

*Franklin County
Middle Fork
from 10/22/92 to 11/1/92
+
Perry State
SE in Albion, T.*

A SURVEY OF THE UNIONIDS (BIVALVIA: UNIONIDAE)
OF THE
ROCKCASTLE RIVER,
MIDDLE FORK TO BILLOWS, KENTUCKY

Ronald R. Cicerello

Kentucky State Nature Preserves Commission
407 Broadway
Frankfort, Kentucky 40601

Prepared for

United States Forest Service
Daniel Boone National Forest

Technical Report
February, 1993

TABLE OF CONTENTS

LIST OF TABLES ii

LIST OF FIGURES iii

ABSTRACT 1

INTRODUCTION 1

STUDY AREA 2

LITERATURE REVIEW 4

METHODS 6

RESULTS 6

SPECIES ACCOUNTS 9

 FEDERAL ENDANGERED SPECIES 9

 FEDERAL CANDIDATE SPECIES 10

 KENTUCKY STATE NATURE PRESERVES COMMISSION SPECIES . . 11

 OTHER SPECIES 13

 INTRODUCED SPECIES 19

DISCUSSION 19

ACKNOWLEDGMENTS 22

LITERATURE CITED 22

LIST OF TABLES

1.	Results of Rockcastle River unionid studies	5
2.	Rockcastle River collection sites, Jackson, Laurel, and Rockcastle counties, Kentucky, 1990-1992	7
3.	Freshwater unionids collected from the Rockcastle River during 1990-1992 by site	8
4.	Unionids found at Livingston during four collecting periods	20

LIST OF FIGURES

1. Rockcastle River collection sites, 1990-1992 3

ABSTRACT

The unionids of the Rockcastle River between the Middle Fork and Billows (Hwy 1956) were studied during 1992 to document the presence of species that are rare in the Daniel Boone National Forest, Kentucky, or nationally. Sampling at 27 sites resulted in the collection of 20 live species and three more as weathered-dry specimens. Two rare unionids, *A. marginata* and *V. trabalis*, were collected, but seven others that previously had been reported from the river were not found. Most members of the fauna are relatively common, but several apparently are declining. The Rockcastle River continues to support a diverse fauna and can play a prominent role in the recovery of rare unionids if pollution in the watershed can be controlled.

INTRODUCTION

Daniel Boone National Forest (DBNF) has some of the highest quality streams remaining in Kentucky. Big and Little South Forks of Cumberland River; Buck, Horse Lick, Marsh, and Rock creeks; and the Rockcastle River are some of the streams in DBNF that have formal state designations as wild rivers, outstanding resource waters, and/or high quality ecological/fishery resources (Kentucky Division of Water 1990, 1991; Kentucky Division of Water and National Park Service 1992). These streams are of central importance in efforts to conserve freshwater unionids such as *Alasmidonta atropurpurea*, *Epioblasma brevidens*, *E. capsaeformis*, *Pegias fabula*, *Pleurobema oviforme*, *Toxolasma lividus*, and *Villosa trabalis* that are rare in Kentucky as well as nationally (Cicerello et al. 1991; United States Fish and Wildlife Service (USFWS) 1991, 1992; Kentucky State Nature Preserves Commission (KSNPC) 1992), the unique Cumberlandian fauna, and the aquatic communities in which they live.

Although some information exists regarding the location of unionids in DBNF (Call and Parmalee 1981, Starnes and Bogan 1982, DiStefano 1984, Thompson 1985, Ahlstedt 1986, Schuster 1988, Schuster et al. 1989, Anderson et al. 1991, Layzer and Anderson 1992, KSNPC 1993), many streams have not been examined adequately or recently. Unionid distribution and status information for DBNF streams is needed by the United States Forest Service for wise resource management and to meet various legal mandates (National Environmental Policy Act of 1969, Endangered Species Act of 1973 as amended, National Forest Management Act of 1976 biodiversity requirements). The DBNF therefore established a Challenge Cost-Share Agreement with KSNPC in 1991 to conduct a unionid inventory of the Middle Fork Rockcastle River (Cicerello 1992). The Agreement was renewed in 1992 to provide information about the unionids in the Rockcastle River from the confluence of the Middle and South forks downstream to the Kentucky Highway (KY) 1956 bridge. The primary objectives were to document the presence of 1) Federal endangered or threatened species, 2) DBNF sensitive species, 3) KSNPC listed species, and 4) unique unionid assemblages.

STUDY AREA

The Rockcastle River is formed by the confluence of the Middle and South forks in west-central Jackson County (Fig. 1) and flows southwest 46.5 km (Bower and Jackson 1981) between Laurel and Jackson counties to the end of the study segment at Billows (KY 1956). From Billows downstream to the Lake Cumberland backwater, the Rockcastle River has been designated a Kentucky Wild River. At Billows, the river drains 1564 km², including the Middle and South fork drainages (588 km²). The stream flows perennially and has a 7-day 10-year low flow of 0.1 m³/s (3.5 ft³/s) (Ruhl and Martin 1991). Habitat consists of riffles, that are generally short (< 100 m), interspersed with long pools, and runs. Riffles are composed of substrate particles ranging from sand to boulders, and usually are bordered by bars or islands supporting *Justicia americana* beds. Limestone bedrock outcrops extensively in pools. Essentially the entire riparian zone is forested.

The watershed is highly dissected by streams that have cut steep-sided valleys with high cliffs and many rockshelters (Jillson 1928). Major tributaries include Eagle, Hawk, Horse Lick, Roundstone, and Skegg creeks, and Little Rockcastle River. Segments or tributaries of Little Rockcastle River and Roundstone Creek have been impounded to create Wood Creek Lake and Lake Linville, respectively. Narrow floodplains are the primary location of farms, dwellings, and primary (United States Highway (US) 25 and KY 89) and secondary roads. The Louisville and Nashville Railroad right-of-way also is located on or near the Rockcastle River floodplain, and Interstate Highway (I)75 and US 25 cross the Rockcastle River just downstream from the Little Rockcastle River confluence. Low water fords cross the river at several locations. These generally are used for access to farms, but Livingston ford provides access to dwellings and the city of London and is maintained by the city or county government. Livingston is located near the Roundstone Creek confluence with Rockcastle River, and other communities are situated on the watershed periphery in the Horse Lick Creek (Sandgap), Little Rockcastle River (East Bernstadt and London), South Fork Rockcastle River (East Bernstadt), Roundstone Creek (Mt. Vernon), and Middle Fork (McKee) drainages. Point discharges are generally associated with these communities, but several others from sources such as schools and coal mines also are scattered throughout the drainage.

Most of the area is underlain with sandstones, siltstones, conglomerates, coals, and shales of Pennsylvanian age Lee and Breathitt formations (Crowder 1963; Hatch 1963a, b; Gualtieri 1968, 1973; Schlanger and Weir 1971; Brown and Osolnik 1974). Lower Rockcastle River; upper Horse Lick, Roundstone, and Skegg creeks; and other streams in the drainage have down cut through Pennsylvanian age rocks and are entrenched in Mississippian age Newman Limestone and the Borden Formation. Many stream segments are underlain with Quaternary alluvium, and some, such as Horse Lick and Roundstone creeks, flow subterraneously. Thompson (1985) reviewed the geology of the area.

