The Freshwater Mussels (Bivalvia: Unionidae) of the

Rolling Fork River Drainage of Kentucky

By

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EXECUTIVE SUMMARY

Living bivalves and shells were collected during the present survey form June 1998 to October 1999 in the Rolling Fork River drainage upstream of the confluence of the Beech Fork and Rolling Fork. This was the only comprehensive survey performed since 1988, and the first to be documented since 1959. Sites were surveyed in Anderson, Larue, Marion, nelson and Washington counties. A total of 41 sites were surveyed, but only 21 had unionids. A total of 978 live individuals were observed from 21 sites and these represented 25 species and 20 genera. Shell collections resulted in a total of 33 species from 26 genera. *Corbicual fluminea* were found at most sites and no *Dreissena polymorpha* were observed. When historical collections are compared to the current survey it appears that the mussel populations of the Rolling Fork River remained fairly stable. However, upon closer inspection it is evident that the river overall has been in decline. It appears that *Anodontoides ferrusacianus, Epioblasma triquetra, Obovaria subrotunda, Pleurobema rubrum* and *Simpsonaias ambigua* are only living in a few areas and are susceptible to disturbances that may lead to extirpation.

CHAPTER I

INTRODUCTION

The decline in the number of native freshwater mussels (Bivalvia: Unionidae) has been documented for many streams across the United States. Many anthropogenic factors have influenced the decline in these mussels, including the introduction of exotic species. Kentucky was of historic significance because of the great diversity of these native unionids. Although the Rolling Fork River in north-central Kentucky had been surveyed previously, no studies had been published in the past 39 years. Previous studies were more focused on the mainstem of the Salt River, and consequently few sites were surveyed on the mainstem of the Rolling Fork River. The sites that were sampled represented only a small portion of the drainage.

This study was conducted in order to fill the gaps in previous research. Primarily, this study assessed the current status of the unionids in the Rolling Fork River drainage. Survey data showed the presence or absence of species of mussels, while historic comparison showed trends in the status of the unionid populations over time. Historical comparison also showed that *Corbicula fluminea* could have had an impact on the native populations and its distribution in the area. Lastly, a thorough survey of the area determined if any species of special concern were located in the drainage.

CHAPTER II

LITERATURE SURVEY

The family Unionidae has been one of the most successful invaders of freshwater among the molluscs (Bogan 1993). Unionids have been found on every continent except Antarctica (Cummings and Mayer 1992). North America, north of Mexico, has historically supported the most species of freshwater bivalves in the world (Bogan 1993). Many scientists including taxonomists C. S. Rafinesque (1820) and Isaac Lea (1870) had studied the highly diverse fauna of freshwater unionid mussels in Kentucky. Kentucky had been noted for a high species diversity and high degree of endemism (Neves 1993). This might be due to a dispersion from an evolutionary center in Georgia (Lea 1870). However, of the 103 species historically or currently known from Kentucky, only 84 were still reported to be found in the Commonwealth (Cicerello, et al 1991). Of those that persisted, as many as 34 were considered to be threatened or endangered (Crowell and Kinman 1993), and the group was considered the most threatened of midwestern animals (Cummings and Mayer 1992).

The future of unionids has never been certain. Stansbery (1971) stated that extinctions began as early as 1900. Declining trends have been noted in the upper Ohio River and in the Little Pigeon and Cumberland rivers in Tennessee during studies of Indian middens and adjacent streams (McMahon 1991). This decline in mussel fauna might be linked to the increase of human activity and the subsequent degradation of habitat (Bogan 1993). The filter feeding of mussels also make them susceptible to pollutants, and declines in mussel communities had been correlated with industrial development in North America (Neves 1993). Shannon et al (1993) reported that no other faunal group had suffered such a dramatic decline as the unionids in the United States.

Neves (1993) cited impoundments, channelization and sport fish species introduction among the factors that had influenced the mussel fauna. Benke (1990) reported that of 5.2 million km of rivers in the United States there remain only 42 rivers that free flow for greater than 200 km. The introduction of locks and dams in the Mississippi River basin attributed to the extinction of at least eleven species of *Epioblasma* that inhabited riffles and shoals of large rivers (Stansbery 1971). The flooding of mussel habitat that followed impoundments affected not only the flow of the river, but also the movement of host fish, thus ensuring the extinction of many species of mussels (Baker 1993). The hypolimnionic release of water from impoundments also affected mussels due to the rapid change in water temperature and flow (McMahon 1991).

Unionids had been used for food and tools since the time of archaic man, about 8000 B.P. Archeologists have found mussel shells in the settlements of these people near the Green and Cumberland rivers in Kentucky. The use of naiads as food decreased with the improved farming capabilities of the Adena people; however, the shells continued to be used in ornamentation (Stansbery 1966). Although it was documented that these early people used unionids, it was doubtful that they had a negative impact on the mussel community.

Later commercial use of mussels also had an impact on the unionid fauna of Kentucky. With the introduction of the pearl button industry in the late 1700's or early 1800's, many mussel shoals were exploited in rivers throughout the United States, including the Ohio River at Paducah, Augusta, Cloverport and Vanceburg, Kentucky. The Kentucky Game and Fish Commission first addressed the harvesting of mussels in 1926. This required musselmen to obtain a license and a provision was made for the closure of mussel beds (Crowell and Kinman 1993).

