

**Cumberland Elktoe**  
**(*Alasmidonta atropurpurea*, Rafinesque, 1831)**

**5-Year Review:**  
**Summary and Evaluation**

**U.S. Fish and Wildlife Service**  
**Cookeville Ecological Services Field Office**  
**Cookeville, Tennessee**

## **5-YEAR REVIEW**

Cumberland Elktoe (*Alasmidonta atropurpurea*)

### **I. GENERAL INFORMATION**

#### **A. Methodology used to complete this review**

This review was completed by the U.S. Fish and Wildlife Service's Cookeville Field Office. All literature and documents on file at the Cookeville Field Office were used for this review. The primary source of information used in this analysis was the final recovery plan (Service 2004). Public notice was given in the *Federal Register* on September 20, 2005 (70 FR 55157) and a 60-day comment period was opened. During this comment period, we obtained information on the status of this species from several experts and our State partners.

#### **B. Reviewers:**

**Lead Region - Southeast Region: Kelly Bibb, (404) 679-7132**

**Lead Field Office - Cookeville, TN: Timothy Merritt, (931) 528-6481**

#### **C. Background**

##### **1. FR Notice citation announcing initiation of this review:**

September 20, 2005; 70 FR 55157

##### **2. Species status:** Stable (2005 and 2006 Recovery Data Calls)

##### **3. Recovery achieved:** 1 = 0%-25% of species recovery objectives achieved.(2005 and 2006 Recovery Data Calls)

##### **4. Listing history**

##### **Original Listing**

FR notice: 62 FR 1647

Date listed: January 10, 1997

Entity listed: species

Classification: endangered

##### **5. Associated actions**

Designation of critical habitat for five endangered mussels (including the Cumberland elktoe) in the Tennessee and Cumberland River basins. August 31, 2004; 69 FR 53136.

##### **6. Review History**

Recovery Data Call: 2006 (stable), 2005 (stable), 2004 (stable, Final Recovery Plan published), 2003 (stable)

**7. Species' Recovery Priority Number at start of review:**

Recovery Priority Number: 5 (degree of threat is high, potential for recovery is low, and the taxonomy is the species level)

**8. Recovery Plan or Outline**

Name of plan: Recovery Plan for **Cumberland Elktoe**, Oyster Mussel, Cumberlandian Combshell, Purple Bean, and Rough Rabbitsfoot.

Date issued: May 4, 2004

**II. REVIEW ANALYSIS**

**A. Application of the 1996 Distinct Population Segment (DPS) policy:** Not applicable. The Cumberland elktoe mussel is an invertebrate, and therefore, not covered by the DPS policy, and the other DPS questions will not be addressed further in this review.

**B. Recovery Criteria**

**1. Does the species have a final, approved recovery plan?**

Yes. Recovery Plan for **Cumberland elktoe**, oyster mussel, Cumberlandian combshell, purple bean, and rough rabbitsfoot. Prepared by Robert S. Butler and Richard G. Biggins, U.S. Fish and Wildlife Service, Region 4. Approved May 4, 2004.

**2. Does the recovery plan contain recovery (i.e., downlisting or delisting) criteria? Yes.**

**3. Adequacy of recovery criteria.**

a. **Do the recovery criteria reflect the best available (i.e., most up-to-date) information on the biology of the species and its habitat? Yes.**

b. **Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and there is no new information to consider regarding existing or new threats)? Yes.**

**4. Recovery criteria**

**a. Criteria for downlisting to threatened status**

Through the protection of extant stream populations (e.g., continuing to use existing regulatory mechanisms, establishing partnerships with various stakeholders, using BMPs, minimizing or eliminating threats), discovery of currently unknown stream populations, and/or reestablishment of historical stream populations, there exists at least

five distinct viable stream populations of the Cumberland elktoe in the Cumberland River system. This will be accomplished by:

**1. Protecting all extant populations (i.e., Laurel Fork, Marsh Creek, Sinking Creek, Big South Fork system, and Rock Creek) and ensuring that all these streams have viable population status.**

While we have not met this criterion yet, we are looking for opportunities to work with our State and Federal partners and The Nature Conservancy (TNC) to protect all five extant populations of the Cumberland elktoe. Our Partners for Fish and Wildlife program has had projects in many of these systems and is looking for additional opportunities to work with landowners in both Tennessee and Kentucky to improve stream habitats for the Cumberland elktoe.