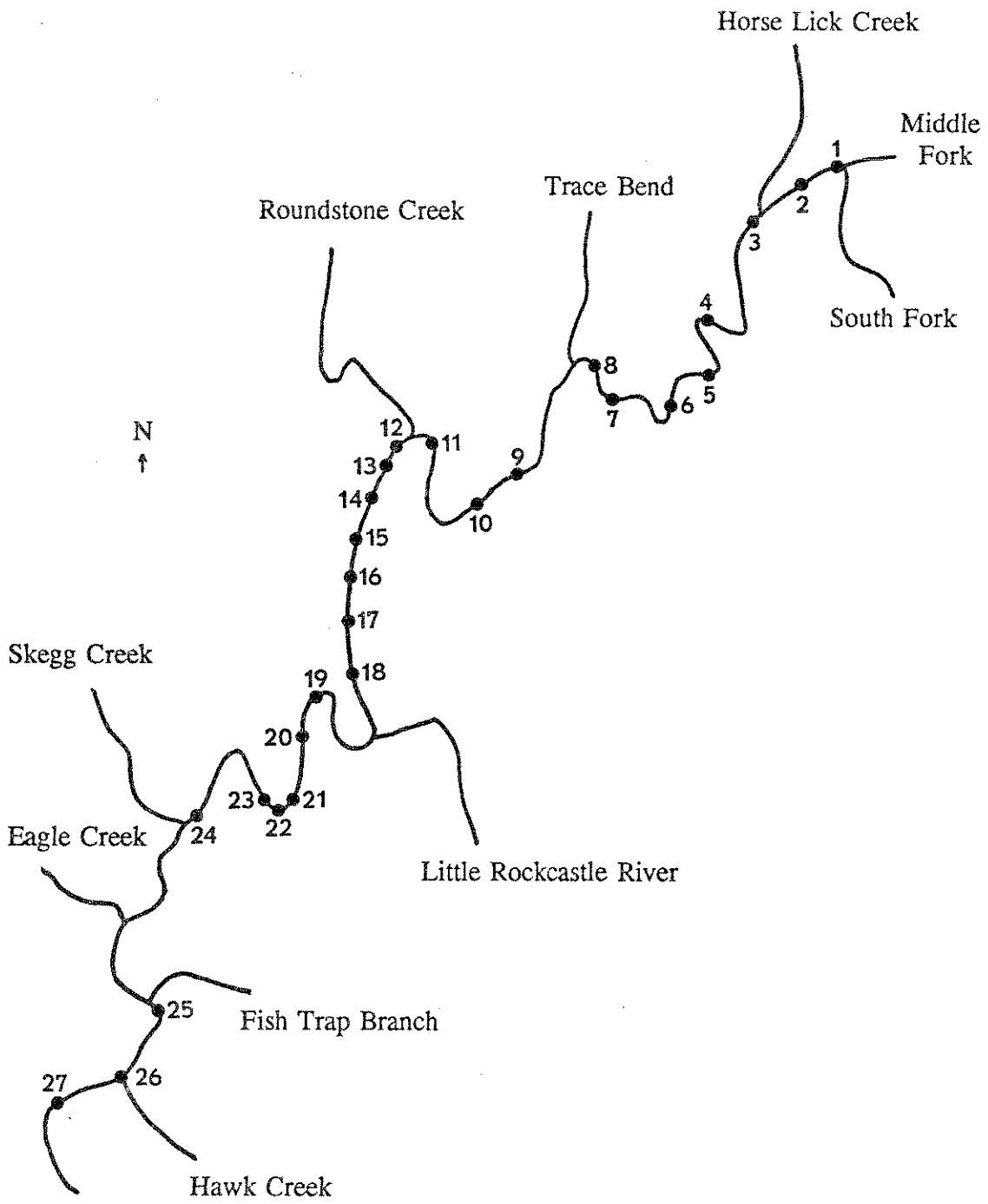


Figure 1. Rockcastle River collection sites, 1990-1992.

Limestone and coal are the principal mineral resources that have been developed in the watershed. Limestone suitable for road use and agriculture has been quarried at several sites. Coal has been mined at numerous sites throughout the watershed. Early mining was conducted underground through adits located along the river near Lameroy, Livingston, and downstream from US 25 (Brown and Osolnik 1974). Since about 1950, coal has been strip mined. Acid drainage and suspended solids from underground and surface mines have degraded sections of Raccoon Creek, Little Raccoon Creek, and South Fork in Laurel County (Mayes, Sudderth, and Etheredge, Inc. 1975). Other acid problems have been noted in Wood Creek, which is now impounded. This apparently has been a long-term problem because Woolman (1892) noted heavy silt loads, discolored water, and a total absence of aquatic life in the stream as early as 1890. Coal has been mined recently in the Middle Fork, Horse Lick Creek, Roundstone Creek, Skegg Creek, and at several locations along the Rockcastle River. Sediment from mines and quarries was identified as a significant pollutant in an inventory of the Rockcastle wild river segment (Soil Systems, Inc. 1979). Nonpoint sources throughout the drainage release bacteria, metals, nutrients, sediments, and sulfates that impact the Rockcastle River and several tributaries (Kentucky Division of Water 1992).

With the exception of the headwaters of Horse Lick, Roundstone and Skegg creeks; South Fork and Little Rockcastle rivers; Laurel Fork; and a segment of Rockcastle River downstream from South Fork, the watershed is completely within the DBNF proclamation boundary. Most of the watershed is forested, but cover estimates are not available. Logging occurs on private and public land throughout the watershed.

LITERATURE REVIEW

The first study of Rockcastle River unionids was published by Williamson (1905), who collected 16 species at Livingston, probably at the ford downstream from town (Table 1). Nearly every subsequent investigator of Rockcastle River unionids has sampled at this site. This was the only Rockcastle River drainage site visited by Wilson and Clark (1914) during an investigation of the distribution, relative abundance, habits, and commercial value of Cumberland River basin unionids. They found 18 species that "... were excessively abundant in the sand and clay patches here..." Although generally not of commercial value, "... the shell bed was markedly unlike any of those in the main [Cumberland] river, containing some species that were not found in the Cumberland at all [e.g., *Pegias fabula*], and others that were quite rare [e.g., *Medionidus conradicus*, *Strophitus undulatus*, *Pleurobema oviforme*]" (Wilson and Clark 1914). Neel and Allen (1964) collected 18 species from three Rockcastle River sites (near Ardery, above Livingston, and at Billows) during 1947-1949 in what was the last study of upper Cumberland River unionids prior to the impoundment of Lake Cumberland in 1950 (United States Army Corps of Engineers 1991). Blankenship and Crockett (1972) re-sampled the unionids of the Rockcastle at Livingston and compared their findings with those of Williamson (1905), Wilson and Clark (1914), and Neel and Allen (1964) to

Table 1. Results of Rockcastle River unionid studies.

	SOURCE								
	1905 ¹	1914 ²	1964 ³	1972 ⁴	1980 ⁵	1985 ⁶	1986 ⁷	1992 ⁸	1992 ⁹
<i>Actinonaias ligamentina</i>	-	-	-	X	X	X*	X*	-	X*
<i>Actinonaias pectorosa</i>	-	X	X	-	X	X*	X*	X	X*
<i>Alasmidonta marginata</i>	X	X	X	-	-	-	-	-	X*
<i>Amblema plicata</i>	-	X	X	X	X*	X*	X*	X*	X*
<i>Anodonta grandis</i>	-	-	-	-	-	-	-	-	X
<i>Cyclonaias tuberculata</i>	-	-	X	X	X	X*	X	X*	X*
<i>Elliptio dilatata</i>	X	X	X	X	X*	X*	X*	X*	X*
<i>Fusconaia subrotunda</i>	-	-	-	-	-	-	X*	-	-
<i>Lampsilis cardium</i>	X	-	X	X	X	X*	X*	X*	X*
<i>Lampsilis fasciola</i>	X	X	X	X	-	X*	X*	X	X*
<i>Lampsilis ovata</i>	-	X	-	-	-	-	-	X*	-
<i>Lasmigona costata</i>	-	X	X	X	X	X*	X*	X*	X*
<i>Leptodea fragilis</i>	-	-	-	-	-	X*	-	-	X*
<i>Ligumia recta</i>	X	X	X	X	X	X*	X*	X*	X*
<i>Medionidus conradicus</i>	X	X	X	-	-	X*	-	X	X*
<i>Pegias fabula</i>	X	X	-	-	-	-	-	-	-
<i>Pleurobema coccineum</i>	X	X	X	X	X	X*	-	X	X*
<i>Pleurobema oviforme</i>	X	X	-	-	-	X	-	-	-
<i>Potamilus alatus</i>	-	-	X	X	X	X*	X*	X	X*
<i>Potamilus ohioensis</i>	-	-	-	X	-	-	-	-	-
<i>Ptychobranchus fasciolaris</i>	X	X	X	X	X*	X*	X*	X*	X*
<i>Ptychobranchus subtentum</i>	X	X	-	-	-	X	-	-	-
<i>Quadrula cylindrica</i>	-	X	-	-	-	-	-	-	-
<i>Quadrula pustulosa</i>	-	-	-	X	X	X*	-	X	X*
<i>Strophitus undulatus</i>	X	X	X	-	-	X	-	-	-
<i>Toxolasma lividus</i>	X	-	-	-	-	X	-	-	X
<i>Tritogonia verrucosa</i>	X	X	X	X	-	X*	X*	X*	X*
<i>Truncilla truncata</i>	-	-	-	-	-	X	-	X	X
<i>Villosa iris</i>	-	-	X	-	-	-	X*	X	X*
<i>Villosa lienosa</i>	-	-	-	-	X	-	-	-	-
<i>Villosa taeniata</i>	X	X	X	-	X	X*	-	X*	X*
<i>Villosa trabalis</i>	X	-	X	X	X	X*	-	X*	X*
Total species	16	18	18	15	15	23	14	19	23

1. Williamson (1905); 2. Wilson and Clark (1914); 3. Neel and Allen (1964); 4. Blankenship and Crockett (1972); 5. Harker et al. (1980); 6. Thompson (1985); 7. Ahlstedt (1986); 8. Layzer and Anderson (1992); 9. this study. * = live or fresh-dead specimen(s).

document changes in the fauna. They found similar species richness but noted the loss of several species which they attributed to increased siltation from various land uses. Harker et al. (1980) collected 15 taxa from the Rockcastle at the mouth of Eagle Creek while locating and characterizing the best remaining streams in the Cumberland River basin. The most extensive examination of Rockcastle River basin unionids was completed by Thompson (1985), who found 23 species at 17 sites sampled within my project area. Two Rockcastle River sites (Livingston ford and Lamero) were examined by Ahlstedt (1986) during a status survey for *Pegias fabula*, now an endangered species (USFWS 1992). *Pegias fabula* was not found, but the Rockcastle sites yielded 14 species. While investigating the impacts of the coal industry on rare unionids, Layzer and Anderson (1992) found 19 species at four Rockcastle River sites, including Livingston ford. They noted reductions in the distribution of several endangered species and concluded that surface mining for coal is incompatible with the existence of rare, endemic aquatic organisms in the upper Cumberland River drainage.