The impact of the pearl button industry declined with the onset of World War II; however, a new danger threatened unionids in the 1950's and 1960's as the Japanese discovered that unionid shells could be used in the cultured pearl industry (Thiel and Fritz 1993). Due to this increased interest in unionid shells, prices per ton increased from $40 in 1945 to $3,000 in 1990. A buyers war in 1991 inflated prices of *Megalonaias nervosa* up to $14,000 per ton (Crowell and Kinman 1993). Illegal musseling and lack of biological information might also have contributed to the increased extinction and extirpation of unionids.

Unionids have a unique stage in their life history. The larval stage of unionids are an obligate fish parasite, excluding the salamander mussel (*Simpsonaias ambigua*) (Neves 1993). Larval unionids, termed glochidia, must attach to the gills of a particular host fish before they metamorphose into a juvenile clam. Some unionid species have developed lures to attract host fish (Cummings and Mayer 1992). Without the specific host fish, metamorphosis is halted and the glochidia cannot develop into mature unionids

(Bogan 1993). Because of this dependence on fish, any factor that changes the fish fauna will affect the unionid fauna as well. (Neves 1993).

Another problem is the lack of reproduction in what appears to be otherwise healthy unionid communities (McMurray et al 1999). This is of concern in part because of the dispersal capabilites of introduced species. *Corbicula* tangle in algae and are transported on wading bird legs to other drainages. They can also float downstream and readily use this passive transport, while unionids rarely float downstream (McMahon 1991).

Introduced species have also threatened the native unionid fauna. *Corbicula fluminea*, the asiatic clam, was first noted in the Salt River drainage in 1978 after dispersal from the Ohio River (Taylor 1980). Although individual *Corbicula* are not large in size, their densities pose a threat to the native unionids. Of special concern is the competition between the asiatic clam and unionids for substrate and food (Neves 1993). More recently, the introduced zebra mussel (*Dreissena polymorpha*) has presented yet another threat to unionids. This mussel was discovered in St. Clair and Lake Erie in 1988 (McMahon 1991). However, zebra mussels have not yet been collected in the Salt River.

CHAPTER III

STUDY AREA

The Rolling Fork River is a seventh order tributary of the Salt River and is located in North-central Kentucky. The mouth of the river is along the border of Bullitt and Hardin counties. The headwaters are located in Casey and Boyle counties. The Rolling Fork River flows northwest to the confluence with the Salt River about twenty kilometers from the Ohio River (Rosewater 1959). The river lies in the Interior Basin and contains mussels of Ohioan fauna (Clench and van der Schalie 1944). The total catchment area of the drainage is approximately 580 square kilometers (Bower and Jackson 1981).

Sites were chosen along the river and its larger tributaries, including but not limited to the Chaplin River and Beech Fork (Figure 1). Smaller tributaries were sampled to insure that all habitats were included, and because smaller streams were often less affected by pollution than larger streams (Taylor 1980). Although the Rolling Fork drainage included Beaver Lake, Sympson Lake and Willisburg Lake, these reservoirs were not searched due to depth regime. In order to adequately search the depths, scuba gear would be required and most unionids prefer four to ten meters in depth due to oxygen saturation (McMahon1991). Sites included historic mussel bed locations (Clench and van der Schalie 1944, Rosewater 1959), as well as unpublished collection sites with voucher specimens placed in the Branson Museum of Zoology at Eastern Kentucky University, Richmond, Kentucky. Over forty sites were searched, although only those containing unionids were included in this report.