**2. One distinct naturally reproduced year class exists within each of the viable populations. The year class must have been produced within 5 years prior to the time the species are reclassified from endangered to threatened. Within 1 year before the delisting date, gravid females of the mussels and their host fish must be present in each viable population.**

This criterion has not been fully met. There are presently three extant populations (Marsh Creek, Rock Creek and Big South Fork system) that meet this criterion (S. Bakaletz, National Park Service biologist, personal communication (pers. comm.), 2006 and R. Cicerello, Kentucky State Nature Preserves Commission, retired mussel biologist, pers. comm., 2006). The remaining two extant populations (Sinking Creek, and Laurel Fork) are much smaller and exhibit more sporadic recruitment (Cicerello, pers. comm., 2006).

**3. Research studies of the mussels' biological and ecological requirements have been completed and any required recovery measures developed and implemented from these studies are beginning to be successful (see Recovery Tasks 1.4.1, 1.4.2, 1.4.5, and 1.4.6), as evidenced by an increase in population density of approximately 20 percent and/or increase in the length of the river reach of approximately 10 percent inhabited by the species as determined through biennial monitoring (see Recovery Task 5).**

Recovery task 1.4.1 involves conducting life history research on the Cumberland elktoe. Virginia Polytechnic Institute (VPI) conducted host fish identification trials on the Cumberland elktoe. Active, pedal-feeding juveniles excysted on four species: northern hogsucker (*Hypentelium nigricans*), banded sculpin (*Cottus*

*carolinae*), redline darter (*Etheostoma rufilineatum*), and fantail darter (*Etheostoma flabellare*). The latter three species were not previously known as hosts. No additional life history research has occurred since the Recovery Plan was approved in May 2004.

Recovery task 1.4.2 involves characterizing the species' habitat for all life history stages. No additional work has occurred on this task since the Recovery Plan was approved.

Recovery task 1.4.5 deals with investigating the need for management, including habitat improvement. No additional work has occurred on this task since the Recovery Plan was approved.

Recovery task 1.4.6 involves determining the number of individuals and the sex ratio required to maintain long-term viable natural populations. No additional work has occurred on this task since the Recovery Plan was approved.

**4. No foreseeable threats exist that would likely impact the survival of any of the species over a significant portions of their ranges (see Recovery Tasks 1.4.3 and 1.4.4).**

Recovery task 1.4.3 involves addressing present and foreseeable threats. Our Partners for Fish and Wildlife biologists in Tennessee and Kentucky are looking for additional opportunities to work with private landowners to protect watersheds that contain threatened and endangered species, including the Cumberland elktoe. Our State partners are working with us to identify and address threats to mussel resources throughout the Cumberland watershed. No threats have been fully addressed since the Recovery Plan.

Recovery task 1.4.4 deals with determining contaminant sensitivity for each life history stage. We have an ongoing project that is looking at the sediment toxicity in the Big South Fork system. The results of this study are not available yet.

**5. Within larger streams (e.g., Big South Fork), the species is distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable (see Recovery Task 4.1).**

Recovery task 4.1 involves refining techniques and methodologies for propagating and translocating mussels as a prelude to potential augmentation and reintroduction efforts. VPI is at the forefront of this work, having propagated and released juvenile mussels from 13 species, including six that are federally listed as of 2005. VPI

plans to collect Cumberland elktöes in 2006 and attempt to propagate them for reintroduction into the Big South Fork system. Females are gravid during the winter and are difficult to collect because stream flows tend to be too high. The States of Kentucky and Tennessee are also working on refining mussel propagation techniques and methodologies. However, neither State has propagated Cumberland elktöes. The Service, with our partners, is developing a comprehensive plan for mussel augmentations and reintroductions in the Tennessee and Cumberland watersheds. This plan is in draft form and should be finalized in 2007.

**6. Biennial monitoring of the five species yields the results outlined in “criterion 1 and 2” over a 10-year period (see Recovery Task 5).**

Biennial monitoring has not occurred to date, primarily due to insufficient funds. Some yearly monitoring does occur by our partners on a site-by-site basis.

**a. Criteria for delisting**

Through the protection of extant stream populations (e.g., continuing to use existing regulatory mechanisms, establishing partnerships with various stakeholders, using BMPs, minimizing or eliminating threats), discovery of currently unknown stream populations, and/or reestablishment of historical stream populations, there exists at least **seven** (five for downlisting) distinct viable stream populations of the Cumberland elktöe in the upper Cumberland River system. **Two** (one for downlisting) distinct naturally reproduced year classes exist within each viable population. All other downlisting criteria remain the same for the delisting criteria. All the work to-date for this species has been described above under the “Criteria for downlisting.” There are presently only five extant populations of the Cumberland elktöe.

