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Distribution and Status of Freshwater Mussels (Bivalvia: Unionoidea) in the Cumberland River Basin Upstream from Cumberland Falls, Kentucky

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ABSTRACT

Freshwater mussels were sampled in the Cumberland River basin upstream from Cumberland Falls in southeastern Kentucky in 1987–1999 to determine their distribution and status. A total of seven species was found at 57 of 434 sampling sites compared to 11 taxa previously reported. *Alasmidonta atropurpurea* and *Anodontoides denigratus*, USFWS- and/or KSNPC-endangered species, are the most abundant taxa and exclusively inhabit tributaries. *Lampsilis ovata* was introduced from below the falls and is extirpated from the basin along with *Toxolasma parvus* and *Villosa lienosa*. We believe that records for *Strophitus undulatus* are based on misidentified *Alasmidonta atropurpurea* and *Anodontoides denigratus*. The Marsh Creek fauna is the richest and most abundant upstream from the falls, and it should be the focus of mussel conservation efforts in the basin.

INTRODUCTION

Despite considerable interest in the freshwater mussels of Kentucky's upper Cumberland River basin (e.g., Miller et al. 1984; Neel and Allen 1964; Schuster et al. 1989; Wilson and Clark 1914), little has been published regarding the fauna upstream from Cumberland Falls. Wilson and Clark (1914) and Neel and Allen (1964) each sampled six sites, all but one in the mainstem, and found a depauperate fauna totaling eight generally uncommon species (Table 1). Recent examination of 14 Cumberland River tributaries revealed mussels only in Marsh Creek and added *Alasmidonta atropurpurea* to the fauna (Call and Parmalee 1981; Harker et al. 1979, 1980; Layzer and Anderson 1992). Museum records for *Toxolasma parvus* and *Villosa lienosa* increase the fauna to 11 species, or ca. 15% of the taxa known from the basin below Cumberland Falls (Cicerello et al. 1991).

The basin above the falls has changed considerably since the work of Wilson and Clark (1914) and Neel and Allen (1964). Communities and infrastructure have expanded, and surface and underground coal mines occur throughout the watershed (Leist et al. 1982). Development has degraded water quality and aquatic communities throughout the basin and downstream from Cumberland Falls (Carter and Jones 1969; Cicerello and Laudermilk 1997; Harker et al. 1979; KDOW 1996). Nonetheless, this area contains many of Kentucky's highest quality streams (KDOW 1997), most of which have not been thoroughly sampled for mussels. We examined streams in the upper Cumberland River basin of Kentucky upstream from Cumberland Falls and museum collections to determine the distribution and status of the mussel fauna.

STUDY AREA

Located in the Appalachian Plateaus Physiographic Province in southeastern Kentucky and Tennessee, the study area encompasses 5120 km^2 of the upper Cumberland River basin in Kentucky extending from Cumberland Falls upstream to the southwest Virginia border (Figure 1). Cumberland Falls is a 17 m high barrier to the upstream movement of aquatic organisms that has receded ca. 72 km from its hypothesized original location near Burnside, Kentucky (McGrain 1966). The Big South Fork Cumberland, Rockcastle, and Laurel rivers and Buck Creek formerly discharged into the river above the falls, but now they enter between its hypothesized original and present locations. The Cumberland River is formed by the confluence of the Poor and Clover forks; it meanders westerly 212 km to the falls. Major tributaries are Marsh, Jellico, Stinking, Straight, and Yellow creeks and Clear and Martins forks. The headwaters of Marsh and Jellico creeks and Clear Fork are in Tennessee. Most streams have moderate to high gradients, clear water, and alternating

Table 1. Mussels collected from the Cumberland River system upstream from Cumberland Falls, following prevailing nomenclature.