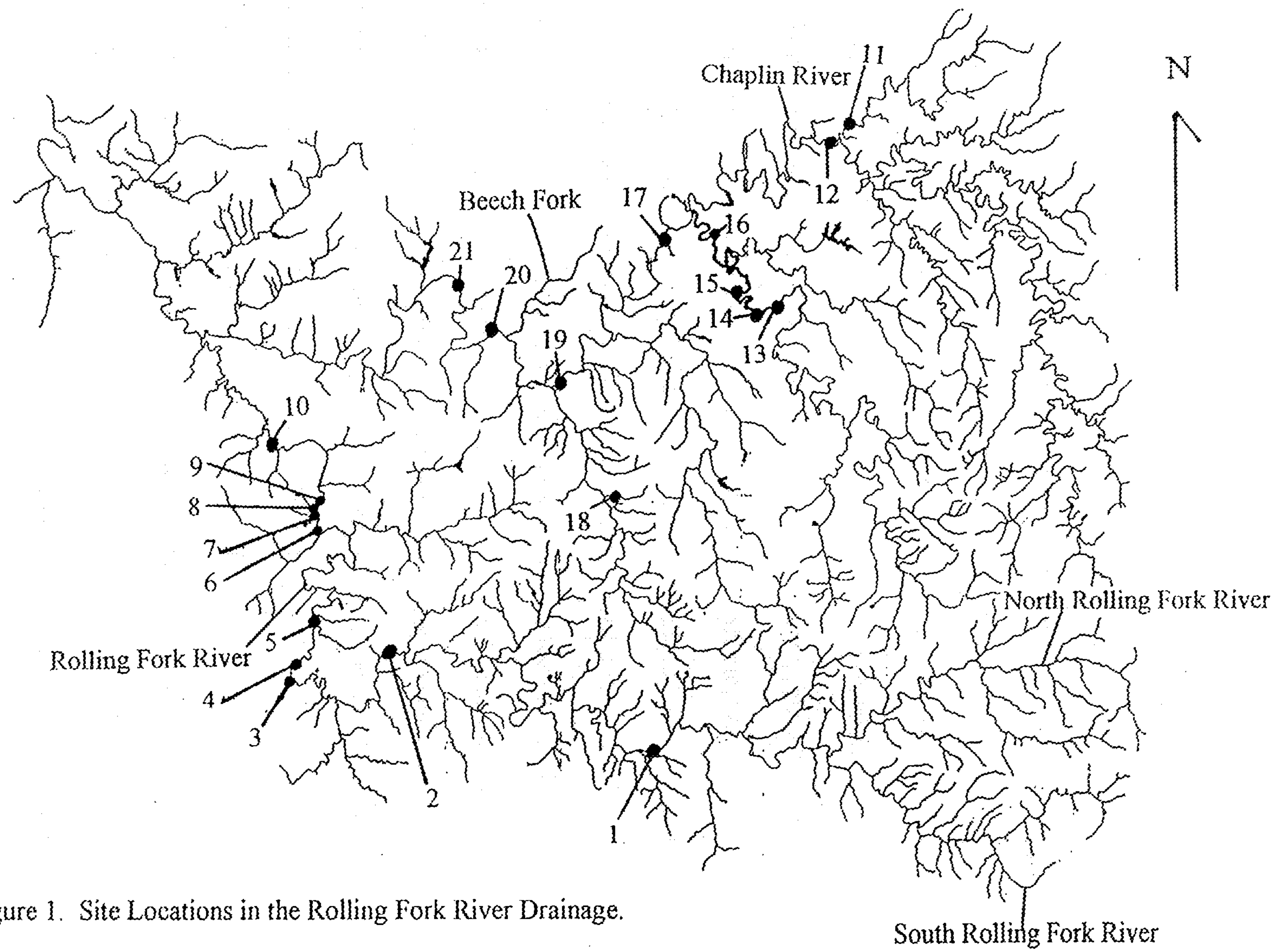

Figure 1. Site Locations in the Rolling Fork River Drainage.

CHAPTER IV

MATERIALS AND METHODS

A. Site Identification

I surveyed sites in Washington, Marion, Nelson, Anderson, Larue and Hardin counties during the period between June 28, 1998 and October 2, 1999. A list of these sites is found in Table 1. Searching was only performed in warm months due to decreased mussel activity and burrowing in the winter months (McMahon 1991). Sites were initially identified using historical locations and ease of road or bridge access. Historic site information was collected from various publications including Clench and van der Schalie 1944, Rosewater 1959 and unpublished collection data from A. Reed and other Branson Museum of Zoology collections. Historic locations were chosen in order to better understand trends by following the changes in the communities over time (Cummings and Mayer 1992). Additional sites were surveyed based on access points for canoe travel.

B. Collection Information

Timed searches were performed to ascertain the number of species present at each collecting site. A record was kept as to the number of live mussels and fresh dead, weathered dry and subfossil shells. Timed searches were chosen because they had been shown to detect even very sparse populations of unionids and at a much lower cost than quadrat sampling (Strayer et al. 1997). It had also been found that quadrat sampling alone tended to underestimate species richness (Vaughn et al. 1997). A minimum of two

Table 1. Site Locations

Site #	County	Site Location	River Kilometer	Order	Catchment Area
1	Marion	Rolling Fork at an old mill dam, ca 1 km downstream from KY55/US68 bridge on Old Mill Dam Rd.	58.6	5	85 km2
2	Nelson/Larue	Rolling Fork at KY 462 bridge at Gleanings, 1.6 km ENE of New Market.	42.8	5	132 km2
3	Nelson/Larue	Rolling Fork at Gaddys Ford just downstream from old bridge off Wayne Ennis Rd, ca 5 km SW Howardstown.	35.4	6	147 km2
4	Nelson/Larue	Rolling Fork at Gaddys Ford Rd., 4.2 km SW Howardstown	34.9	6	148 km2
5	Nelson	Rolling Fork at sand bar, ca 0.6 km downstream from Howardstown boat ramp.	32.7	6	150 km2
6	Nelson/Larue	Rolling Fork, ca 0.6 km upstream from US 31E bridge near New Haven.	24.3	6	184 km2
7	Nelson/Larue	Rolling Fork at US 31E bridge near New Haven.	24.1	6	185 km2
8	Nelson/Larue	Rolling Fork ca 0.6 km downstream from US 31E bridge near New Haven.	23.8	6	185 km2
9	Nelson	Rolling Fork at sand bar ca 0.8 km upstream from New Haven boat ramp.	23.6	6	186 km2
10	Nelson/Larue	Rolling Fork at sand bar 200 m downstream from confluence with Murphy's Creek.	19.7	6	197 km2
11	Washington/Anderson	Log Lick of Chaplin River off Sulphur Lick Road.		2	1.3 km2
12	Washington	Chaplin River at Tatham Springs off Marshall Lane, downstream from old dam across stream from old hotel.	17.1	5	64 km2
13	Washington	Beech Fork at Hardesty Road, ca .93 km SE of Hardesty.	41	6	43 km2
14	Washington	Beech Fork, ca 100 m downstream from confluence with Lincoln Run.	40	6	44 km2
15	Washington	Beech Fork, ca 5 km downstream from Hardesty Road, ca 1.9 km upstream from confluence with Long Lick Creek.	36	6	46 km2

Table 1 (continued).