**C. Updated Information and Current Species Status**

**1. Biology and Habitat**

**a. Abundance/population trends:** We have no new information since the Recovery Plan was finalized in 2004. Based on information from the Recovery Plan, populations of the Cumberland elktöe persist in 12 tributaries: Laurel Fork, Claiborne County, Tennessee and Whitley County, Kentucky; Marsh Creek, McCreary County, Kentucky; Sinking Creek, Laurel County, Kentucky; Big South Fork, Scott County, Tennessee and McCreary County, Kentucky; Rock Creek, McCreary County, Kentucky; North White Oak Creek, Fentress

County, Tennessee; Clear Fork, Fentress, Morgan and Scott Counties, Tennessee; North Prong Clear Fork, Fentress County, Tennessee; Crooked Creek, Fentress County, Tennessee; White Oak Creek, Scott County, Tennessee; Bone Camp Creek, Morgan County, Tennessee; and New River, Scott County, Tennessee. The latter nine streams, which comprise the Big South Fork system, may represent a single, viable metapopulation of the Cumberland elktoe.

Marsh Creek harbors the largest population known in Kentucky (Cicerello, pers comm., 2006). The population in Rock Creek is also sizable (Cicerello, pers comm., 2006). The largest populations in Tennessee are in the Big South Fork system in the headwaters of Clear Fork. Good recruitment occurs within the Marsh Creek, Rock Creek and Big South Fork system populations. The Laurel Fork and Sinking Creek populations are much smaller and it is harder to find individuals to determine recruitment levels.

- b. Genetic variation:** No new information since the Recovery Plan.
- c. Taxonomic classification or changes in nomenclature:** None
- d. Spatial distribution:** In 2005, a fresh dead specimen was found in Jellico Creek in Kentucky (Cicerello, pers. comm., 2006). This is a new record for this creek.
- e. Habitat or ecosystem conditions:** The Big South Fork system is in risk of being impaired due to increases in oil, gas, and coal exploration and development. The National Park Service has partnered with a grass roots organization to develop a watershed association that has received funding from the Environmental Protection Agency to begin preparation of a watershed management plan that covers both Tennessee and Kentucky. The group is focusing on water resources and enhancement of endangered mussels such as the Cumberland elktoe. We have no new information on the habitat conditions of Rock, Sinking, Marsh and Laurel Fork Creek populations since the Recovery Plan.

**2. Five Factor Analysis (threats, conservation measures, and regulatory mechanisms).**

**Factor A. The present or threatened destruction, modification, or curtailment of its habitat or range:** Oil, gas, and coal exploration and development are on the increase in the New River watershed (Steve Bakaletz, National Park Service biologist, pers. comm., 2006). The New River is a major tributary to the Big South Fork that influences the quality of the Cumberland elktoe habitat. The potential negative impacts to mussels and their habitat

will have to be monitored closely as exploration and development increase. We have an ongoing project that is looking at the sediment toxicity in the Big South Fork system. The results of this study are not available yet.

There are no known additional habitat threats to the Cumberland elktoe populations in Rock, Sinking, Marsh and Laurel Fork Creeks beyond the ones listed in the Recovery Plan.

**Factor B. Overutilization for commercial, recreational, scientific or educational purposes:** The overutilization for commercial, recreational, scientific or educational purposes was not considered to be a limiting factor in the Recovery Plan. We have no new information to indicate that this has changed.

**Factor C. Disease and predation:** The Recovery Plan stated that there is little data indicating that disease or predation are limiting factors for this species. We have no new information on disease or predation of the Cumberland elktoe. We continue to believe that disease or predation are not limiting factors for this species.

**Factor D. Inadequacy of existing regulatory mechanisms:** We have no new information on the inadequacy of existing regulatory mechanisms for protecting the Cumberland elktoe and its habitat. The sediment toxicity study being conducted on the Big South Fork system may provide some insights into potential water quality issues associated with the Clean Water Act. However, the results of that study are not available yet.