METHODS

Freshwater unionids were collected from 27 sites on Rockcastle River (Table 2, Fig. 1) during September and October 1992. This information was supplemented with data collected in 1990 and 1991. All habitats at each site were sampled by hand. The primary focus was to find live unionids, but fresh-dead and some weathered-dry specimens also were collected. With the exception of a few difficult to identify individuals, living specimens were identified and tallied at each site and returned to the stream. Voucher specimens were deposited at Eastern Kentucky University (EKU) or retained at KSNPC (KNP) as reference material. Collection records were obtained from Harvard University Museum of Comparative Zoology (MCZ), Ohio State University Museum of Zoology (OSUMZ), and the University of Michigan Museum of Zoology (UMMZ). The nomenclature in this report follows Turgeon et al. (1988).

RESULTS

Twenty species were collected alive and three others as weathered-dry specimens from 27 sites sampled in the Rockcastle River (Table 3). Previous studies yielded a total of 32 species and museum records add two others (*Alasmidonta viridis* and *Elliptio crassidens*). (Thompson (1985) found 18 species alive among the total of 23 she located at 17 sites in the study area, and Neel and Allen (1964) collected 18 species at three sites in 1947-1949 (Table 1). *Elliptio dilatata*, *A. plicata*, *P. fasciolaris*, *V. taeniata*, and *L. cardium* were the most common and widely distributed species in 1992. *Elliptio dilatata* and *P. fasciolaris* were the most abundant taxa according to Neel and Allen (1964) and Thompson (1985), who indicated that *L. cardium* and *A. plicata* also were common and widely distributed. Five species were represented by only one or three living or weathered-dry specimens (*A. marginata*, *A. grandis*, *L. fragilis*, *T. lividus*, and *T.*

Table 2. Rockcastle River collection sites, Jackson, Laurel, and Rockcastle counties, Kentucky, 1990 - 1992.

Site	Location
1	immediately downstream from Middle Fork-South Fork. 23 Jul 1991, 10 Sep 1992.
2	1.5 km upstream from Horse Lick Cr. 10 Sep 1992.
3	0.3 km downstream from Horse Lick Cr. 15 Sep 1992.
4	unnamed trib 1.4 km NNE of KY 89-KY 490 jct at Lamero. 15 Sep 1992.
5	1.1 air km ENE from KY 89-KY 490 jct at Lamero. 15 Sep 1992.
6	immediately downstream from KY 490 bridge at Lamero. 9 Sep 1992.
7	mouth of Lawson Hollow. 15 Sep 1992.
8	mouth of Jason Branch. 5 Oct 1992.
9	1.0 stream km upstream from Jennings Hollow. 5-6 Oct 1992.
10	0.2 km downstream from Jennings Hollow. 9 Sep 1992.
11	unnamed trib 0.9 stream km upstream from Roundstone Cr. 6 Oct 1992.
12	0.2 km upstream from low water ford at Ford Hollow. 9 Sep 1992.
13	immediately downstream from low water ford at Ford Hollow. 3 Aug 1990, 9 Sep 1992.
14	1.5 km downstream from low water ford at Ford Hollow. 16 Sep 1992.
15	unnamed eastern trib 2 km downstream from ford at Ford Hollow. 16 Sep 1992.
16	island 3 km S of Livingston. 16 Sep 1992.
17	island 4.25 km S of Livingston. 16 Sep 1992.
18	5.25 km S of Livingston. 16 Sep and 6 Oct 1992.
19	unnamed northern trib 1.0 km upstream from I-75. 16 Sep 1992.
20	I-75 bridge. 31 Jul 1991, 18 Sep 1992.
21	unnamed southeastern trib 1.5 stream km downstream from I-75. 17 Sep 1992.
22	1.7 stream km downstream from I-75 bridge. 17 Sep 1992.
23	2.0 stream km downstream from I-75 bridge. 17 Sep 1992.
24	0.25 km upstream from Skegg Cr. 10 Sep 1992.
25	0.25 km downstream from Fish Trap Br. 7 Oct 1992.
26	mouth of Hawk Cr. 6 Oct 1992.
27	KY 1965 bridge. 7 Oct 1992.

Table 3. Freshwater unionids collected from the Rockcastle River during 1990-1992 by site. All specimens were collected alive unless denoted by F (fresh-dead) or W (weathered-dry). * = specimen sacrificed.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
<i>Actinonaias ligamentina</i>	5	6	1*	1	5	2	3	-	1	10	-	4	5	3	5	2	1	-	3	1	8	8	5	3	4	1	2
<i>Actinonaias pectorosa</i>	-	-	1*	-	2	5	-	2	2F	3	1	1W	-	-	2	-	-	-	-	1	1	2	1	-	7	13	6
<i>Alasmidonta marginata</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1*	-	-	-	-	-
<i>Ambleria plicata</i>	10	>15	40	25	>50	15	>25	4	15	8	4	1	2	5	6	7	3	-	8	30	36	19	4	>5	7	4	8
<i>Anodonta grandis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1W	-	-	-	-	-	-	-
<i>Cyclonaias tuberculata</i>	2	-	-	-	1	-	1	-	4	-	-	1	-	2	1	4	1	-	2	2	13	5	1	10	8	1	-
<i>Elliptio dilatata</i>	25	>100	45	50	>50	200	>50	11	10	40	13	15	15	>25	>30	>12	10	1	>60	15	30	60	15	50	40	17	30
<i>Lampsilis cardium</i>	6	7	1	1	4	5	2	-	3	6	1	3	2	5	6	4	3	-	18	8	11	7	3	3	10	4	10
<i>Lampsilis fasciola</i>	4	3	2	2	2	1	-	1	-	1F	-	1W	1	-	1	2	2F	-	2	1	4	5	2	2	4	-	5
<i>Lasmigona costata</i>	3	-	1	6	4	-	3	2	-	-	1	1W	-	1	-	2	1W	-	3	23	3	7	3	-	4	3	-
<i>Leptodea fragilis</i>	-	-	-	-	1	-	-	-	-	-	-	-	1*	-	-	-	-	-	-	-	-	1	-	-	-	-	-
<i>Ligumia recta</i>	1	2	1W	2	-	3	2	1W	1W	3	1W	4	3	1	1	2	F	1F	4	2	1	1	1	1	2	1W	-
<i>Medionidius conradicus</i>	-	-	1	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1W	-	-	-	-	-	-	-
<i>Pleurobema coccineum</i>	-	1	15	1	3	8	11	1	13	15	2W	1W	1	4	2F	1W	2W	-	1	2	1W	2	2	4	2	4	-
<i>Potamilus alatus</i>	2	4	6	8	>15	2	-	1W	1W	-	-	1W	1W	3	-	1	2W	-	3	3	7	5	1	-	1	1	3
<i>Psychobranchius fasciolaris</i>	9	25	7	20	>15	16	>12	8	4	20	9	4	1	11	6	4	2	-	15	7	12	25	5	>10	15	6	6
<i>Quadrula pustulosa</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	5	11	3	1	3	1	3
<i>Toxolasma lividus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1W	-	-	-
<i>Tritogonia verrucosa</i>	2	5	3	7	1	4	-	1W	-	1	-	-	-	-	-	-	-	-	-	-	1	1F	-	-	-	-	-
<i>Truncilla truncata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1W	-	-	-	-
<i>Villosa tris</i>	1F	1	-	-	3	-	1F	-	1	3	-	1	-	-	-	-	-	3F	1W	1	-	-	-	-	-	-	
<i>Villosa taeniata</i>	15	>15	8	4	>10	6	7	4	1W	15	1	1	-	1W	1W	2	1	23F	5	4	5	6	4	15	5	1W	5
<i>Villosa trabalis</i>	1F/1W	-	1/1F	2W	1W	-	-	2	1W	-	1W	3W	-	-	1,2W	1W	1/1W	1F	-	1W	1W	1W	1W	-	1W	1W	-
Total species alive/F	14	12	14	13	15	13	12	8	10	12	7	10	9	10	11	11	10	5	13	15	14	17	14	11	14	11	10
Total species	14	12	15	14	16	13	12	11	14	12	10	15	11	11	12	13	13	5	14	18	16	19	15	12	15	14	10

truncata). *Alasmidonta marginata* was last collected from the mainstem Rockcastle River in 1947-1949 by Neel and Allen (1964), who reported that it was rare. *Anodonta grandis* is a new record for the drainage. Two USFWS-listed or candidate taxa (1991, 1992) and a rare Kentucky unionid (KSNPC 1992) were collected. *Villosa trabalis*, a USFWS endangered species, was found alive or fresh-dead at several sites throughout the river. Only one weathered-dry *Toxolasma lividus*, a USFWS candidate for listing, was located. Two sites yielded specimens of *A. marginata*, which is considered threatened in Kentucky (KSNPC 1992). Faunal richness was greatest at site 22 where 17 taxa were collected alive or fresh-dead and two other species were represented by weathered-dry shells. However, site diversity was rather uniform except for a decline in diversity in the vicinity of Livingston. The Rockcastle River continues to support a relatively diverse freshwater unionid fauna that includes at least two rare species and several representatives of the unique though significantly diminished Cumberlandian fauna.