Site #	County	Site Location	River Kilometer	Order	Catchment Area
16	Washington	Beech Fork at Mt Zion covered bridge on Hwy 458, 3.8 km N of Mooresville.	33.1	6	60 km2
17	Washington/Nelson	Beech Fork at KY 55 bridge near Maud	29.9	6	168 km2
18	Marion	Hickory Camp Run, ca 0.1 km N of Makers Mark Distillery off Hwy 52.		1	1.2 km2
19	Washington/Nelson/ Marion	Beech Fork off Hwy 605 S of Botland.	21	6	210 km2
20	Nelson	Beech Fork, 1.9 km S of Bardstown on Hwy 49.	17	6	246 km2
21	Nelson	Beech Fork at Hwy 31E, outside of Bardstown.	13	6	258 km2

man-hours were spent at each collecting site searching banks, beds of water willow (*Justicea americana*) and bars for shells. An additional two or more man-hours were spent searching for live specimens. Searching was performed while wading with a water scope or searching visually unaided. The substrate was searched by hand to locate buried individuals. Live mussels were identified and recorded in the field and the handling time of living specimens was kept to a minimum in order to decrease the possibility of mortality due to exposure (Waller et al. 1995). Living mussels were returned to the habitat where they were encountered. A detailed description of each sampling site was recorded.

Representative shells of all species found were collected in bags and returned to the laboratory for cleaning, identification and curation. Shells were rinsed with water and then scrubbed with a brush. A toothbrush was used on fragile shells or shells with numerous pustules, and a manicure brush was employed on large, thick shells. Dishwashing detergent or a paste cleanser was used to remove dirt and stains from the shells. Following cleaning and sorting, unionids were identified and counted in the laboratory. Voucher specimens were placed in the Branson Museum of Zoology at Eastern Kentucky University.

CHAPTER V

RESULTS AND DISCUSSION

A. Current Study

Thirty-three species of mussels belonging to the family Unionidae were found in the Rolling Fork River drainage (Table 2). These species included individuals from twenty-six genera. A total of 978 individuals were observed alive from twenty-one locations, and comprised of twenty-five species from twenty genera (Table 3). Shells were collected in the mainstem of the Rolling Fork River, Chaplin River, Beech Fork and other tributaries. An additional twenty sites (Appendix A) were surveyed where no mussels were found. These sites were in extreme headwaters where water flow may have been intermittent, and in areas of bedrock substrate with very little cobble. Although no fish were collected with this study, distribution of mussels may also have been related to the presence of suitable habitat for the host fish.

Low amounts of disturbance were noted in the Rolling Fork River drainage. Row crops could be seen from the water at a few sites, although no livestock were noted in the stream at any area surveyed. A pig farm was noted on the hill within the catchment area of sites 3 and 4, although diversity and abundance at site 3 were high (Tables 2 and 3) and does not currently appear to be affected by the organic runoff. During the warm summer months, people often used the streams for recreational purposes including fishing, boating and swimming.

The increased population in the urban areas of the drainage might have caused the low diversity at site 21 (Table 2). However, the sites near New Haven (sites 6-9) do not appear to be affected by the close proximity of the town. This might have been due to the easy access at the Bardstown site as compared to the relatively difficult access to the New Haven sites. Recently, historic site 21 at Bardstown has been affected by a road construction project during the summer of 2000, which involved a widening of the 31E bridge.

Of the thirty-three unionid species observed, one federally endangered mussel, *Cyprogenia stegaria*, was found as fresh dead at one location. This mussel is also listed as threatened by Kentucky Academy of Science-Kentucky State Nature Preserves Commission (Cicerello et al 1991). No live *Cyprogenia stegaria* were observed during the present survey. *Simpsonaias ambigua*, a state threatened species (Cicerello et al 1991), was found living at one location (Site 1). It was found living in an area with low flow, below a dam, on an area that was mostly bedrock. At this site, shells of *Villosa lienosa*, a state species of special concern (Cicerello et al 1991), was also found. This site was the only site where mussels were found had predominantly bedrock substrate where any mussels were found.

No shells were found of *Epioblasma triquetra*, a state special concern species (Cicerello et al 1991). This species had been found previously by Rosewater (1959) and Reed in 1986/1988. Another state endangered species, *Lampsilis ovata*, was not found, and has not been recorded in the drainage since the 1927 survey by Clench and van der Schalie (1944). The state endangered *Pleurobema rubrum* (Cicerello et al 1991) was found as a weathered dead shell at one location. It is thought that these species have all been extirpated from the Rolling Fork River drainage.

One introduced species, *Corbicula fluminea* from the family Corbiculidae, was observed throughout most of the drainage. The high numbers of this species at each location prohibited accurate counts. *Corbicula* was not found at site 11, however, perhaps due to the low flow and headwater characteristics of the stream at this point. The zebra mussel, *Dreissena polymorpha*, was not observed.

B. Annotated List

The following annotation of species includes distribution patterns according to definitions provided in Smith (1965).

Actinonaias ligamentina – Shells collected at sites 2-9, 16, 20, 21. Live observed at 3, 5-9, 16, 20. Generally distributed throughout drainage, particularly mainstem and high flow areas. Most abundant mussel at site 3 (50%), 7 (40%) and 5 (29%). Comprised 28% of total live mussels found (274/978).