**Factor E. Other natural and manmade factors affecting its continued existence:** The Recovery Plan listed the presence or potential introduction of alien species (especially zebra mussels and black carp), insufficient densities of host fish species, inbreeding depression and other genetic considerations, and possible weak links in the species' life cycles. We have no new information on any of these issues

## **D. Synthesis**

The Cumberland elktoe is limited in distribution to the upper Cumberland River system in southeast Kentucky and north-central Tennessee, occupying streams both above and below Cumberland Falls. This species appears to have occurred only in the main stem of the Cumberland River and primarily its southern tributaries upstream from Cumberland Falls near Burnside, Pulaski County, Kentucky. All verified sites of occurrence are in the Cumberland Plateau Physiographic Province, giving it one of the most



restricted ranges of any Cumberlandian mussel species. The Cumberland elktoe has apparently been extirpated from the main stems of the Cumberland and Laurel Rivers (and its tributary, Lynn Camp Creek). However, it was rediscovered in the New River in 2002. In 2005, a fresh dead specimen was found in Jellico Creek in Kentucky (Cicerello, pers. comm., 2006). This is a new record for this creek. Extant populations exist in 12 tributaries: Laurel Fork, Claiborne County, Tennessee and Whitley County, Kentucky; Marsh Creek, McCreary County, Kentucky; Sinking Creek, Laurel County, Kentucky; Rock Creek, McCreary County, Kentucky; Big South Fork, Scott County, Tennessee, and McCreary County, Kentucky; North White Oak Creek, Fentress County, Tennessee; Clear Fork, Fentress, Morgan, and Scott Counties, Tennessee; North Prong Clear Fork, Fentress County, Tennessee; Crooked Creek, Fentress County, Tennessee; White Oak Creek, Scott County, Tennessee; Bone Camp Creek, Morgan County, Tennessee; and New River, Scott County, Tennessee. The latter eight streams, which comprise the Big South Fork system, may represent a single, viable metapopulation of the Cumberland elktoe. Good recruitment occurs within the Marsh Creek, Rock Creek and Big South Fork system populations. The Laurel Fork and Sinking Creek populations are much smaller and it is harder to find individuals to determine recruitment levels.

The Recovery Plan listed excessive sedimentation (primarily resulting from nonpoint-source loading), coal mining, gravel mining, reduced water quality below existing dams, developmental activities, water withdrawal, impoundments, and alien species as threats to the Cumberland elktoe and its habitat. Due to the restricted range of the remaining five extant populations, toxic spills are also a threat that could wipe out an entire population. All of these threats remain. As discussed above in Section C, the Big South Fork watershed is also experiencing an increase in oil, gas, and coal exploration and development. The effects of an increase in these activities on the Cumberland elktoe are unknown at this time.

Since the Recovery Plan was written in May 2004, the following has occurred. A fresh dead Cumberland elktoe was found in the Jellico River in 2005. To date, no additional specimens have been found. The Service's Partners for Fish and Wildlife program is looking for opportunities to work with landowners in the watersheds where Cumberland elktoe occurs. The National Park Service (NPS) is working to protect the Cumberland elktoe and its habitat throughout the Big South Fork National River and Recreation Area (BSFNRR). NPS has partnered with a grass roots organization to develop a watershed association. This association has received an EPA grant to begin preparation of a watershed management plan for the Big South Fork watershed that covers both Tennessee and Kentucky. NPS has also developed a mussel reintroduction plan for the BSFNRR that includes Cumberland elktoe. VPI has plans to collect Cumberland elktoes in 2006 and attempt propagation for release back into the Big South Fork system.

The recovery criteria listed in Section B above have not been met for delisting or downlisting the species. Because of the Cumberland elktoe's limited distribution and continued threats to the 5 extant populations, it remains in danger of extinction throughout all or a significant portion of its range. Therefore, the status of the Cumberland elktoe should remain as endangered.

At the time of listing (USFWS 1997), this species had a high degree of threat and a low recovery potential, which results in a Recovery Priority Number of 5 for the taxonomic level of species. The Recovery Plan (USFWS 2004) also describes this species as having a high degree of threat and a low recovery potential. While the NPS is working to protect the Big South Fork watershed, the degree of threat remains high for this species. Oil, gas, and coal exploration and development are an increasing threat in the upper Big South Fork watershed. Pollution and sedimentation continue to be threats to all the extant populations. A detailed description of the past and present threats to this species can be found in the Recovery Plan. We continue to believe that the threats to this species remain high and that the recovery potential remains low. Therefore, a change to the existing Recovery Priority Number is not warranted.

### **III. RESULTS**

#### **A. Recommended Classification**

No change is needed for the existing classification of endangered.