SPECIES ACCOUNTS

The following accounts give the distribution and status of each unionid species reported from the Rockcastle River study area. Accounts are presented alphabetically within each of four categories: federal endangered species, federal candidate species, KSNPC listed species, and other species.

FEDERAL ENDANGERED SPECIES

Pegias fabula (Lea, 1838). Little-wing pearlymussel.

I did not find any specimens of this Cumberlandian species. This unionid lives in small streams and is sometimes found completely buried in the substrate, wedged between or under cobbles and boulders, or lying on or partially in sand and gravel bottoms (Gordon and Layzer 1989). Such habitat is common in the Rockcastle River. The first drainage record was reported by Williamson (1905) from Livingston, where Wilson and Clark (1914) subsequently collected two specimens. In addition to weathered-dry specimens collected by D.H. Stansbery (OSUMZ) at Livingston ford in 1967 and Ahlstedt (1986) in the Middle Fork, living or fresh-dead specimens were found 8 km south of Livingston in 1963 and 4.5 km south of Livingston in 1964 by D.H. Stansbery and C. Stein (OSUMZ). As judged from these limited records, *P. fabula* was either a rare component of the fauna or had been greatly reduced in number and distribution early in this century. The lack of recent collections, including relict shells, suggests that *P. fabula* is now either extremely rare or, more likely, extirpated from the river. The potential exists for *P. fabula* to recolonize the Rockcastle River because Horse Lick Creek, a headwater tributary, supports perhaps the largest extant population (J. Layzer pers. comm.).

Villosa trabalis (Conrad, 1834). Cumberland bean.

The first Rockcastle River record for the Cumberland bean was collected by Williamson (1905) at Livingston. During 1947-1949, Neel and Allen (1964) examined the river near the Middle Fork, above Livingston, and at Billows and reported that it was common at each site. D.H. Stansbery et al. (OSUMZ) made collections at several sites during the 1960's, some of which provide a glimpse of the former abundance of the Cumberland bean in the Rockcastle. At Billows, 25 living and 39 fresh-dead specimens were collected in 1963. During 1963 and 1964, a total of 68 fresh-dead specimens were found at the ford at Livingston. Finally, in 1964, 39 fresh-dead specimens were collected about 6 km upstream from Livingston, and 30 living specimens were collected about 7.2 km downstream from Livingston. As recently as 1967, Stansbery (OSUMZ) collected three living and four fresh-dead Cumberland bean specimens at Livingston. And in 1969, he found two living and three fresh-dead specimens 4 km south of Livingston.

Recent efforts have been far less successful. Thompson (1985) found shells throughout the study segment, but live individuals were located at only six sites, and multiple specimens (3) were found only at Trace Branch. Single live specimens were found at Billows in 1985 or 1986 (R. Houpp pers. comm.) and near the mouth of Skegg Creek in 1990 (KNP). Layzer and Anderson (1992) collected six live specimens at unspecified sites between Lamero and Livingston. During this study, living or fresh-dead specimens were found at six of the 27 sites examined. Site 8 at the mouth of Jason Branch produced two specimens, but the other sites each yielded only one. Weathered-dry specimens were found at 12 additional sites. Live specimens generally were found away from the main current at the head of islands or near bars in mixed gravel and sand, and sometimes near cobble or boulders. An additional fresh-dead specimen was found at the mouth of Hawk Creek (site 26) in November 1992 (EKU). Layzer and Anderson (1992) hypothesized that during certain periods, the Cumberland bean lives completely buried in the substrate. During these periods, specimens are difficult to find and could be more vulnerable to adverse impacts from excess siltation. While this behavior could affect the results of field surveys and status assessments, the Cumberland bean is clearly far less abundant than during the 1960's and persists at low numbers at sites throughout the river.

FEDERAL CANDIDATE SPECIES

Pleurobema oviforme (Conrad, 1834). Tennessee clubshell.

The last living specimens collected from the river were reported by Williamson (1905) and Wilson and Clark (1964) (as *P. clava*) from Livingston. Only a few weathered-dry specimens have been collected subsequently (Thompson 1985, OSUMZ), suggesting that the Tennessee clubshell is either extremely rare or extirpated from the

river. This endangered Kentucky unionid (KSNPC 1992) and USFWS (1991) category 2 candidate for listing inhabits flowing water in the vicinity of riffles in small to large rivers (Gordon and Layzer 1989). In the Rockcastle River drainage, this Cumberland species is known to persist only in Horse Lick Creek (DiStefano 1984, Layzer and Anderson 1992) and possibly in Middle Fork (Cicerello 1992).

Toxolasma lividus (Rafinesque, 1831). Purple lilliput.

This small unionid generally lives in or near riffles in small streams to medium-sized rivers (Watters 1988, Gordon and Layzer 1989). The purple lilliput is classified as a category 2 candidate for listing by the USFWS (1991) and as endangered by KSNPC (1992). With the exception of Horse Lick Creek, all Rockcastle River drainage collection records for living or fresh-dead *T. lividus* are from Livingston. Williamson (1905) collected specimens there in 1904, and OSUMZ personnel made the remaining collections in 1963 (22 fresh-dead), 1964 (4 living), and 1967 (1 fresh-dead)(OSUMZ). All other drainage records, including the specimen found at site 24, are weathered-dry specimens (Thompson 1985, Cicerello 1992, KSNPC 1993, ECU, OSUMZ). Other workers (Ahlstedt 1986; Layzer and Anderson 1992; E.L. Lauder milk pers. comm.) recently examined the Rockcastle River without finding specimens. In streams such as Buck Creek, Horse Lick Creek, and Little South Fork Cumberland River that continue to support populations of *T. lividus* (Schuster et al. 1989, Anderson et al. 1991, Layzer and Anderson 1992, KSNPC 1993), a diligent search in appropriate habitat usually will reveal fresh-dead specimens (pers. obs.). However, even weathered-dry specimens are difficult to find in the Rockcastle River and Middle Fork (Cicerello 1992). These findings suggest that *T. lividus* has been lost from the Rockcastle River and Middle Fork.

KENTUCKY STATE NATURE PRESERVES COMMISSION SPECIES

Alasmidonta marginata Say, 1818. Elktoe.

Single specimens of this KSNPC (1992) threatened unionid were collected from sand mixed with gravel and some cobble in moderate to swiftly flowing, shallow (<0.3 m) water near the heads of riffles at sites 9 and 22. *Alasmidonta marginata* previously had been collected from the Rockcastle River at KY 80 (KY 1965) (Clarke 1981, OSUMZ), several km south of Livingston (UMMZ), and at or near Livingston (Williamson 1905, Wilson and Clark 1914, Neel and Allen 1964, OSUMZ), but all these collection were made prior to 1964 (KSNPC 1993). Subsequent Rockcastle River unionid studies did not yield specimens (Blankenship and Crockett 1972, Thompson 1985, Cicerello 1992, Layzer and Anderson 1992). In addition to the Horse Lick Creek population (DiStefano 1984, Layzer and Anderson 1992), the Little South Fork Cumberland River supported the only additional extant population in the upper Cumberland River drainage in Kentucky (Starnes and Bogan 1982, KSNPC 1993). However, pollution from strip mines has caused a recent catastrophic decline in the Little

South Fork unionid fauna, including *A. marginata* (Anderson et al. 1991). This lends considerably more importance to the Horse Lick Creek and Rockcastle River population(s).

Fusconaia subrotunda (Lea, 1831). Long-solid.