Alasmidonta viridis – Shells collected at sites 7, 8, 11, 12, 17. Live observed at 8. Occasionally distributed throughout drainage. Specimens were difficult to find in visual search because of small size.

Amblema plicata – Shells collected at sites 2-9, 11,15, 19-21. Live observed at 2,3,5-9,19,20. Generally distributed. Most abundant at sites 8 (37%) and 9 (56%). Often found as the second most abundant species at mainstem sites.

Cyclonaias tuberculata – Shells collected at sites 2, 3, 7-9, 19, 20. Live observed at 7 and 8. Occasionally distributed.

Table 2. Listing of Bivalves Collected at Each Site (x Indicates Presence)

Species Name	Sites																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Actinonaias ligamentina		x	x	x	x	x	x	x	x							x				x	x
Alasmidonta viridis							x	x			x	x					x				
Amblema plicata		x	x	x	x	x	x	x	x		x				x				x	x	x
Corbicula fluminea	x		x				x	x	x			x	x	x	x	x	x	x	x	x	x
Cyclonaias tuberculata		x	x				x	x	x										x	x	
Cyprogenia stegaria			x																		
Elliptio dilatata		x	x		x	x	x	x	x	x		x					x		x	x	x
Fusconaia flava			x	x			x	x	x								x		x	x	
Lampsilis cardium	x	x		x	x	x	x	x	x			x					x		x	x	x
Lampsilis siliquoidea	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x		x	x	
Lampsilis teres							x		x								x			x	x
Lasmigona complanata			x			x		x	x								x		x	x	
Lasmigona costata		x	x				x	x	x										x	x	
Leptodea fragilis	x		x	x	x	x	x	x									x		x	x	x
Ligumia recta					x														x	x	
Megalonaias nervosa			x		x		x	x	x										x	x	
Obliquaria reflexa			x					x												x	
Obovaria subrotunda			x																		
Pleurobema coccineum								x													x
Pleurobema rubrum																				x	
Potamilus alatus	x	x	x	x	x	x	x	x	x								x		x	x	
Ptychobranchus fasciolaris		x	x			x	x	x	x										x	x	

Table 2 (continued).

Species Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pyganodon grandis		x				x		x		x	x	x	x	x	x	x	x		x	x	
Quadrula nodulata							x														x
Quadrula pustulosa			x	x	x			x	x										x	x	x
Quadrula quadrula		x	x			x	x	x	x			x					x		x	x	
Simpsonaias ambigua	x																				
Strophitus undulatus				x									x	x	x		x	x			
Toxolasma parvus																		x			
Tritogonia verrucosa		x	x	x	x	x	x	x	x								x		x	x	
Truncilla donaciformis																			x	x	x
Truncilla truncata			x	x				x									x		x	x	x
Utterbackia imbecillis	x																				
Villosa lienosa	x		x																		
Total Species	8	12	21	10	10	12	18	22	17	3	4	7	4	4	5	4	15	3	20	24	12

Table 3. Total Number of Live Unionidae Specimens Observed at Each Site

Species Name	Sites																					Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Actinonaias ligamentina			153		9	6	77	19	6							2				2		274
Alasmidonta viridis								1														1
Amblema plicata		2	84		5	2	20	30	31										27	14		215
Cyclonaias tuberculata							3	1														4
Cyprogenia stegaria																						0
Elliptio dilatata			7			1	15	1		1		1							42	2		70
Fusconaia flava			8				1												1	1		11
Lampsilis cardium	1				1	4	9	2											8	5	1	31
Lampsilis siliquoidea	2					1	5	1			2	2	4	14	4	26	2		14			77
Lampsilis teres																	1					1
Lasmigona complanata						1			1										3	1		6
Lasmigona costata			4				3												12	2		21
Leptodea fragilis	2		2		1																	5
Ligumia recta					1														1			2
Megalonaias nervosa			20		1		8	4	2										8	8		51
Obliquaria reflexa			1																			1
Obovaria subrotunda																						0
Pleurobema coccineum																						0
Pleurobema rubrum																						0
Potamilus alatus	2		2		8	8	3										1		4			28
Ptychobranchus fasciolaris			10				2	1											3	4		20
Pyganodon grandis								1			1	8	1		1	2			1	1		16

Table 3 (continued).

Species Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total
Quadrula nodulata																						0
Quadrula pustulosa			2						1											1		4
Quadrula quadrula			12			8	10	4	4										2			40
Simpsonaias ambigua	1																					1
Strophitus undulatus													1	1	1							3
Toxolasma parvus																						0
Tritogonia verrucosa			3		5	14	36	17	10										4	2		91
Truncilla donaciformis																						0
Truncilla truncata																						0
Utterbackia imbecillis	5																					5
Villosa lienosa																						0
Total	14	4	311	4	36	51	199	90	64	11	14	23	19	29	21	46	21	18	149	63	22	
																					Grand Total	978

Cyprogenia stegaria – Federally endangered. Shells found at site 3. None observed living. Probably still living at this one location. Sporadic distribution.

Elliptio dilatata – Shells collected at sites 2, 3, 5-10, 12, 17, 19-21. Live observed at 3, 6-8, 10, 12, 19, 20. Generally distributed. Most abundant at site 19 (32%).

