as presumptive habitat the springs known to drain Tumbling Creek Cave and most of the lands immediately underlain by the chert unit in locations tributary to the springs.

Credible hydrogeologic and biologic data, including the uniformity of conditions, support recognition of this downgradient area as presumptive habitat for the cavesnail and warrant its designation as critical habitat.

### **Ozark Cavefish, Neosho, Missouri, USA**

The Ozark Cavefish (*Amblyopsis rosae*) is a small cave-adapted fish that can be found in Southwest Missouri Ozarks into northwest Arkansas and northeast Oklahoma. The Ozark Cavefish is a federally listed threatened species by the U.S. Fish and Wildlife Service. Several population sites have been identified in and around the small community of Neosho, Missouri USA.

Hearrell Spring is located near the Neosho National Fish Hatchery and provides water to the operations there. Due to the presence of Ozark Cavefish in the spring, the Hatchery acquired the spring in 1995 in order to protect the threatened species. Five groundwater traces were performed to delineate the recharge area for Hearrell Spring (Aley and Aley 1997). A recharge area of 14.7 square kilometers (5.67 square miles) was delineated for the spring and consisted of lands in two different topographic basins. Few portions of the Hearrell Spring recharge area contribute water only to Hearrell Spring. All three traces that were detected at Hearrell Spring were also detected at South Big Spring, located approximately 1220 meters (4000 feet) to the northwest. Although not identified in the recharge area report from 1997, the presumptive habitat for the cavefish population in Hearrell Spring would also include lands between Hearrell Spring and South Big Spring. Following this study another spring was identified between Hearrell and South Big Spring. This spring, known as Walbridge Spring, was identified as having Ozark Cavefish in 2006 (Aley et al. 2011). The subsequent identification of a cavefish population in an area that was previously considered to be presumptive habitat based on groundwater tracing provides confirmation of this important hydrobiological concept.

Portions of the Hearrell Spring recharge area are also shared with the recharge areas of four other springs located 1370 to 2130 meters (4500 to 7000 feet) to the east. This distributary groundwater system is draining a well-developed and saturated epikarstic zone. Aley et al. (2007) summarized recharge area delineation results from 24 Ozark Cavefish sites in Missouri, Arkansas, and Oklahoma. They found that 79% of the sites had at least

some habitat in epikarstic zones. The epikarstic zone is the weathered upper portion of soluble bedrock units. Its thickness is highly variable, but road cuts near Ozark Cavefish sites in southwest Missouri indicate that it is often at least 6 to 10 meters (20 to 30 feet) thick. The thickness of the epikarstic zone in valleys, and especially those with perennial flow, is generally unknown since highway excavations do not cross them. However, it is likely that typical thicknesses equal and probably exceed those observed in highway road cuts passing through hills. Epikarstic zones beneath the floors of perennial stream valleys are largely saturated with water and, as a result, provide substantial habitat for cave fauna including the Ozark Cavefish.

Dye tracing can yield detections at two or more springs. Distributary spring systems can be common in areas of well-developed epikarst. If one of the springs is known habitat for a species of concern, then it is reasonable to conclude that all of the hydrologically linked spring system should be viewed as presumptive habitat. In the Ozark Cavefish example in Neosho, the springs are draining a saturated epikarstic system. This hydrogeologic condition further supports presumptive habitat within the other springs with hydrologic interactions.

### **Hell Creek Cave Crayfish, Yellville, Arkansas, USA**

A population of the Hell Creek Cave Crayfish (*Cambarus zophonastes*) was discovered in a small spring located along a perennial stream that bisects the small town of Yellville, Arkansas. This troglobitic species is federally listed as endangered and previously known only from two caves located approximately 65 kilometers (40 miles) to the southeast.

The cave crayfish spring, known as Legion Spring, is located along the main stem of Town Branch Creek, just downstream of the confluence of East Prong, a major tributary. The recharge area delineation was performed in 2011-2012 (Kirkland and Aley 2012). Although several good rainfall events did occur that allowed for the introduction of tracer dyes, the study was largely performed under regional drought conditions.