The only study area record is based on two living specimens collected at Lamero in 1985 by Ahlstedt (1986). The specimens were returned to the river and no vouchers are available. An additional Rockcastle River drainage record was reported by Neel and Allen (1964). They found that the long-solid was common near the mouth in 1947-1949 and present in the mainstem Cumberland River and tributaries below the Falls. However, these populations were extirpated by the impoundment of the Cumberland River (Thompson 1985, Cicerello et al. 1991). Ahlstedt's (1986) record is questionable and this threatened Kentucky unionid (KSNPC 1992) probably has been extirpated from the Rockcastle River.

Lampsilis ovata (Say, 1817). Pocketbook.

Only two records are available for this KSNPC (1992) endangered species. In 1911, Wilson and Clark (1914) collected three specimens at Livingston. Layzer and Anderson (1992) reported finding at least one living specimen at Billows, but retained no voucher specimens. Anderson (pers. comm.) suggested that the identification of the latter specimen is questionable because of the similarity to the closely related *L. cardium*, which is common in the river. The pocketbook inhabits a range of substrate types and current regimes in medium to large-sized rivers (Gordon and Layzer 1989). It has not been collected in the upper Cumberland River drainage since Neel and Allen's (1964) collections in 1947-1949, and is believed extirpated from the region.

Ptychobranhus subtentum (Say, 1825). Fluted kidneyshell.

The fluted kidneyshell is a threatened Kentucky unionid (KSNPC 1992) that is uncommon throughout the Cumberlandian region of Kentucky (Cicerello et al. 1991). The first Rockcastle River record was reported by Williamson (1905) from Livingston, the site of subsequent collections by Wilson and Clark (1914)(four specimens in 1911), and C.B. Stein (OSUMZ)(one apparently weathered-dry specimen in 1963). Thompson (1985) found the last Rockcastle River specimen, "...one relict shell in good condition. taken from the mouth of Hawk Creek..." The fluted kidneyshell persists in Horse Lick Creek (DiStefano 1984, Layzer and Gordon 1992), and a small population apparently is present in the Middle Fork (Ahlstedt 1986, Cicerello 1992, Layzer and Anderson 1992). No specimens were collected during this study, and the fluted kidneyshell may be extirpated from the Rockcastle River mainstem. According to Bogan and Parmalee (1983), specimens of this Cumberlandian species should be sought in shallow riffles with moderate to swift currents and sand, gravel, and cobble substrates in small to medium-sized rivers.

Quadrula cylindrica (Say, 1817). Rabbitsfoot.

A single specimen collected by Wilson and Clark (1914) at Livingston in 1911 is the only Rockcastle River drainage record. This endangered Kentucky unionid (KSNPC 1992) probably has been extirpated from the Rockcastle River and the entire upper Cumberland River drainage. Neel and Allen (1964) collected the last upper Cumberland River drainage specimens from the Cumberland River in 1948, just prior to the closure of Wolf Creek Dam in 1950 (United States Army Corps of Engineers 1991). In small rivers such as the Rockcastle, the rabbitsfoot has been found laying on the bottom in slack water (Watters 1988) and in gravel and cobble bars near swift currents (Gordon and Layzer 1989).

Villosa lienosa (Conrad, 1834). Little spectaclecase.

In 1986, a single weathered-dry specimen was collected about 2 km SSE of Livingston by G.T. Watters (OSUMZ). The only additional drainage record is a weathered-dry specimen from the wild river segment collected in 1979 (Harker et al. 1980, OSUMZ). This unionid is listed as of special concern in Kentucky (KSNPC 1992) and lives in small to large-sized rivers under a variety of current and substrate conditions (Gordon and Layzer 1989). It is rare throughout the upper Cumberland River drainage (Cicerello et al. 1991), and is either extremely rare in the Rockcastle River drainage or, more likely, has been extirpated from the drainage.

OTHER SPECIES

Actinonaias ligamentina (Lamarck, 1819). Mucket.

The mucket was moderately abundant, occurred in a variety of habitats, and was distributed throughout the study area.

Actinonaias pectorosa (Conrad, 1834). Pheasantshell.

Studies conducted during the first half of this century by Wilson and Clark (1914) and Neel and Allen (1964) indicated that the pheasantshell was common to very abundant. Thompson (1985) found specimens throughout the river, but reported that it was rare. She also collected relatively few living specimens. During this study, the pheasantshell was found at about half of the sites examined, but generally only one or two specimens were found at each site. This Cumberlandian species appears to be less common than it was prior to 1950. It generally occurred in association with but was less common than the mucket.

Alasmidonta viridis (Rafinesque, 1820). Slippershell mussel.

This unionid typically lives in small headwater streams, but occasionally is found in larger rivers (Gordon and Layzer 1989). In addition to Horse Lick and Middle Fork (Thompson 1985, Cicerello 1992, Layzer and Anderson 1992), *A. viridis* is known from one specimen collected at Livingston by D.H. Stansbery in 1964 (OSUMZ).

Amblema plicata (Say, 1817). Threeridge.

Amblema plicata was found at all but one site and was second in abundance only to *E. dilatata*. Specimens were found in habitats ranging from swift riffles underlain with gravel and cobble to backwaters with little or no flow, and silt, mud, and sand substrates. Neel and Allen (1964) reported that *A. plicata* was very common in the Rockcastle, and Thompson (1985) also found that it was widespread and common, especially in riffles with sand and gravel substrates.

Anodonta grandis Say, 1829. Giant floater.

A weathered-dry specimen collected at site 20 is the first record for the Rockcastle River drainage. Within the upper Cumberland River drainage, the only additional collections are from the Little South Fork Cumberland River (Schuster 1988, MCZ). Although *A. grandis* typically inhabits low gradient streams and wetlands with mud, sand, and/or gravel bottoms, and sometimes vascular plant beds or detritus, rocky streams with current also are inhabited (Watters 1988, Gordon and Layzer 1989). This adaptable unionid is able to colonize reservoirs (Kessler and Miller 1978) and probably is invading the Rockcastle River. It likely is more common in Lake Cumberland and the lower impounded section of the Rockcastle River than formerly thought (Cicerello et al. 1991).

Cyclonaias tuberculata (Rafinesque, 1820). Purple wartyback.

The purple wartyback has been collected by every Rockcastle River unionid investigator starting with Neel and Allen (1964). They reported that it was common to abundant at three sites examined between the Middle Fork and Billows. Thompson (1985) found living specimens at only two sites and considered it rare and in precarious condition. I found specimens at two-thirds of the sites examined, with occurrences increasing downstream. This unionid is moderately common in the Rockcastle River and Kentucky (Cicerello et al. 1991).

Elliptio crassidens (Lamarck, 1819). Elephant-ear.

A single weathered-dry specimen collected in 1986 by G.T. Watters (OSUMZ) about 2 km SSE of Livingston is the only record for the study area. Additional specimens have been collected near the mouth of the river, where it was common (Neel

and Allen 1964), at the Narrows, where Thompson (1985) reported it was rare, from Horse Lick Creek (DiStefano 1984), and from the wild river segment, where a live specimen was observed in 1987 (KNP). Although usually considered a large river unionid, the elephant-ear also lives in gravel, cobble, and boulder substrates in the lower segments of medium-sized rivers (Gordon and Layzer 1989). This unionid is a rare component of the lower Rockcastle River fauna that occasionally occurs in the upper drainage. The Rockcastle River population is important because the only records for live or fresh-dead specimens from the upper Cumberland River drainage in Kentucky are single collections from the Big South Fork Cumberland River and the Cumberland River below the falls (KNP).

Elliptio dilatata (Rafinesque, 1820). Spike.

As observed by Neel and Allen (1964) and Thompson (1985), this is the most ubiquitous and abundant unionid in the study area. Thompson (1985) found more than 20 specimens in sandy gravel deposits in slow to moderately fast riffles. In 1992, four sites with similar habitat yielded several times as many specimens.

Lampsilis cardium (Rafinesque, 1820). Plain pocketbook.

As noted by Neel and Allen (1964) and Thompson (1985), this is among the most abundant and widely distributed species in the Rockcastle River.

Lampsilis fasciola Rafinesque, 1820. Wavy-rayed lampmussel.

In the late 1940's, Neel and Allen (1964) found that the wavy-rayed lampmussel was widespread and common. Thompson (1985) also observed that it was widespread, but usually present in low numbers. The same was true in 1992, but specimens were slightly more common in the lower section of the river than reported by Thompson (1985). Specimens were usually deeply buried in sand, gravel, and cobble in the vicinity of riffles.

Lasmigona costata (Rafinesque, 1820). Fluted-shell.

Wilson and Clark (1914) and Neel and Allen (1964) considered the fluted-shell to be an abundant to common member of the fauna. Thompson (1985) found that it was widespread but rare. During this study, the fluted-shell was collected at more than half of the sites and was moderately common. Specimens were generally found in muddy-clay to sand and gravel along stream margins or where current velocity was reduced.

Leptodea fragilis (Rafinesque, 1820). Fragile papershell.