Fusconaia flava – Shells collected at sites 3, 4, 7-9, 17, 19, 20. Live observed at 3, 7, 19, 20. Occasionally distributed.

Lampsilis cardium – Shells collected at sites 1, 2, 4-9, 12, 17, 19-21. Live observed at 1, 5-8, 19-21. Generally distributed. Fairly abundant when present. Tended to prefer high flow areas.

Lampsilis siliquoidea – Shells collected at sites 1-3, 6-9, 10-17, 19, 20. Live observed at 1, 6-8, 11-17, 19. Generally distributed. Most abundant at sites 11 (67%), 13 (67%), 14 (93%), 15 (67%), 16 (87%) and 17 (50%). At sites where *L. siliquoidea* was most abundant, *A. ligamentina* was generally not found live, except at site 16.

Lampsilis teres – Shells collected at sites 7, 9, 17, 20, 21. Live observed at site 17. Sporadically distributed.

Lasmigona complanata – Shells collected at sites 3, 6, 8, 9, 17, 19, 20. Live observed at 6, 9, 19, 20. Occasionally distributed.

Lasmigona costata – Shells collected at sites 2, 3, 7-9, 19, 20. Live observed at 3, 7, 19, 20. Occasionally distributed.

Leptodea fragilis – Shells collected at sites 1, 3-8, 17, 29-21. Live observed at 1, 3, 5. Occasionally distributed.

Ligumia recta – Shells collected at sites 5, 19, 20. Live observed at 5, 19. Sporadic distribution.

Megalonaias nervosa – Shells collected at sites 3, 5, 7-9, 19, 20. Live observed at 3, 5, 7-9, 19, 20. Occasionally distributed. Fairly abundant when present. Tended to prefer high flow areas.

Obliquaria reflexa – Shells collected at sites 3, 8, 20. Live observed at site 3. Sporadic distribution.

Obovaria subrotunda – Shell collected at site 3. No living observed. Very sporadic distribution, possibly extirpated.

Pleurobema coccineum – Shells collected at sites 8 and 21. No living observed. Sporadic distribution. Possibly still living in drainage.

Pleurobema rubrum - Shell collected at site 20. No living observed. Sporadic in distribution. Probably extirpated.

Potamilus alatus – Shells collected at sites 1-9, 17, 19, 20. Live observed at 1, 3, 5-7, 17, 19. Generally distributed. Fairly abundant when present.

Ptychobranchus fasciolaris – Shells collected at sites 2, 3, 6-9, 19, 20. Live observed at 3, 7, 8, 19, 20. Occasionally distributed.

Pyganodon grandis – Shells collected at sites 2, 6, 9, 10-17, 19, 20. Live observed at 8, 11-13, 15, 16, 19, 20. Generally distributed. Often found in lower flow areas where *L. siliquoidea* was abundant.

Quadrula nodulata – Shells collected at sites 7 and 21. No living observed. Possibly still living in the drainage

Quadrula pustulosa – Shells collected at sites 3-5, 8, 9, 19-21. Live observed at 3, 9, 21. Occasionally distributed.

Quadrula quadrula – Shells collected at sites 2, 3, 6-9, 12, 17, 19, 20. Live observed at 3, 6-9, 19. Occasionally distributed.

Simpsonaias ambigua – State listed species. Shells collected at site 1. Live observed at site 1. Sporadic distribution. Only found in bedrock crevices of low flow area.

Strophitus undulatus – Shells collected from sites 4, 13-15, 17, 18. Observed live at 13-15. Occasionally distributed in areas of low flow with cobble.

Toxolasma parvus – Shell collected at site 18. No living observed. Probably still living in drainage, but easily missed due to it's small size. Sporadic distribution.

Tritogonia verrucosa – Shells collected at sites 2-9, 17, 19, 20. Live observed at 3, 5-9, 19, 20. Most common at site 6 (31%). Generally distributed.

Truncilla donaciformis – Shells collected at sites 19-21. None observed living. Sporadic distribution. Possibly still living in drainage and missed due to small size and presence only in higher flow areas.

Truncilla truncata – Shells collected at sites 3, 4, 8, 17, 19-21. None observed living. Sporadic distribution. Probably still living in drainage.

Utterbackia imbecillis – Shells collected at site 1. Live observed at site 1. Sporadic distribution. Most abundant living species at site 1 (38%).

Villosa lienosa – Shells collected from sites 1 and 3. No living observed. Sporadic distribution. Possibly still living in low flow areas of drainage.

C. Historic Comparison

When studying the current populations of unionids in the Rolling Fork River drainage, historic collections and records are very important to present analyses. William J. Clench and Peter Okkelberg conducted the first known naiad survey of the drainage area in 1927 (Clench and van der Schalie 1944). In the 1927 survey two sites were surveyed; one on Beech Fork at Bardstown and one on Rolling Fork at New Haven, referred to as site 21 and site 7, respectively. In 1958, William Clench returned to the Salt River drainage with Joseph Rosewater and they surveyed the previously mentioned sites and an additional five sites. The additional sites included Rolling Fork at KY55 and Beech Fork at KY49, sites 1 and 20, respectively. The other three sites surveyed had no bivalves present or water too deep to search (Rosewater 1959).