1910–1911[1]	1947–1949[2]	1978–1980[3]	1987–1988[4]	This study and museum records
—	*Actinonaias pecterosa*	*A. pectorosa*	—	*A. pectorosa*
—	—	*Alasmidonta atropurpurea*	*A. atropurpurea*	*A. atropurpurea*
Alasmidonta minor	—	*A. viridis*	—	*A. viridis*
Anodontoides ferussacianus	—	—	*A. ferussacianus*	*A. denigratus*
—	*Lampsilis fasciola*	*L. fasciola*	*L. fasciola*	*L. fasciola*
Lampsilis ovata	—	—	—	—
—	*L. o. ventricosa*	*L. ventricosa*	—	*L. cardium*
Strophitis edentulus	—	—	—	—
Unio gibbosus	*Elliptio dilatatus*	*E. dilatatus*	*E. dilatata*	*E. dilatata*
—	—	—	—	*Toxolasma parvus*
—	—	—	—	*Villosa lienosa*

[1] Wilson and Clark (1914); [2] Neel and Allen (1964); [3] Harker et al. (1979, 1980) and Call and Parmalee (1981); [4] Layzer and Anderson (1992).

pools and riffles underlain with substrates ranging from exposed sandstone bedrock to mixed sand and silt. Mean annual discharge and 7-day 10-year low flow at Cumberland Falls are 89.7 m^3/s and 0.65 m^3/s, respectively; major tributaries such as Jellico and Stinking creeks have summer low flows of zero (Ruhl and Martin 1991; USGS 1993). The watershed is mountainous and land use is ca. 84% forest, 13% agriculture, 2.5% mining, and 0.5% urban and developed areas (MSE 1975). Williamsburg, Barbourville, Pineville, Middlesboro, and Harlan, the largest communities in the basin, have a combined population of less than 30,000. Although water quality is improving, many streams continue to be impacted by pollutants associated with coal mining, domestic waste, highway construction, and poor land use (Harker et al. 1980; KDOW 1996).

MATERIALS AND METHODS

We examined 434 upper Cumberland River basin sites for mussels in 1987–1999. All habitats at each site were sampled using a viewing bucket or while snorkeling during low flow when the water was clear. Mussel collections at the Academy of Natural Sciences of Philadelphia (ANSP), Eastern Kentucky University (EKU), Harvard University (MCZ), National Museum of Natural History (NMNH), Ohio State University Museum of Zoology (OSU), and University of Michigan Museum of Zoology (UMMZ) were examined. Species accounts are presented alphabetically following scientific names in Gordon (1995) and Turgeon et al. (1998). Cumberlandian regional endemics and Cumberland River endemics (Gordon 1995; Gordon and Layzer 1989; Ortmann 1924) are indicated. Each annotation includes collection site numbers (Appendix A) followed in parentheses by the number of specimens collected (L = living specimen(s), F = freshly dead, R = relic) during each sampling visit. Results for sites visited more than once are in chronological order. Terms used to summarize distribution follow Smith (1965) and include "generally distributed" (any suitable habitat should yield specimens with a reasonably thorough search), "occasional" (suitable-appearing habitat may or may not yield specimens even after prolonged search), and