Prior to 1980, records for *L. fragilis* were limited to collections from upstream of Livingston (OSUMZ) and from the ford at Livingston (EKU, OSUMZ). Thompson

(1985) subsequently found living specimens at five sites and shells at four others, and considered this unionid rare in the Rockcastle. In 1992, single specimens were found in areas with slack water and soft substrates at three widely separated sites (5, 13, and 22). This habitat is common throughout the river and was examined. However, the fragile papershell is relatively rare in the Rockcastle River and specimens probably were missed at some sites.

Ligumia recta (Lamarck, 1819). Black sandshell.

As noted by Wilson and Clark (1914), Neel and Allen (1964), and Thompson (1985), the black sandshell is present throughout the river. Whereas Neel and Allen (1964) and Thompson (1985) reported that it was common to abundant, I found, as did Wilson and Clark (1914), that it was not abundant. This habitat generalist (Gordon and Layzer 1989) either was overlooked in 1992 or is less common today than reported previously.

Medionidus conradicus (Lea, 1834). Cumberland moccasinshell.

Historically, the moccasinshell was widely distributed and abundant in the Rockcastle River. At Livingston, Wilson and Clark (1914) reported that specimens almost covered the bottom and were exceedingly abundant. Neel and Allen (1964) also found that it was common to abundant at Livingston and throughout the Rockcastle drainage. This Cumberlandian species remained common in the river into the 1960's. In 1964, D.H. Stansbery (OSUMZ) collected 29 living specimens from the river about 4.5 km south of Livingston. At Livingston ford, he collected 28 living or fresh-dead specimens in 1963 and 23 in 1967. Recent surveys indicate that the distribution and abundance of the Cumberland moccasinshell in the Rockcastle River has declined. Blankenship and Crockett (1972) attributed its disappearance from Livingston to increased siltation. Among subsequent collectors, only Thompson (1985) secured living or fresh-dead specimens. She found one living specimen at a site upstream from Livingston. I found one or two specimens, generally under or among cobbles or boulders, at four upper Rockcastle sites (3-6), but none at Livingston and only one weathered-dry elsewhere. The Cumberland moccasinshell persists in Horse Lick Creek and Middle Fork (DiStefano 1984, Cicerello 1992, Layzer and Anderson 1992), but, as noted by Thompson (1985), it apparently has undergone a significant decline in range and abundance in the Rockcastle River.

Pleurobema coccineum (Conrad, 1834). Round pigtoe.

Despite finding specimens throughout the mainstem Rockcastle, Thompson (1985) found living *P. coccineum* at only three sites. She suggested that it was less abundant than in the 1940's, when Neel and Allen (1964) reported that *P. coccineum* reached maximum concentrations in the Rockcastle River. During this study, the round pigtoe was widely distributed and relatively common. Living or fresh-dead specimens were

found at two-thirds of the sites examined, and it was among the most common species at sites 3, 9, and 10. As reported by Gordon and Layzer (1989), the round pigtoe is often deeply buried in sand, gravel, and cobble riffles.

Potamilus alatus (Say, 1817). Pink heelsplitter.

After finding the first specimen of this common Kentucky unionid at Livingston, Blankenship and Crockett (1972) reported that the range of the pink heelsplitter was expanding up the Rockcastle River following the impoundment of the Cumberland River. Wilson and Clark (1914) and Neel and Allen (1964) had collected specimens upstream only as far as Billows (site 27), where it was common. Thompson (1985) extended the range upstream into the headwaters, and found that the heelsplitter was common to abundant at several Rockcastle River sites. I found that *P. alatus* was distributed throughout the river and moderately common.

Potamilus ohiensis (Rafinesque, 1820). Pink papershell.

Blankenship and Crockett (1972) reported an unvouchered collection from Livingston that Thompson (1985) suggested may have been *L. fragilis*. The only additional drainage record is from near the mouth of the river, where Neel and Allen (1964) found that *P. ohiensis* was rare. This lake and reservoir tolerant species (Gordon and Layzer 1989) is present in upper Lake Cumberland (KNP) and may persist in the lower impounded segment of the Rockcastle River.

Ptychobranhus fasciolaris (Rafinesque, 1820). Kidneyshell.

Third in abundance behind only *E. dilatata* and *A. plicata*, this common Kentucky unionid was found at all but one site. Neel and Allen (1964) and Thompson (1985) also found that it was abundant in the Rockcastle River.

Quadrula pustulosa (Lea, 1831). Pimpleback.

The first drainage record for the pimpleback was collected by Blankenship and Crockett (1972) at Livingston in 1968. They attributed this range extension to habitat changes resulting from the impoundment of the Cumberland River at Wolf Creek Dam. Thompson (1985) found specimens at several additional sites, where the pimpleback was rare, and extended the known range into Middle Fork. In 1992, specimens were found only in the lower end of the study area, but at two sites (21 and 22) the pimpleback was relatively common.

Strophitus undulatus (Say, 1817). Squawfoot.

As judged from the limited number of drainage records and specimens collected (Williamson 1905, Wilson and Clark 1914, Neel and Allen 1964, Thompson 1985,

OSUMZ), the squawfoot is a rare member of the Rockcastle River unionid fauna. Thompson (1985) collected the last specimens and suggested that previous workers had overlooked the squawfoot at some sites because of its rarity. This unionid inhabits creeks to large rivers, but is most abundant in smaller rivers (Gordon and Layzer (1989), such as Horse Lick Creek and Middle Fork (Cicerello 1992, Layzer and Anderson 1992). With increasing stream size, it also has a tendency to live in deeper water (Gordon and Layzer 1989).

Tritogonia verrucosa (Rafinesque, 1820). Pistolgrip.

The pistolgrip has been collected by all investigators of Rockcastle River unionids, except Harker et al. (1980). Neel and Allen (1964) reported that it was quite abundant in 1947-1949. Thompson (1985) found that it was widespread but less abundant in 1982-1985. Its 1992 distribution and abundance were similar to that found by Thompson (1985), except that it was less common downstream from Livingston in 1992.

Truncilla truncata Rafinesque, 1820. Deertoe.

A single weathered-dry specimen was found at site 22, and additional weathered-dry *T. truncata* have been collected in the study area by Thompson (1985), Layzer and Anderson (1992), and D.H. Stansbery (OSUMZ). Fresh-dead specimens collected from downstream of Livingston in 1969 (OSUMZ) and 1981 (KNP) suggest that the deertoe may persist in very low numbers in the Rockcastle River. However, the deertoe is slowly vanishing from the entire upper Cumberland River system in Kentucky (Cicerello et al. 1991, KSNPC 1993), as these are the only records for the drainage since Neel and Allen's (1964) collections in 1947-1949.

Villosa iris (Lea, 1829). Rainbow.

As judged from collection records, the rainbow has always been rare or perhaps difficult to find in the study area, with most specimens coming from the upper section of the river. According to Neel and Allen (1964), it was rare in the upper river in 1947-1949. Stansbery et al. (OSUMZ) collected 13 living or fresh-dead specimens at or near Livingston ford between 1964 and 1967, and an additional fresh-dead specimen at Billows in 1963. Ahlstedt (1986) found a single living specimen at Lamero. During this study, the rainbow was collected from several sites upstream from Livingston and two downstream. These generally were found in mud or sand and gravel under flat boulders. The rainbow inhabits riffles with various substrates in creeks to medium-sized rivers (Gordon and Layzer (1989). It is widely distributed in Horse Lick Creek (DiStefano 1984, Layzer and Anderson 1992) and the Middle Fork (Thompson 1985, Cicerello 1992), and extends down Rockcastle River, apparently in diminishing numbers, as far as Billows.

Villosa taeniata (Conrad, 1834). Painted creekshell.

Although this was the fourth-most abundant unionid collected in 1992, Wilson and Clark (1914) reported that it was rare and Neel and Allen (1964) considered it moderately common (rare to common at five sites). As observed by Thompson (1985), this is the most abundant and widely distributed of the Cumberlandian species present in the river. Specimens often were found in soft substrates along the river margin, or under or wedged between cobbles and/or boulders.

INTRODUCED SPECIES

Corbicula fluminea (Muller, 1774). Asian clam.

This member of the Order Veneroida is common throughout the river. It appeared to be most abundant in sand-dominated substrates.

DISCUSSION

Of the 72 unionid species documented from the upper Cumberland River drainage in Kentucky, 38 have been found in the Rockcastle River drainage (Cicerello et al. 1991, KSNPC 1993). The diversity of the Rockcastle River fauna probably has been limited by barriers to upstream fish migration on the Cumberland and lower Rockcastle rivers (Burr and Warren 1986). Prior to impoundment, these rivers flowed through boulder-strewn gorges with low waterfalls and high gradients that probably acted as filters to immigrating fishes bearing unionid glochidia.