#### **B. New Recovery Priority Number**

No change is needed for the existing Recovery Priority Number of 5.

### **IV. RECOMMENDATIONS FOR FUTURE ACTIONS**

Develop propagation technology.

Augment and expand the range of extant populations to ensure their viability.

Reestablish viable populations in other streams within the historical range that have suitable habitat and water quality.

Determine the degree of threat that increased coal mining, and oil and gas drilling may have on this species.

Protect habitat through acquisitions and easements.

### **V. REFERENCES**

U. S. Fish and Wildlife Service. 1997. Endangered and Threatened Wildlife and Plants; Endangered Status for the Cumberland Elktoe, Oyster Mussel, Cumberlandian Combshell, Purple Bean, and Rough Rabbitsfoot (FR Vol 62, No. 7; Friday, January 10, 1997; 1647-1658).

U. S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Five Endangered Mussels in the Tennessee and Cumberland River Basins (FR Vol. 69, No. 168; Tuesday, August 31, 2004; 53136-53180).

U. S. Fish and Wildlife Service. 2004. Recovery Plan for **Cumberland Elktoe**, Oyster Mussel, Cumberlandian Combshell, Purple Bean, and Rough Rabbitsfoot. Atlanta, Georgia. 168 pp.

**U.S. FISH AND WILDLIFE SERVICE**  
**5-YEAR REVIEW of Cumberland Elktoe (*Alasmidonta atropurpurea*)**

**Current Classification:** Endangered.

**Recommendation resulting from the 5-Year Review:**

- ☐ Downlist to Threatened
- ☐ Uplist to Endangered
- ☐ Delist
- ☒ No change needed

**2007 Review Conducted By:** Tim Merritt

**2015 Review Conducted By:** Stephanie Chance, Tennessee Ecological Services Field Office

**FIELD OFFICE APPROVAL:**

**Lead Field Supervisor, Fish and Wildlife Service**

Approve *Josh Bailey* Date 11/14/06

**REGIONAL OFFICE APPROVAL:**

**Lead Regional Director, Fish and Wildlife Service**

Approve *Norman E. Walsh* Date 1/24/07

**FY 2015 APPROVAL\***

**Lead Field Supervisor, Fish and Wildlife Service**

Approve *Reggie W. Shute* Date 7/16/15

\* In 2014, Southeast Region Field Supervisors have been delegated authority to approve 5-year reviews that do not recommend a status change.

Field Supervisor signature on this document reflects:

1. ☐ We have no new information, received no new public comments, and the original five factor analysis remains an accurate reflection of the species current status.
2. ☒ We have obtained a small amount of new information that we have summarized in Appendix B, received no new public comments, and the original five factor analysis remains an accurate reflection of the species current status.

**U.S. FISH AND WILDLIFE SERVICE**  
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**Appendix B. Summary of new information obtained since the 2007 5 Year Review.**

**Distribution/Status**

In April 2014, Ahlstedt (2014, pers. comm.) found 12 live Cumberland elktote at Bone Camp Creek and 1 live at North White Oak Creek, both sites in Morgan County, Tennessee. In September 2014, Dinkins (2014) found 2 Cumberland elktote downstream of the Zenith Crossing on North White Oak Creek. In April 2013, 15 gravid females were observed in Clear Fork in the Big South Fork Cumberland River (McGregor 2013, unpubl. report). In 2011 qualitative and quantitative samples at the same site (Peter's Bridge – Clear Fork), Cumberland elktote was the most abundant species (McGregor 2012). Forty-seven individuals were found measuring from 34-124 mm in length and from 2 to 15 years of age (McGregor 2012, pers. comm.).

In 2007, 5 live individuals were found in soft substrates in Buffalo Creek, a tributary to the New River (Ahlstedt et al. 2008). Coal fines were observed at the site, and mussels were found at the head of a shoal.

In 1988, Layzer and Moles (2009) estimated the population size of Cumberland elktote in North Prong Clear Fork (2.33/square meter) and Bone Camp Creek (0.52/square meter). In 2008, only one live mussel was found at North Prong Clear Fork and no live mussels were found in the same Bone Camp Creek site (Layzer and Moles 2009). The authors hypothesized that Cumberland elktote continue to persist because they have adapted to the unpredictable nature of life in headwater streams (i.e., variability of flows and predation).