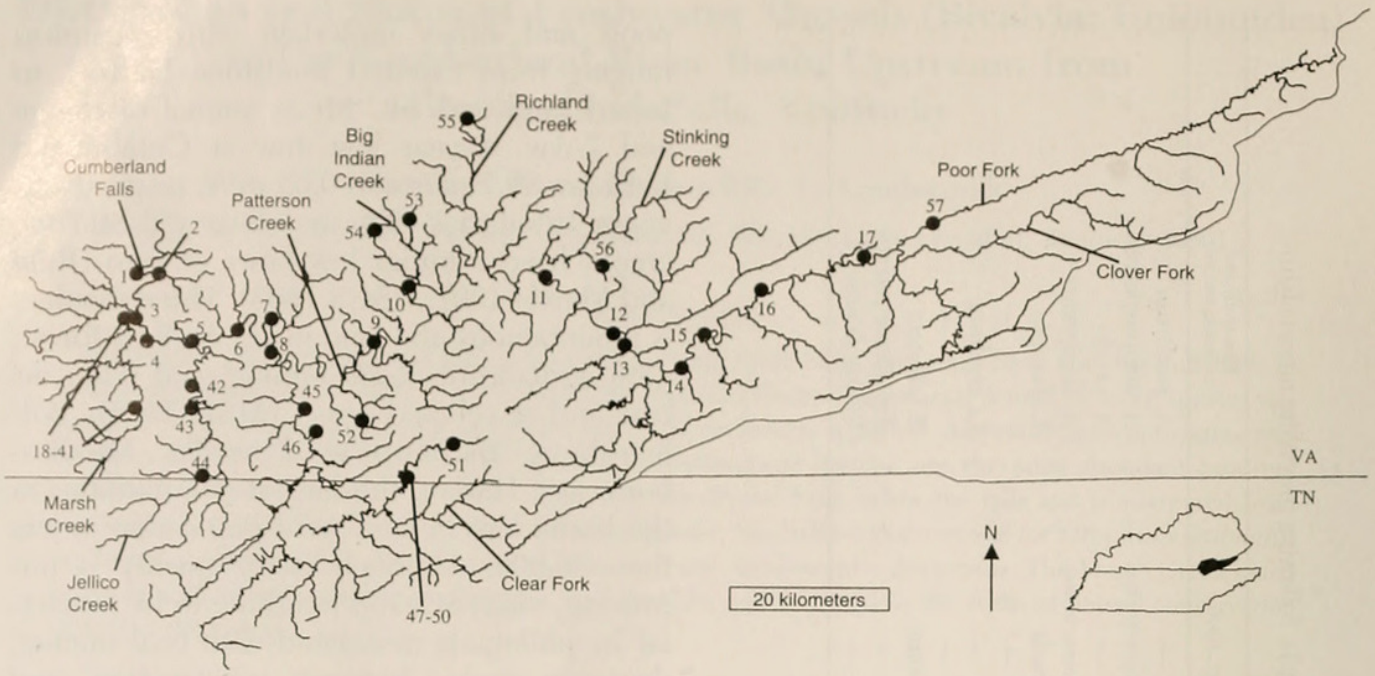

Figure 1. Freshwater mussel collection sites in the upper Cumberland River basin above Cumberland Falls, southeastern Kentucky, 1987–1999. Site numbers are referenced in Appendix A.

"sporadic" (encountering specimens cannot be predicted at all).

SPECIES ACCOUNTS

A brief discussion of the historical and present distribution and status of mussels reported upstream from the falls follows. Only generalized distributional information is presented for *Corbicula fluminea.*

Actinonaias pectorosa (Conrad). Pheasantshell. Cumberlandian regional endemic. Sites: 1(0; 19L, 3R; 16L); 2(8L); 3(14F; 1L); 4(1L); 5(7L); 6(1R); 7(1R); 8(1R); 9(1R); 10(1F); 11(1L, 1R; 1L, 1R); 13(1R; 0); 14(2 2/2R; 0); 16(1R); 18(1F); 19(8L, 1R; 7L, 1F, 1R; 4L, 3F); 20(8L, 1F); 21(3L); 22(1F); 23(1L); 46(1L). This is the most common species in the upper Cumberland River and lower Marsh Creek, where it is occasional to generally distributed; it is sporadic in Clear Fork. It inhabits sand among cobbles or boulders, and sand and coal fines in bedrock fractures. It was not collected by Wilson and Clark (1914), and Neel and Allen (1964) found only one specimen (near Williamsburg) which "appeared to be a recent immigrant."

Alasmidonta atropurpurea (Rafinesque). Cumberland elktoe. Cumberland River endemic. Sites: 19(5L, 3R; 0; 3L, 2R); 20(5L); 21(2L); 22(2L); 23(2L); 24(1L); 25(7L); 26(2L); 27(2L); 28(4L); 29(4L, 5F); 31(8L, 2F); 32(2L, 1R); 33(1L, 1F); 34(9 1/2R; 5L, 2F); 35(1L, 17F; 22L; several L; 5L; 42L); 36(0; 1L); 37(2L; 0); 38(1F); 39(1F); 40(1F); 47(0; 1L); 48(1L; 0; 0); 49(1L); 50(1L). Until recently, this mussel was synonymized under *A. marginata* (Call and Parmalee 1981; Clarke 1981). It historically inhabited the Cumberland River and its southern tributaries in Kentucky and Tennessee, including the Big South Fork of the Cumberland River, upstream from the hypothesized original location of Cumberland Falls near Burnside, Pulaski County, Kentucky (Gordon 1991; Gordon and Layzer 1993). It was not reported by Wilson and Clark (1914) or Neel and Allen (1964), but, as observed by Gordon (1991), historic records for *A. marginata* from the Cumberland River just above the falls, McCreary/Whitley counties (UMMZ 63954), and at Williamsburg, Whitley County (Clarke 1981, MCZ 224076), are *A. atropurpurea.* Downstream from the present falls location, it occurred in the Laurel River, Laurel County, (as *Strophitus undulatus*) (Neel and Allen 1964; UMMZ 172886), Lynn Camp Creek, Whitley County (Clarke 1981), and in the Big South Fork of the Cumberland River above Burnside, Pulaski County (as *A. marginata*) (Wilson and Clark 1914). Wilson and Clark's (1914) record for *A. mar-*