These four sites were surveyed during the present study and Jaccard coefficients of similarity are shown in Tables 4-7. Sites 20 (Table 6) and 7 (Table 5) showed similarities greater than 0.5. This, along with inspection of the species present at each time point, lead to the belief that the populations present at these locations were fairly stable. The few dissimilar species were probably those that were just overlooked in the short time periods that were searched in previous studies.

However, site 21 (Table 7) showed a low degree of similarity when comparing either Rosewater (1959) or Clench and van der Schalie (1944) to the current study. This was probably due to the increased organic pollution at this site. Even Rosewater (1959) stated that the large size of the unionids in the Bardstown area could be a correlation with the distillery waste that was being dumped into the local streams.

Table 4. A Comparison of Unionids Collected During Historic and Present Surveys at Site 1.

Species	Rosewater (1959)	Akers (1998/99)
Alasmidonta viridis	x	
Actinonaias ligamentina	x	
Lampsilis cardium	x	x
Lampsilis siliquoidea		x
Leptodea fragilis	x	x
Potamilus alatus		x
Simpsonaias ambigua		x
Utterbackia imbecillis		x
Villosa lienosa		x
Total species	4	7

Jaccard Coefficient of Similarity

Rosewater/Akers 0.22

Table 5. A Comparison of Unionids Collected During Historic and Present Surveys at Site 7.

Species	Clench & van der Schalie (1944)	Rosewater (1959)	Reed (1986/88)	Akers (1998/99)
Actinonaias ligamentina	x	x	x	x
Alasmidonta viridis				x
Amblema plicata	x	x	x	x
Anodontoides ferrusicans	x	x		
Cyclonaias tuberculata				x
Cyprogenia stegaria	x			
Elliptio dilatata	x	x	x	x
Fusconaia flava	x		x	x
Lampsilis cardium	x	x	x	x
Lampsilis siliquoidea	x	x		x
Lampsilis teres			x	x
Lasmigona complanata		x		
Lasmigona costata	x	x	x	x
Leptodea fragilis		x	x	x
Megalonaias nervosa	x	x	x	x
Obovaria subrotunda	x			
Potamilus alatus	x	x	x	x
Ptychobranchus fasciolaris	x	x	x	x
Pyganodon grandis		x		
Quadrula nodulata				x
Quadrula pustulosa	x		x	
Quadrula quadrula	x	x	x	x
Tritogonia verrucosa	x	x	x	x
Truncilla truncata	x		x	
Utterbackia imbecillis	x			
Total species	18	15	15	18

Jaccard Coefficient of Similarity

Clench and van der Schalie/ Rosewater	0.57
Clench and van der Schalie/Reed	0.65
Clench and van der Schalie/Akers	0.50
Rosewater/Reed	0.58
Rosewater/Akers	0.57
Reed/Akers	0.65

Table 6. A Comparison of Unionids Collected During Historic and Present Surveys at Site 20.

Species	Rosewater (1959)	Akers (1998/99)
Actinonaias ligamentina		x
Amblema plicata	x	x
Anodontoides ferrusciamus	x	
Cyclonaias tuberculata		x
Elliptio dilatata	x	x
Fusconaia flava	x	x
Lampsilis cardium	x	x
Lampsilis siliquoidea	x	x
Lampsilis teres		x
Lasmigona complanata		x
Lasmigona costata	x	x
Leptodea fragilis	x	x
Ligumia recta		x
Megalonaias nervosa	x	x
Obliquaria reflexa	x	x
Pleurobema rubrum		x
Potamilus alatus	x	x
Ptychobranchus fasciolaris	x	x
Pyganodon grandis	x	x
Quadrula pustulosa	x	x
Quadrula quadrula	x	x
Strophitus undulatus	x	
Tritogonia verrucosa		x
Truncilla donaciformis	x	x
Truncilla truncata	x	x
Total species	18	23

Jaccard Coefficient of Similarity
Rosewater/Akers 0.64

Table 7. A Comparison of Unionids Collected During Historic and Present Surveys at Site 21.

Species	Clench and van der Schalie (1944)	Rosewater (1959)	Akers (1998/99)
Actinonaias ligamentina			x
Amblema plicata	x		x
Anodontoides ferruscianus	x	x	
Elliptio dilatata			x
Lampsilis cardium		x	x
Lampsilis siliquoidea	x		
Lampsilis teres			x
Lasmigona complanata	x	x	
Lasmigona costata	x		
Leptodea fragilis	x	x	x
Megalonaias nervosa	x		
Obliquaria reflexa		x	
Pleurobema coccineum			x
Potamilus alatus	x		x
Pyganodon grandis		x	
Quadrula nodulata			x
Quadrula pustulosa	x		x
Quadrula quadrula	x	x	
Tritogonia verrucosa	x		
Truncilla donaciformis			x
Truncilla truncata			x
Total species	11	6	11

Jaccard Coefficient of Similarity	
Clench and van der Schalie/Akers	0.16
Rosewater/Akers	0.13
Clench and van der Schalie/Rosewater	0.31

Table 8. A Comparison of All Unionids Collected During Historic and Present Survey.