Thirty-three (87%) of the 38 species known from the Rockcastle River drainage have been collected from the study area, and 23 were collected in 1992 (Tables 1 and 3). Eighteen of the 33 are relatively common, although *A. pectorosa*, *L. recta*, and *M. conradicus* appear to be declining relative to previous studies, while *A. ligamentina* and *P. coccineum* appear more common.

Eight species (*A. marginata*, *A. viridis*, *A. grandis*, *E. crassidens*, *P. ohiensis*, *S. undulatus*, *T. truncata*, and *V. trabalis*) are rare. *Potamilus ohiensis* is present in Lake Cumberland and, along with *A. grandis*, probably inhabits the impounded section of the Rockcastle River. *Alasmidonta viridis* and *S. undulatus* are more common in headwater tributaries, such as Horse Lick Creek and Middle Fork. The Rockcastle River has produced the only fresh specimens of *T. truncata* in the upper Cumberland River drainage in Kentucky since those reported by Neel and Allen (1964). It is also one of only three sites in the upper Cumberland drainage that is known to continue to support populations of *E. crassidens* (KSNPC 1993). *Alasmidonta marginata* was found at only two sites in the Rockcastle and is extremely rare. *Villosa trabalis* is somewhat more

Table 4. Unionids found at Livingston ford during four collecting periods.

Species	1905-1914 ¹	1961-1967 ²	1968 ³	1982-1992 ⁴
<i>Actinonaias ligamentina</i>	-	X*	X*	X*
<i>Actinonaias pectorosa</i>	X	X*	-	X*
<i>Alasmidonta marginata</i>	X	X*	-	-
<i>Alasmidonta viridis</i>	-	X*	-	-
<i>Amblema plicata</i>	X	X*	X*	X*
<i>Cyclonaias tuberculata</i>	-	X*	X*	X
<i>Elliptio dilatata</i>	X	X*	X*	X*
<i>Lampsilis cardium</i>	X	X*	X*	X*
<i>Lampsilis fasciola</i>	X	X*	X*	X*
<i>Lampsilis ovata</i>	X	-	-	-
<i>Lasmigona costata</i>	X	X*	X*	X
<i>Leptodea fragilis</i>	-	X*	-	X*
<i>Ligumia recta</i>	X	X*	X*	X*
<i>Medionidus conradicus</i>	X	X*	-	-
<i>Pegias fabula</i>	X	-	-	-
<i>Pleurobema coccineum</i>	X	X*	X*	X*
<i>Pleurobema oviforme</i>	X	X*	-	-
<i>Potamilus alatus</i>	-	-	X*	X
<i>Potamilus ohiensis</i>	-	-	X*	-
<i>Ptychobranthus fasciolaris</i>	X	X*	X*	X*
<i>Ptychobranthus subtentum</i>	X	-	-	-
<i>Quadrula cylindrica</i>	X	-	-	-
<i>Quadrula pustulosa</i>	-	X*	X*	-
<i>Strophitus undulatus</i>	X	-	-	-
<i>Toxolasma lividus</i>	X	X*	-	-
<i>Tritogonia verrucosa</i>	X	X*	X*	X*
<i>Villosa iris</i>	-	X*	-	-
<i>Villosa taeniata</i>	X	X*	-	X
<i>Villosa trabalis</i>	X	X*	X*	X*
Total species	21	22	15	16

1. Williamson (1905) and Wilson and Clark (1914); 2. D. H. Stansbery and associates (OSUMZ); 3. Blankenship and Crockett (1972); 4. Thompson (1985), Ahlstedt (1986), Layzer and Anderson (1992), this study. * = specimens collected alive or fresh-dead.

common and widely distributed in the river, but is considerably less common than in the 1960's.

The remaining seven species (*L. ovata*, *P. fabula*, *P. oviforme*, *P. subtentum*, *Q. cylindrica*, *T. lividus*, and *V. lienosa*) probably have been extirpated from the mainstem Rockcastle River. There have been no collections of living or fresh-dead specimens of these species since 1967, and even badly weathered-dry shells have become hard to find. However, caution should be exercised in proclaiming that a particular species has been extirpated. Rare unionids can be difficult to locate even when known to exist at a site. Some unionids are found in a stream after a long absence, as demonstrated by the rediscovery of *A. marginata* during this study.

Blankenship and Crockett (1972) presaged the loss of several of these unionids from the Rockcastle by pointing out their disappearance from the river at Livingston. They reported the loss of eight species (*A. marginata*, *M. conradicus*, *P. fabula*, *P. oviforme*, *P. subtentum*, *Q. cylindrica*, *S. undulatus*, and *T. lividus*) from the site after comparing their data with that of Williamson (1905), Wilson and Clark (1914), and Neel and Allen (1964)(Table 4). Siltation from farms, timber harvest activities, and surface mining was suggested as the cause of the decline.

Several of these species were last found at Livingston ford by D.H. Stansbery and associates (OSUMZ) between 1963 and 1967, just before and independent of the 1968 investigations by Blankenship and Crockett (1972). Stansbery and associates found a total of 22 species, many in relatively large numbers. Populations probably were not as large as those witnessed by Wilson and Clark (1914), who called them "...excessively abundant...", but they apparently were larger than anyone has seen since at Livingston ford. Subsequent searches for unionids at Livingston have failed to reveal the species Blankenship and Crockett (1972) identified as lost, as well as *V. iris*. Efforts by Thompson (1985), Ahlstedt (1986), Layzer and Anderson (1992), and in 1992 produced a total of 16 species, 12 of which were found alive. Stansbery and associates apparently collected just before or during the decline of the Livingston ford fauna. The reasons for the losses at Livingston and the Rockcastle River in general are not clear, but they could include those listed by Blankenship and Crockett as well as effluent from the Livingston sewage treatment plant. An accurate assessment of the status of the fauna will require quantitative studies to determine such characteristics as population size, density, and structure.

Despite the loss of several species, the Rockcastle River is one of the most diverse and important streams remaining in the upper Cumberland drainage of Kentucky. The diverse and unique fauna of the mainstem upper Cumberland River and lower segments of its tributaries was lost with the closing of Wolf Creek Dam in 1950 (Miller et al. 1964). Among major tributaries, only Big and Little South Forks of the Cumberland River, Buck Creek, and Horse Lick Creek continue to support diverse unionid communities, species of state and federal conservation interest, and remnants of

the unique Cumberlandian fauna (Schuster et al. 1989, Cicerello et al. 1991, Richardson 1989, KSNPC 1993). Although the quality of each stream and their faunas have declined, especially Little South Fork (Anderson et al. 1991), each is important to aquatic community conservation efforts. In addition to supporting slightly different faunas (Burr and Warren 1986, Schuster et al. 1989), these are the only available sites in Kentucky for the recovery of rare aquatic organisms such as *Epioblasma brevidens*, *E. capsaeformis*, and *P. fabula*.

Together with Horse Lick Creek and the Middle Fork, the Rockcastle River is the largest of these important streams in Kentucky and is situated largely within DBNF. Horse Lick Creek and Middle Fork are located in the Rockcastle River headwaters and support populations of several unionids that are rare or have been extirpated from the Rockcastle (*A. marginata*, *P. fabula*, *P. oviforme*, *P. subtentum*, *T. lividus*, and *V. trabalis*). The Kentucky Chapter of The Nature Conservancy, DBNF, and KSNPC are cooperating to protect these and other important biotic resources of the Horse Lick Creek watershed. If pollution sources in these streams can be identified and controlled, the Rockcastle River represents an excellent opportunity to expand the range and population size of these rare unionids.

ACKNOWLEDGMENTS

Thanks to C.J. Bailey (formerly EKU), R.G. Biggins (USFWS), E. Laudermilk (EKU), and J.R. MacGregor (DBNF) for field assistance. D.H. Stansbery (OSUMZ) graciously shared collection information from Kentucky. G.A. Schuster (EKU) shared collections records from the MCZ. The manuscript was improved by the review and comments of C.T. Bloom (KSNPC), and E.L. Laudermilk and Dr. G.A. Schuster (EKU). Thanks to M.F. Shramm (KSNPC) for preparing sections of the manuscript and formatting the final copy.

LITERATURE CITED

- Ahlstedt, S. 1986. A status survey of the Little-winged pearly mussel *Pegias fabula* (Lea 1838). Report submitted to the Endangered Species Field Office, United States Fish and Wildlife Service, Asheville, North Carolina, USA.
- Anderson, R.M., J.B. Layzer, and M.E. Gordon. 1991. Recent catastrophic decline of mussels (Bivalvia: Unionidae) in the Little South Fork Cumberland River, Kentucky. *Brimleyana* 17:1-8.
- Blankenship, S., and D. R. Crockett. 1972. Changes in the freshwater mussel fauna of the Rockcastle River at Livingston, Kentucky. *Transactions of the Kentucky Academy of Science* 33:37-39.