ginata from the Cumberland River near Burnside could be this species. This endangered mussel (KSNPC 1996; USFWS 1998) is sporadic in Laurel Fork of Clear Fork, and it is generally distributed and common in Marsh Creek, where it was discovered by Harker et al. (1980) and Call and Parmalee (1981). It also inhabits the Big South Fork of the Cumberland River, Kentucky and Tennessee, the Rockcastle River, where it occurs sympatrically with *A. marginata* (*contra* Gordon 1991; Gordon and Layzer 1993), and Rock Creek, Kentucky (Cicerello et al. 1991; Gordon 1991, EKU). It lives in sand and silt often among cobbles and boulders in relatively shallow pools and runs (Gordon and Layzer 1989).

Alasmidonta viridis (Rafinesque). Slippershell mussel. Sites: 19(0; 0; 1R); 22(1F); 23(1F); 27(1L); 28(4L); 33(1L); 47(1L; 1L); 48(0; 1R; 1R). Wilson and Clark (1914) collected specimens from the Cumberland River between the falls and Pineville and from the Clear Fork. Neel and Allen (1964) did not find this species and hypothesized that it was lost to acid coal mine drainage. This species is occasional in Marsh Creek, where it was discovered by Harker et al. (1980) and Call and Parmalee (1981), and it is sporadic in Laurel Fork, a Clear Fork tributary. In both streams, small numbers of this easily overlooked mussel inhabit sand or mixed sand, gravel, and silt near boulders.

Anodontoides denigratus (Lea). Cumberland papershell. Cumberland River endemic. Sites: 18(1R); 23(1L); 25(1L); 30(3L); 31(2L, 3F); 32(1L, 1F); 33(1L, 1R); 34(1F, 2 3/2R; 1L); 35(35L, 1F, 2R; 21F; 1L, 4 1/2F; 40L; 73L, 3F); 36(9L; 6L); 37(15L, 3F; 1R); 38(1L, 3F); 39(4F); 40(5L, 1F); 41(3L); 51(15L); 52(8L, 1R; 13L; 10L, 3F); 53(2L; 3L); 54(5L, 1F, 2R; 18L, 1F); 55(10L, 1F, 1/2R; 8L); 56(1R; 1L). This species was described by Lea (1852) and has been confused with *A. ferussacianus* and *Strophitus undulatus*. It is distinctive from the allopatric *A. ferussacianus* according to Gordon (1995), who is redescribing it. It is restricted to the upper Cumberland River on the Cumberland Plateau in Kentucky and Tennessee upstream from the original location of the falls (Gordon 1995). Historically, *A. denigratus* was collected from the Cumberland River at Pineville and Orby, Bell County (Ortmann 1918; Wilson and Clark 1914; UMMZ 105530) (as *A. ferussacianus*), and from the Clear Fork (UMMZ 66141) (as *S. undulatus*). Downstream from the present location of the falls, it is known from Lynn Camp Creek, Whitley County (UMMZ 105533) (as *A. ferussacianus*), and from the Laurel River, Laurel County (Neel and Allen 1964; UMMZ 172886) (as *S. undulatus*). Wilson and Clark's (1914) record for *A. ferussacianus* from the Clear Fork, Jellico, Tennessee, probably is this species (Gordon 1995). This species inhabits Marsh, Moore, Pine, and Rose creeks, Mills Fork, Billies Branch, Demps Hollow, and Rockcastle River tributaries in Kentucky (EKU, KSNPC), and Big South Fork of the Cumberland River tributaries in Tennessee (Gordon 1995). The best population of this endangered mussel (KSNPC 1996) is generally distributed in the middle segment of Marsh Creek, where it comprised 57% of 282 live mussels specimens collected in 1994. Its habitat is identical to that of *A. atropurpurea*, slowly flowing or still pools and runs underlain with silt and sand. It is locally abundant in Moore, Pine, and Rose creeks, Mills Fork, Billies Branch, and Demps Hollow, all first- and second-order streams inhabited only by *A. denigratus*.