Species	Clench and van der Schalie (1944)	Rosewater (1959)	Reed (1986/88)	Akers (1998/99)
Actinonaias ligamentina	x	x	x	x
Alasmidonta viridis			x	x
Amblema plicata	x	x	x	x
Anodontoides ferruscianus	x	x		
Cyclonaias tuberculata			x	x
Cyprogenia stegaria	x			x
Elliptio dilatata	x	x	x	x
Epioblasma triquetra		x	x	
Lampsilis cardium	x	x	x	x
Lampsilis fasciola			x	
Lampsilis ovata	x			
Lampsilis siliquoidea	x	x	x	x
Lampsilis teres			x	x
Lasmigona complanata	x	x	x	x
Lasmigona costata	x	x	x	x
Leptodea fragilis	x	x	x	x
Ligumia recta				x
Megalonaias nervosa	x	x	x	x
Obliquaria reflexa		x		x
Obovaria subrotunda	x		x	x
Pleurobema coccineum				x
Pleurobema rubrum				x
Potamilus alatus	x	x	x	x
Ptychobranchus fasciolaris	x	x	x	x
Pyganodon grandis		x	x	x
Quadrula nodulata				x
Quadrula pustulosa	x	x	x	x
Quadrula quadrula	x	x	x	x
Simpsonaias ambigua			x	x
Strophitus undulatus		x	x	x
Toxolasma parvus			x	x
Tritogonia verrucosa	x	x	x	x
Truncilla donaciformis		x	x	x

Table 8 (continued).

Species	Clench and van der Schalie (1944)	Rosewater (1959)	Reed (1986/88)	Akers (1998/99)
Truncilla truncata	x	x	x	x
Utterbackia imbecillis	x		x	x
Villosa lienosa		x	x	x
Total species	21	23	29	33

Jaccard Coefficient of Similarity

Clench and van der Schalie/Akers	0.54
Rosewater/Akers	0.60
Reed/Akers	0.77
Rosewater/Reed	0.68
Clench and van der Schalie/Reed	0.56
Clench and van der Schalie/Rosewater	0.63

Site 1 (Table 4) also has a low similarity coefficient. This was due to the increased number of species found in this study as compared to Rosewater (1959). This increase was not due to immigration into the habitat, but to the increased collecting effort and drought conditions during the current survey.

When comparing the total unionids collected by all surveyors (Table 8), a higher degree of similarity was shown between studies than when comparing one site alone. Those closest in time were more similar to each other than the surveys performed many years apart. Reed (1986/88) and Akers (1998/99) were the most similar, although all similarity coefficients were above 0.5.

Each survey also added new species to the list of those encountered on the drainage. The present survey found four species not observed by any of the historic surveys; they included *Ligumia recta, Pleurobema coccineum, Pleurobema rubrum* and *Quadrula nodulata*. In addition, four previously found species were not collected during the present survey; they included *Anodontoides ferrusicanus, Epioblasma triquetra, Lampsilis fasciola* and *Lampsilis ovata*.

CHAPTER VI

SUMMARY

Living bivalves and shells were collected during the present survey from June 1998 to October 1999 in the Rolling Fork River drainage upstream of the confluence of the Beech Fork and Rolling Fork. This was the only comprehensive survey performed since 1988, and the first to be documented since 1959. Sites were surveyed in Anderson, Larue, Marion, Nelson and Washington counties.

A total of 41 sites were surveyed, but only 21 had unionids. A total of 978 live individuals were observed from 21 sites and these represented 25 species and 20 genera. Shell collections resulted in a total of 33 species from 26 genera. *Corbicula fluminea* were found at most sites and no *Dreissena polymorpha* were observed.

When historical collections are compared to the current survey it appears that the mussel populations of the Rolling Fork River remained fairly stable. However, upon closer inspection it is evident that the river overall has been in decline. It appears that *Anodontoides ferrusicanus, Epioblasma triquetra, Obovaria subrotunda, Pleurobema rubrum* and *Pleurobema clava* have been extirpated. Furthermore, *Cyprogenia stegaria* and *Simpsonaias ambigua* are only living in a few areas and are susceptible to disturbances that may lead to extirpation.

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APPENDIX A

Site Locations Without Unionids.

County	Site Location
Boyle	North Rolling Fork at Carpenter Fork Road off Hwy 37.
Marion	North Rolling Fork at intersection of hwy 37/1108.
Marion	Jones Creek at Jones Creek Road.
Marion	North Rolling Fork at River Road.
Marion	Rolling Fork at Hwy 337/49 near Bradfordsville.
Marion	Rolling Fork at Hwy 42 near St. Joseph.
Larue	West Fork Otter Creek at Hwy 210.
Larue	Knob Creek at Blanton Road near Athertonville.
Boyle	Doctors Fork at Bull Lane, about 5 km SW of Perryville.
Mercer	Chaplin River off Hwy 1941, about 5 km SE of Cornishville.
Washington	Chaplin River off Hwy 53 about 2 km N of Sharpsville.
Washington	Cartwright Creek at Grundy Home Road.
Nelson/Washington	Beech Fork at unnamed road off Hwy 1872 near Fredericktown.
Marion/Washington	Hardins Creek at Hwy 1183 near Manton.
Nelson	Rowan Creek at low water dam upstream of confluence with Beech Fork near 31E bridge in Bardstown.
Nelson	Lick Creek off Lick Creek Lane, E of Boston.
Nelson	Beech Fork at Hwy 52 near Boston.
Hardin	Younger Creek at Hwy 583.
Bullitt/Nelson	Wilson Creek at Hwy 733 near Boston.
Bullitt/Nelson	Wilson Creek at Hwy 61 near Boston.