Tracer dyes were introduced in six adjacent topographic basins, including East Prong and Town Branch upstream of Legion Spring. Under the low flow conditions

present at the time of the study, only one of these dye introductions (East Prong) was detected in Legion Spring (Kirkland and Aley 2012). Although gaining stream flow conditions were noted upstream of Legion Spring, groundwater tracing results indicated water from Town Branch downstream of Legion Spring was sinking into the subsurface and recharging two small springs in the adjacent Crooked Creek topographic basin.

Dye tracing indicated the recharge area for the spring with the observed cave crayfish population during the conditions of the study included 18.4 square kilometers (7.1 square miles). However, based upon the setting of the spring in an area of well-developed epikarst on the edge of a valley floor, a larger habitat than the one small spring was reasonable.

Several lines of evidence pointed to a larger presumptive habitat for the cave crayfish population. First of all, well developed epikarst was observed in road cuts and encountered in borings at a nearby petroleum release site. The spring was located on the main branch of a small creek below the confluence of a major tributary. Even though only water from the tributary valley was traced to the spring under the low flow conditions of the tracer study, it is reasonable to expect the cave crayfish population also to be present within the epikarst on the across the small creek. Upstream of Legion Spring on Town Branch is a gaining segment of the creek that drains the epikarst, as evidenced by a healthy population of watercress in the creek immediately downstream of the point where water begins to flow under low flow conditions. Therefore, it is reasonable that the areas of saturated epikarst also be included within the presumptive habitat. Areas downstream of Legion Spring along Town Branch were also included within the presumptive habitat due to the presence of perennial springs with hydrologic interactions with Town Branch below Legion Spring. These downgradient areas were also located under valley floors and expected to have extensively developed and saturated epikarst.

A larger presumptive habitat was reasonable for the observed population of cave crayfish in Legion Spring. The designated presumptive habitat area consisted of 2.2 square kilometers (0.85 square miles) in areas both upgradient and downgradient of the observed population site. In consideration of the larger presumptive habitat, a larger recharge area (18.4 square kilometers or 7.1 square miles) was delineated in contrast to the smaller recharge area for just

the spring site based upon the dye tracing under the low flow conditions (12.6 square kilometers or 4.9 square miles). The expanded presumptive habitat designation and subsequently the larger recharge area provide a more reasonable area for conservation management for species protection.

## Summary

From a conservation perspective, the entire recharge area must be managed for subterranean, aquatic species of concern. However, to determine the most appropriate recharge area, the presumptive habitat must be considered in addition to the known habitats of observed populations.

In most cases it is more reasonable to extend presumptive habitat downgradient from a known site than upgradient. This was the case with Tumbling Creek Cavesnail. Hydrobiological conditions support the management of an expanded area downgradient from the known habitat within the cave stream even though direct observation in this area is not available.

Other cases of important presumptive habitat designation include distributary spring systems that drain saturated epikarstic areas. As illustrated by the Ozark Cavefish, it is reasonable that if a known population exists in one spring, populations could exist in other areas with hydrogeologic connections and similar hydrogeologic conditions. Presumptive habitat designations in these areas result in identified habitat areas that are often more laterally expansive, and can therefore result in larger recharge areas for the species of concern. Hydrogeologic connections between observed population sites and other springs where the species have not been identified are important to be established during the recharge area delineation of a known population of concern.

In some settings, it is reasonable to extend the presumptive habitat upgradient from a known population site. The recognition of well-developed epikarstic systems, their hydrologic connections through seasonal groundwater fluctuations, and the hydrobiological relationship with subterranean species of concern has led to a presumptive habitat designation that was expanded to include some areas upgradient and down-gradient for the Hell Creek Cave Crayfish in Yellville, Arkansas USA. This larger presumptive habitat is important to identify an adequate recharge area for effective species protection, especially considering the population growth and ongoing development in this area.

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