Elliptio dilatata (Rafinesque). Spike. Sites: 8F(1F); 11(0; 1R); 19(5L, 1R; 1R; 1F); 20(1L, 2F); 21(1L); 24(1R); 26(1L); 42(1R); 43(1R); 44(1R); 45(1 1/2R). Historically, the spike was the most widely distributed and abundant species above the falls. Wilson and Clark (1914) collected specimens at all of their sampling sites and found that it comprised about 90% of the Clear Fork mussel population. In the late 1940s, it was the predominant species in the upper Cumberland (Neel and Allen 1964). Call and Parmalee (1981) considered the spike common in Marsh Creek, where Layzer and Anderson (1992) also noted its presence. The distribution and abundance of *E. dilatata* have declined greatly throughout the basin. It is sporadic in the Cumberland River, Jellico Creek, and Clear Fork, where we found mainly relic specimens, and relatively common only in lower Marsh Creek.

Lampsilis cardium Rafinesque. Plain pocketbook. Sites: 3(1F; 0); 11(1R; 0); 12(1F); 13(3 1/2R; 0); 14(0; 1L, 3 1/2R); 15(1F, 1R); 16(1R); 19(0; 1L, 1F; 1L, 1F); 20(1L); 22(1R); 23(1L); 24(1R); 35(1L; 0; 0; 0; 1L); 45(2L, 3

3/2R); 46(2L). The plain pocketbook is widely distributed but sporadic in the Cumberland River from the falls upstream to Harlan County, and in Marsh Creek, where it was collected by Harker et al. (1980) and Call and Parmalee (1981). It is sporadic in the Clear Fork, Whitley County. Marsh Creek supports the best population above the falls, but only seven living or freshly dead specimens were found at 21 sampling sites in 1994. It formerly was very abundant above and below the falls (Neel and Allen 1964), where Wilson and Clark (1914) failed to find specimens. The only records we found from above the falls that pre-date Neel and Allen (1964) are an undated Bryant Walker collection from the Cumberland River at Williamsburg, Whitley County (MCZ 46747), and collections made in 1941 and 1945 by Clark from the Cumberland River at Molus, Harlan County (MCZ 123966), and 5 miles east of Pineville (UMMZ 165273), respectively.

Lampsilis fasciola Rafinesque. Wavyrayed lampmussel. Sites: 1(1/2R; 0; 0); 9(1R); 10 (1R); 11(1L, 2R; 1/2F); 12(2 F); 13 (4R; 1R); 14(1 2/2R; 2L); 16(2/2F); 17(1L); 19(0; 1F, 1R; 2L); 20(1L); 22(1R); 46(1/2R); 48(0; 0; 2F); 57(1F). Although *L. fasciola* was not collected by Wilson and Clark (1914), Neel and Allen (1964) reported that it was very abundant. Call and Parmalee (1981) and Layzer and Anderson (1992) collected specimens from Marsh Creek. *Lampsilis fasciola* is widely distributed but sporadic in the Cumberland River, Poor Fork, Marsh Creek, and Clear Fork, where it inhabits sand and/or sand, pebbles, and gravel often near cobbles or boulders in shallow pools or runs.

Lampsilis ovata (Say). Pocketbook. Sites: none. Wilson and Clark (1914) collected a few dwarfed specimens from the Cumberland River and reported that *L. ovata* was transplanted into the river above the falls, possibly by pearl collectors (Neel and Allen 1964). This apparent effort to develop a commercially valuable stock failed. Now considered endangered in Kentucky (KSNPC 1996), *L. ovata* apparently has not been collected subsequently; it is considered extirpated from above the falls.

