TENNESSEE CASE STUDY: The Eastern Hellbenders of Tennessee - A species indicative of good water quality provides a focus for conservation statewide

Perhaps no other species in Tennessee is more emblematic of the widespread, interacting, and complex mix of threats posed by society to healthy aquatic systems than the Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*). Picturesquely dubbed "The Last Dragons" in a 2014 film produced by Freshwaters Illustrated and the U.S. Forest Service, this giant salamander subspecies was once distributed throughout most streams in the eastern two-thirds of Tennessee.

With a fascinating life history – including a relatively long life (25 years or more), a fierce attachment to home territory, annual battles by males vying for mates, and males that guard their eggs and young – this species has become a flagship for what is extraordinary about Tennessee and southern Appalachian streams. Hellbenders have experienced precipitous population declines across much of the state in the past several decades, and their plight clearly illustrates an issue for which conservation efforts beyond the boundaries of Conservation Opportunity Areas must and will continue.

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The Hellbenders' descent into rarity

Dr. Brian Miller, a salamander expert who first came to Middle Tennessee State University in 1989 to study Hellbenders, has been observing the species' decline for more than 20 years. He began working with Hellbenders in the Collins and Buffalo Rivers where populations seemed relatively high. After a survey hiatus from 1995 to 2001, he returned to the Collins River to find only one Hellbender. "I did not know then that that individual would be the last Hellbender I would find in the Collins River," says Miller.

Top to bottom: Hellbender in typical habitat at night, Hiwassee River -Dave Herasimtschuk, Freshwaters Illustrated; Small hellbender indicative of a reproducing population, lower Little River - TWRA staff; The Hiwassee River: some of the best remaining Hellbender habitat in Tennessee - LookoutBelle/next page: Hellbender in Tellico River - Dave Herasimtschuk, Freshwaters Illustrated

His assessment after searching numerous middle Tennessee rivers over subsequent years is that populations crashed over a 10-year span, going from low densities to almost non-existent. Miller notes, "In retrospect, I was probably working with an aged and dwindling population in the Collins River in the early 1990s, since I never found small Hellbenders back then."

This picture is complicated by one of the quintessential problems in ecology: a lack of historical information with which to compare current conditions. Miller estimates that the initial decline may have begun as early as the 1970s. However, the lack of data on the original size of Hellbender populations hinders any definitive assessment.

Unraveling Hellbender problems

Hellbenders require extremely good water quality. They need clear swift-flowing streams that keep crevices under streambed rocks open and available for Hellbender lairs. This species also breathes through its skin, making it dependent upon high levels of oxygen in the water. For these reasons, most stream modifications impact Hellbenders, including impoundments, channelization, siltation, acid mine drainage, and thermal pollution.

Increased levels of siltation from agriculture and other forms of runoff essentially bury Hellbender habitat. Silt may often carry with it herbicides and other chemicals, which some research has implicated as a potential contributor to Hellbender reproductive problems (Solis et al. 2007). Further complicating this picture is the fact that streams in Tennessee completely lack historical or current records on the chemical loads they carry. People who move or collect river stones for building often directly destroy Hellbender habitat. Finally, in the early 2000s there was also a question about whether Hellbenders were succumbing to diseases that have been spreading among amphibian populations on a global scale.

Responding to the unnerving decline that Miller had found in middle Tennessee's Hellbenders, in 2010 TWRA provided State Wildlife Grant (SWG) support to a collaborative group of researchers, including the University of Tennessee and the Nashville Zoo, to bring together salamander experts and develop a coordinated program of research aimed at improving Hellbender conservation. The program they developed aimed to achieve four goals:

1. Conduct field surveys of historic Hellbender locations to determine current distribution.
2. Determine the extent to which Hellbenders are susceptible to two widespread diseases affecting amphibians: chytrid fungus and ranavirus.
3. Develop an "e-DNA" (environmental DNA) protocol to allow sampling of Hellbender DNA from the water column to discern presence/absence and genetic differences among populations.

4. Develop techniques to study and boost wild Hellbender populations, including cryopreservation of sperm for captive breeding and development of crèche methods for rearing wild caught Hellbender young to increase their survival rate.

A complicated picture emerges

Research implemented by partners in this effort since 2010 has yielded the following:

- The Upper Tennessee Drainage has some of the best remaining Hellbender populations in the state, and the Middle Tennessee has remnant populations (the Duck and Buffalo watersheds), while the Cumberland Drainage populations are imperiled, with over 140 man hours of search effort yielding 0 Hellbenders. Moreover, moderate to high degrees of siltation were found in all the Cumberland waterways surveyed.
- Hellbenders can contract both chytrid fungus and ranavirus. In captivity, nearly all Hellbenders with ranavirus die when water temperature exceeds 68 degrees Fahrenheit (a common occurrence in streams during Tennessee summers).
- The Buffalo River in Middle Tennessee has a genetically unique strain of Hellbenders, which is different from those found in the Hiwassee and Ocoee Rivers of East Tennessee.
- Researchers successfully collected Hellbender sperm, using cryopreservation to "bank" their genes. Captive breeding of Hellbenders has been largely unsuccessful.
- Placing concrete Hellbender houses in streams has allowed fertilized eggs to be removed and hatched in captivity -- either for study or to improve survival of salamander larvae by growing them out for release back into the environment.

Bringing back Hellbenders: 2015 and beyond

People value rarity, and as Hellbender populations across the state have crashed, support and interest in their conservation has increased. Unfortunately, the level of effort required to assist rapidly declining wildlife populations is often quite high and quite complex.

The status of Hellbenders in Tennessee is inspiring concern and action: to understand where they are still found, what threatens them, and what conservation measures will be most effective.

TWRA and the U.S. Fish and Wildlife Service are supporting efforts aimed at further cataloguing Hellbender populations. In 2015, Dr. Miller at MTSU initiated (with TWRA SWG support) a population survey in the Little Buffalo River, the middle Tennessee stream with the best breeding densities of Hellbender according to a 2012 survey. Meanwhile, additional SWG funds are supporting researchers with the University of Tennessee Forestry, Wildlife, & Fisheries Department who are attempting to develop a means of inoculating Hellbenders against chytrid fungus to create disease-resistant populations in the wild.

The brightest part of the big picture is that steeper gradient rivers like the Hiwassee still have some of the best remaining Hellbender populations and could serve as potential sources for reintroduction efforts. However, if population crashes are associated with a decrease in water quality, then those issues must be remedied prior to any stocking efforts (see the Elk River case study). Dr. Miller sums it up by saying, "Some of these east Tennessee streams appear to have somewhat stable populations. Time will tell."