**Five Factor Analysis: Factor A. The present or threatened destruction, modification, or curtailment of its habitat or range:**

While oil and gas development and coal mining were listed as threats to the Cumberland elktote in both the Recovery Plan and the last 5 year review, new research is beginning to shed light on the specific chemical constituents primarily responsible for declines in freshwater mussels, such as the Cumberland elktote. In sites impacted by coal mining or natural gas extraction, total recoverable metals, PAHs, major ions, or a combination of the three have contributed to sediment toxicity and mussel declines in the Upper Tennessee and Cumberland River basins (Wang et al. 2013). Oil and gas wastewater from both conventional and unconventional wells have been shown to be a risk to aquatic organisms due to halide and ammonium levels in these waters, even after brine treatment (Harkness et al., accepted 2014).

Price et al. (2014) found a temporal increase of dissolved solids in the Clinch River between 1964 and 2010 that corresponds to declining mussel densities in the Virginia portion of

the river. In addition, water-column ammonia and sediment metals have occurred at levels likely contributable to the decline of freshwater mussels in the Virginia portion of the Clinch River (Price et al. 2014). The increased levels of ammonia, metals, and dissolved solids were seen in watersheds drained by both agricultural activity and coal mining, however, mussel declines are greater in close proximity to and downstream of watersheds impacted by coal mining (Guest River tributary to the Clinch River) (Price et al. 2014).

### **Synthesis**

The Cumberland elktote has a restricted range and continues have a high degree of threats. The recovery criteria have not been met and the recovery potential remains low. Therefore, the status of the Cumberland elktote should remain as endangered and the Recovery Priority Number should remain as a 5.

### **Recommendations for Future Actions**

Conduct a trial reintroduction of the Cumberland elktote into its historical range in the Cumberland River system above Cumberland Falls (Cumberlandian Region Mollusk Restoration Committee 2010).

### **Literature Cited**

Ahlstedt, S. 2014. Personal communication to Stephanie Chance, U.S. Fish and Wildlife Service, Tennessee. Cumberland elktote survey results. (April 24, 2014).

Ahlstedt, S.A., C. Walker, and S. Bakaletz. 2008. Status of freshwater mussels in the Coal Mining Basin of the New River (Big South Fork Cumberland River Drainage) in portions of Scott, Anderson, Morgan, and Campbell County, Tennessee (2006-2008). Final report to the Office of Surface Mining Reclamation and Enforcement, Knoxville, Tennessee. 50 pp.

Cumberlandian Region Mollusk Restoration Committee. 2010. Plan for the population restoration and conservation of freshwater mollusks of the Cumberlandian Region. V + 145 pp.

Dinkins, G.R. 2014. Survey for Cumberland elktote (*Alasmodonta atropurpurea*) in North White Oak Creek at the site of the zenith crossing. Final report to the National Park Service, Big South Fork, Tennessee. 6 pp.

Harkness, J.S., G.S. Dwyer, N.R. Warner, K.M. Parker, W.A. Mitch, and A. Vengosh. Accepted 2014. Iodide, bromide, and ammonium in hydraulic fracturing and oil and gas wastewaters: environmental implications. Environmental Science and Technology.

Layzer, J.B. and K.R. Moles. 2009. Relationship between stream discharge and recruitment of the Cumberland Elktoe *Alasmodonta atropurpurea* (Rafinesque, 1831) and the Cumberland Papershell *Anadontoides denigrata* (Lea, 1852). Tennessee Cooperative Fishery Research Unit, Tennessee Tech University, Cookeville, TN. 33 pp.

McGregor, M.A. 2013. Personal communication to Rebecca Schapansky of the National Park Service. Cumberland elktoe survey results. (April 24, 2013).

McGregor, M.A. 2012. Quantitative assessment of the freshwater mussel population at three locations within the Big South Fork National River and Recreation Area in Tennessee. In association with Third Rock Consultants, Lexington, KY. 57 pp.

Price, J.E, C.E. Zipper, J.W. Jones, and C.T. Franck. 2014. Water and sediment quality in the Clinch River, Virginia and Tennessee, USA, over nearly five decades. Journal of the American Water Resources Association 1-22.

Wang, N., C.G. Ingersoll, J.L. Kunz, W.G. Brumbaugh, C.M. Kane, R.B. Evans, S. Alexander, C. Walker, and S. Bakaletz. 2013. Toxicology of sediments potentially contaminated by coal mining and natural gas extraction to the unionid mussels and commonly tested benthic invertebrates. Environmental Toxicology and Chemistry 32(1): 207-221.