Strophitus undulatus (Say). Creeper. Sites: none. Wilson and Clark (1914) reported specimens from the Cumberland River at Pineville, collected by their collaborator J. F. Boepple, and from the Clear Fork, Tennessee. Neel and Allen (1964) listed it from the Cumberland River at Pineville and at Wallins (near Harlan), but stated that "[i]n the present survey only 4 forms occurred above the falls: *L. fasciola*, *L. ovata ventricosa* (=*L. cardium*), *E. dilatatus*, and *A. pectorosa*." We did not find *S. undulatus* and we were unable to locate specimens from the area for re-examination. Based on the following, we believe Wilson and Clark's (1914) records for *S. undulatus* from above the falls are actually *A. denigratus*. We re-identified two specimens of *S. undulatus* collected by Hubbs from the Clear Fork, Whitley County, (UMMZ 66141) as *A. denigratus*. Wilson and Clark (1914) and Neel and Allen (1964) also reported *S. undulatus* from the Rockcastle and Laurel rivers. Both *S. undulatus* and *A. denigratus* inhabit the Rockcastle River basin (KSNPC, MCZ), but we re-identified Neel and Allen's (1964) *S. undulatus* specimens from the Laurel River at Lily (UMMZ 172886) as *A. denigratus* and *A. atropurpurea*. Wilson and Clark (1914) noted that their *S. undulatus* specimens were "exceedingly variable and presented many puzzling forms," indicating difficulty in making identifications. Finally, the shell descriptions and the picture of *S. undulatus* in Wilson and Clark (1914) and Neel and Allen (1964) also could be interpreted as *A. denigratus*.

Toxolasma parvus (Barnes). Lilliput. Sites: none. Known from only one specimen collected by C. Goodrich from the Cumberland River northwest of Pineville, Bell County (UMMZ 99672). The lilliput can be overlooked because of its small size, but it probably is extirpated.

Villosa lienosa (Conrad). Little spectaclecase. Sites: none. A specimen collected by H.D. Athearn from the Cumberland River near Barbourville, Knox County, (HDA 13857) in 1966 is the only record of this rare Kentucky mussel (KSNPC 1996) from above the falls. This record is interesting because Richland Creek, a nearby tributary, lies in close proximity to Collins Fork, a Kentucky River tributary that supports one of Kentucky's largest *V. lienosa* populations (Cicerello pers. obs.). Geological evidence and fish distribution patterns identify this area as a stream capture theater, with probable multiple faunal exchanges between the drainages during recent

geological times (Burr and Warren 1986; Kuehne and Bailey 1961). Stream capture occurs when natural erosion cuts across a headwater drainage divide and a stream segment and its biota are diverted from one basin into another. *Villosa lienosa* is absent, extirpated, or rare in the adjacent Tennessee, Cumberland (below the falls), and Big Sandy rivers (Beetle 1973; Cicerello et al. 1991; Starnes and Bogan 1988), and it is tempting to invoke stream capture and transfer of its fish host from the Kentucky River drainage as the source of this highly localized record. However, even the most suggestive stream capture evidence may lead to invalid conclusions, and limited distributions may result from introductions rather than natural factors (Jenkins et al. 1971). The origin of *V. lienosa* is unclear; the species probably is extirpated.

INTRODUCED SPECIES

Corbicula fluminea (Müller). Asian clam. This introduced, exotic clam is the most common and widely distributed mussel above the falls. It inhabits the mainstem from the falls to near the headwaters of the Poor Fork, the lower half of Marsh Creek, Jellico Creek nearly to the Tennessee border, Clear Fork upstream into Mud Creek and Laurel Fork, Big Indian Creek including Mills Fork, lower Stinking Creek, and Martins Fork upstream to Martins Fork Lake. Densities exceed 100/m^2 in Marsh Creek.

DISCUSSION

We found a total of seven species, all living or freshly dead, at 57 of the 434 sites sampled (Table 1). With the exception of Marsh Creek and other streams inhabited by *A. denigratus*, mussels generally are sporadic and restricted to the mainstem Cumberland River and to the Clear and Poor forks. Species richness is greatest in Marsh Creek (7 species), Clear Fork (6), and the mainstem Cumberland River (4), and several streams support only one species (e.g., Big Indian, Jellico, Patterson creeks, and the Poor Fork). *Lampsilis fasciola* is the most widely distributed native species, inhabiting the Cumberland River from the falls upstream ca. 216 river km into Poor Fork, Marsh Creek, and Clear Fork.

Three species found mainly in tributaries comprised ca. 92% (613/667) of the living or freshly dead specimens encountered. *Anodontoides denigratus*, the most abundant species, is restricted to Marsh Creek, Clear Fork, and segments of Big Indian, Patterson, Richland, and Stinking creeks. *Alasmidonta atropurpurea* is found primarily in Marsh Creek, as is *A. pectorosa*, which lives also in the Cumberland River from the falls to above Yellow Creek. *Elliptio dilatata* and, to a lesser extent, *L. cardium* and *L. fasciola*, formerly were the dominant species in the mainstem Cumberland River (Neel and Allen 1964; Wilson and Clark 1914). Their decline in abundance is a result of persistent and varied water quality problems (Charles 1966; Jillson 1927; KDOW 1996, 1998).