- Bogan, A.E., and P.W. Parmalee. 1983. Tennessee's rare wildlife, Volume II: the mollusks. Tennessee Wildlife Resource Agency, Nashville, Tennessee, USA.
- Bower, D.E., and W.H. Jackson. 1981. Drainage areas of streams at selected locations in Kentucky. Open File Report 81-61. Geological Survey, United States Department of the Interior, Louisville, Kentucky, USA.
- Brown, W.R., and M.J. Osolnik. 1974. Geologic map of the Livingston quadrangle, southeastern Kentucky. Map GQ-1179. United States Geologic Survey, Reston, Virginia, USA.
- Burr, B.M., and M.L. Warren, Jr. 1986. A distributional atlas of Kentucky fishes. Kentucky Nature Preserves Commission Scientific and Technical Series 4:1-398.
- Call, S.M., and P.W. Parmalee. 1981. The discovery of extant populations of *Alasmidonta atropurpurea* (Rafinesque) (Bivalvia: Unionidae) in the upper Cumberland River basin. Bulletin of the American Malacological Union, Incorporated 1981:42-43.
- Cicerello, R.R. 1992. A survey of the unionids (Bivalvia: Unionidae) of Middle Fork Rockcastle River, Kentucky. Kentucky State Nature Preserves Commission, Technical Report, Frankfort, Kentucky, USA.
- Cicerello, R.R., M.L. Warren, Jr., and G.A. Schuster. 1991. A distributional checklist of the freshwater unionids (Bivalvia: Unionoidea) of Kentucky. American Malacological Bulletin 8(2):113-129.
- Clarke, A.H. 1981. The tribe Alasmidontini (Unionidae: Anodontinae), Part I: *Pegias*, *Alasmidonta*, and *Arcidens*. Smithsonian Contributions to Zoology 326:1-101.
- Crowder. 1963. Geology of the Parrot quadrangle, Kentucky. Map GQ-236. United States Geological Survey, Washington, District of Columbia, USA.
- DiStefano, R.J. 1984. Freshwater mussels (Bivalvia: Unionidae) of Horse Lick Creek, Rockcastle River, Kentucky. Nautilus 98:110-113.
- Gordon, M.E., and J.B. Layzer. 1989. Mussels (Bivalvia: Unionoidea) of the Cumberland River. Review of life histories and ecological relationships. Biological Report 89(15). Fish and Wildlife Service, United States Department of the Interior, Washington, District of Columbia, USA.
- Gualtieri, J.L. 1968. Geologic map of the Johnetta quadrangle, Rockcastle and Jackson counties, Kentucky. Map GQ-685. United States Geological Survey, Washington, District of Columbia, USA.

- Gualtieri, J.L. 1973. Geologic map of the Sandgap quadrangle, Jackson County, Kentucky. Map GQ-1100. United States Geological Survey, Washington, District of Columbia, USA.
- Harker, D.F., Jr., M.L. Warren, Jr., K.E. Camburn, S.M. Call, G.J. Fallo, and P. Wigley. 1980. Aquatic biota and water quality survey of the upper Cumberland River basin. Kentucky Nature Preserves Commission, Technical Report, Frankfort, Kentucky, USA.
- Hatch, N.L., Jr. 1963a. Geology of the Bernstadt quadrangle, Kentucky. Map GQ-202. United States Geological Survey, Washington, District of Columbia, USA.
- Hatch, N.L., Jr. 1963b. Geology of the Billows quadrangle, Kentucky. Map GQ-228. United States Geological Survey, Washington, District of Columbia, USA.
- Jillson, W.R. 1928. The geology and mineral resources of Kentucky. Kentucky Geological Survey, Frankfort, Kentucky, USA.
- Kentucky Division of Water. 1990. Kentucky water quality standards. Kentucky Division of Water, Department for Environmental Protection, Frankfort, Kentucky, USA.
- Kentucky Division of Water. 1991. Kentucky wild river system. Kentucky Division of Water, Department for Environmental Protection, Frankfort, Kentucky, USA.
- Kentucky Division of Water. 1992. 1992 Kentucky report to congress on water quality. Kentucky Division of Water, Natural Resources and Environmental Protection Cabinet, Frankfort, Kentucky, USA.
- Kentucky Division of Water and National Park Service. 1992. Kentucky rivers assessment. Kentucky Division of Water, Frankfort, Kentucky, USA.
- Kentucky State Nature Preserves Commission. 1992. Endangered, threatened, and special concern plants and animals of Kentucky. Kentucky State Nature Preserves Commission, Frankfort, Kentucky, USA.
- Kentucky State Nature Preserves Commission. 1993. Natural Heritage Database. Kentucky State Nature Preserves Commission, Frankfort, Kentucky, USA.
- Kessler, J., and A. Miller. 1978. Observations on Anodonta grandis (Unionidae) in Green River Lake, Kentucky. Nautilus 92:125-129.
- Layzer, J. B., and R. M. Anderson. 1992. Impacts of the coal industry on rare and endangered aquatic organisms of the upper Cumberland River basin. Final report

submitted to Kentucky Department of Fish and Wildlife Resources, Frankfort, Kentucky, USA, and Tennessee Wildlife Resources Agency, Nashville, Tennessee, USA.

Mayes, Sudderth, and Etheredge, Incorporated. 1975. The river basin water quality management plan for Kentucky. Upper Cumberland River 303(e) plan. Prepared for Division of Water Quality, Kentucky Department for Natural Resources and Environmental Protection, Frankfort, Kentucky, USA.

Miller, A.C., L. Rhodes, and R. Tippit. 1984. Changes in the naiad fauna of the Cumberland River below Lake Cumberland in central Kentucky. *Nautilus* 98:107-110.

Neel, J.K., and W.R. Allen. 1964. The mussel fauna of the upper Cumberland basin before its impoundment. *Malacologia* 1:427-459.

Richardson, J.B. 1989. Distribution, abundance, and community structure of freshwater mussels within the Big South Fork National River and Recreation Area, Kentucky and Tennessee. Master's Thesis, Tennessee Technological University, Cookeville, Tennessee, USA.

Ruhl, K.J., and G.R. Martin. 1991. Low-flow characteristics of Kentucky streams. Water-Resources Investigations Report 91-4097, United States Geological Survey, Louisville, Kentucky, USA.

Schlanger, S.O., and G.W. Wier. 1971. Geologic map of the Mount Vernon quadrangle, Rockcastle County, Kentucky. Map GQ-902. United States Geological Survey, Washington, District of Columbia, USA.

Schuster, G.A. 1988. The distribution of unionids (Mollusca: Unionidae) in Kentucky. Project Number 2-437R. Report to Kentucky Department of Fish and Wildlife Resources, Frankfort, Kentucky, USA.

Schuster, G.A., R.S. Butler, and D.H. Stansbery. 1989. A survey of the unionids (Bivalvia: Unionidae) of Buck Creek, Pulaski County, Kentucky. *Transactions of the Kentucky Academy of Science* 50:79-85.

Soil Systems, Incorporated. 1979. Environmental inventory Rockcastle wild river. Earth Systems Division, Soil Systems, Inc., Marietta, Georgia, USA.

Starnes, L.B., and A.E. Bogan. 1982. Unionid Mollusca (Bivalvia) from Little South Fork Cumberland River, with ecological and nomenclatural notes. *Brimleyana* 8:101-119.

- Thompson, Y.L. 1985. The mussel fauna of the Rockcastle River system, Kentucky (Bivalvia: Unionidae). Master's Thesis, Eastern Kentucky University, Richmond, Kentucky, USA.
- Turgeon, D.D., A.E. Bogan, E.V. Coan, W.K. Emerson, W.G. Lyons, W.L. Pratt, C.F.E. Roper, A. Scheltema, F.G. Thompson, and J.D. Williams. 1988. Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks. American Fisheries Society Special Publication 16:1-277.
- United States Army Corps of Engineers. 1991. Water resources development in Kentucky 1991. United States Army Corps of Engineers, Louisville District, Louisville, Kentucky, USA.
- United States Fish and Wildlife Service. 1991. Endangered and threatened wildlife and plants; animal candidate review for listing as endangered or threatened species, proposed rule. Federal Register 56:58804-58836.
- United States Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants. Department of the Interior, Washington, District of Columbia, USA.
- Watters, G.T. 1988. A field guide to the freshwater mussels of Ohio. Museum of Zoology, Ohio State University, Columbus, Ohio, USA.
- Williamson, E. B. 1905. Odonata, Astacidae, and Unionidea collected along the Rockcastle River at Livingston, Kentucky. Ohio Naturalist 5:309-312.
- Wilson, C.B., and H.W. Clark. 1914. The mussels of the Cumberland River and its tributaries. United States Fish Commission, United States Bureau of Fisheries Document No. 781:1-63.
- Woolman, A.J. 1892. Report of an examination of the rivers of Kentucky, with lists of the fishes obtained. Bulletin of the United States Fish Commission 10:249-288.