Eleven species have been reported above the falls, but only as many as nine are native to the area. Specimens previously reported as *S. undulatus* probably were mis-identified *A. atropurpurea* and *A. denigratus*. *Lampsilis ovata* was introduced into the basin (Wilson and Clark 1914). *Toxolasma parvus* and *V. lienosa* each were collected only once from the basin and are considered extirpated from there.

Marsh Creek is the most important refuge for mussels in the upper Cumberland River basin. It is the most species-rich, and it supports the best populations of all mussels except *A. pectorosa*. More than 70% (471/667) of all living and freshly dead specimens we encountered were found in Marsh Creek. The presence of *Phoxinus cumberlandensis* (USFWS (1998) threatened species) and *Etheostoma nigrum susanae* (KSNPC (1996) threatened species), upper Cumberland River basin endemic fishes, increase the importance of Marsh Creek as an epicenter for recolonization of degraded streams throughout the basin.

We note several challenges to the protection of the biological diversity and integrity of Marsh Creek that also threaten other basin streams. Marsh Creek has relatively good water quality, but it is being impacted by silt from farms and inactive coal strip mines (KDOW 1996). A National Resources Conservation Service (formerly the Soil Conservation Service) proposal to remove the silt by channelizing upper Marsh Creek was rebuffed, but this proposal could resurface despite recommendations to identify and revegetate eroding

areas. Previously mined areas also could be remined to obtain formerly inaccessible or unprofitable coal deposits. The development of oil resources in uplands along the stream poses a renewed threat to the biota. A 1987 oil spill killed hundreds of *A. atropurpurea* and *A. denigratus* along an undetermined length of Marsh Creek (Cicerello pers. obs.). Finally, a 1965 United States Army Corps of Engineers proposal to construct a 24+ m high dam on the Cumberland River 1.6 km upstream from Cumberland Falls was revived in 1995 by local entities interested in hydroelectric generation and recreation. This project would embay the Cumberland River upstream into lower Marsh Creek and adversely impact the aquatic biota and water quality.

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APPENDIX A

Upper Cumberland River basin mussel collection sites in southeastern Kentucky listed by and within sub-basins from down- to upstream. Site numbers refer to numbers in Figure 1.

CUMBERLAND RIVER MAINSTEM: (1.) Just above Cumberland Falls. McCreary/Whitley cos. 28 Apr, 10 Sep 1987; 14 Sep 1995. (2.) Between Cumberland Falls and Ryans Branch. McCreary/Whitley cos. 30 Jul 1993. (3.) At Marsh Creek. McCreary/Whitley Cos. 3 Jul, 10 Aug 1993. (4.) Between Buck Shoals and Crow creeks. McCreary/Whitley cos. 10 Aug 1993. (5.) At Summer Shoals. Whitley Co. 29 Jul 1993. (6.) At Rough Shoals Creek. Whitley Co. 27 Jul 1994. (7.) At Interstate 75. Whitley Co. 27 Jul 1994. (8.) KY 296 at Williamsburg. Whitley Co. 27 Jul 1994. (9.) At Whetstone Creek. Whitley Co. 28 Jul 1994. (10.) Ca. 1 km downstream from Big Indian Creek. Knox Co. 30 Sep 1994. (11.) Ca. 1.9 km upstream from Stinking Creek. Knox Co. 14 Jul, 22 Sep 1993. (12.) At Pineville. Bell Co. 5 Aug 1993. (13.) Ca. 1.6 km downstream from KY 119. Bell Co. 2 Aug 1990; 29 Sep 1994. (14.) KY 1344 at Calvin. Bell Co. 10, 23 Sep 1993. (15.) At KY 987. Bell Co. 23 Sep 1993. (16.) At Minton Branch. Bell Co. 29 Jul 1994. (17.) At Fourmile Branch. Harlan Co. 8 Jun 1994. MARSH CREEK: (18.) Ca. 0.8 km upstream from mouth. McCreary Co. 10 Aug 1994. (19.) Ca. 0.2 km downstream from Brushy Creek. McCreary Co. 16 Aug 1989; 9, 18 Aug 1994. (20.) At Hens Nest Creek. McCreary Co. 10 Aug 1994. (21.) Ca. 2.7 km upstream from Hens Nest Creek. McCreary Co. 11 Aug 1994. (22.) Ca. 3.3 km upstream from Hens Nest Creek. McCreary Co. 11 Aug 1994. (23.) At trib. 3.6 km upstream from Hens Nest Creek. McCreary Co. 10 Aug 1994. (24.) At tributary ca. 1 km downstream from KY 679. McCreary Co. 3 Aug 1994. (25.) At KY 679. McCreary Co. 15 Aug 1989. (26.) At tributary ca. 0.5 km downstream from KY 679. McCreary Co. 3 Aug 1994. (27.) Ca. 0.4 km upstream from KY 679. McCreary Co. 3 Aug 1994. (28.) Ca. 0.5 km downstream from Laurel Creek. McCreary Co. 8 Aug 1994. (29.) Ca.

1 km downstream from Duck Run. McCreary Co. 9 Aug 1994. (30.) Ca. 0.2 km downstream from Taylor Branch. McCreary Co. 3 Aug 1994. (31.) At KY 478. McCreary Co. 30 Aug 1987. (32.) Ca. 0.3 km upstream from KY 478. McCreary Co. 11 Aug 1994. (33.) At Big Branch. McCreary Co. 12 Aug 1994. (34.) Downstream from Kidd School Road Ford. McCreary Co. 15 Aug 1989; 4 Aug 1994. (35.) Ca. 0.3 km upstream from Kidd School Road Ford. McCreary Co. 30 Aug 1987; 28 Apr 1993; 12 Jul 1994; 4, 17 Aug 1994. (36.) Ca. 0.5 km upstream from Kidd School Road Ford. McCreary Co. 4, 17 Aug 1994. (37.) Ca. 0.7 km downstream from KY 1044. McCreary Co. 2, 12 Aug 1994. (38.) Ca. 0.2 km downstream from KY 1044. McCreary Co. 2 Aug 1994. (39.) At KY 1044. McCreary Co. 18 Jul 1989. (40.) Ca. 0.1 km upstream from KY 1044. McCreary Co. 2 Aug 1994. (41.) Ca. 0.2 km downstream from Clear Creek. McCreary Co. 2 Aug 1994. JELLICO CREEK: (42.) Ca. 4.4 km downstream from KY 92. Whitley Co. 6 Jul 1994. (43.) Ca. 2.0 km downstream from KY 92. Whitley Co. 6 Jul 1994. (44.) Downstream from Shut-in Branch. McCreary Co. 12 May 1993. CLEAR FORK: (45.) At Tackett Creek. Whitley Co. 7 Jul 1994. (46.) At Buck Creek. Whitley Co. 7 Jul 1994. (47.) Laurel Fork at TN border. Whitley Co. 27 Jul 1993; 21 Sep 1996. (48.) Laurel Fork ca. 0.4 km upstream from TN border. Whitley Co. 27 Jul 1993; 11 Jan 1994; 26 Sep 1996. (49.) Laurel Fork ca. 0.7 km upstream from TN border. Whitley Co. 27 Jul 1993. (50.) Laurel Fork ca. 0.9 km upstream from TN border. Whitley Co. 27 Jul 1993. (51.) Pine Creek at KY 190. Bell Co. 28 May 1999. PATTERSON CREEK: (52.) Rose Creek ca. 0.2 km upstream from Patterson Creek. Whitley Co. 16 Jun, 15 Oct 1993; 22 May 1997. BIG INDIAN CREEK: (53.) Demps Hollow ca. 1.3 km upstream from Big Indian Creek. Knox Co. 21 Jul 1993, 20 May 1997. (54.) Mills Fork ca. 0.8 km upstream from Big Indian Creek. Knox Co. 21 Jul 1993, 21 May 1997. RICHLAND CREEK: (55.) Billies Branch ca. 3.2 km upstream from Richland Creek. Knox Co. 22 Jul 1993, 20 May 1997. STINKING CREEK: (56.) Moore Creek ca. 10.5 km NW Pineville. Knox Co. 28 Jan 1993, 21 May 1997. POOR FORK: (57.) 0.6 km upstream from Middleton Branch. Harlan Co. 24 May 1994.