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Unionid Mussel Fauna of the Apple River above Hanover, Illinois

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INTRODUCTION

The Apple River is the largest stream drainage in Jo Daviess County, Illinois. The river and its two principal tributaries, the North and South Forks, drain approximately 679 square kilometers (Page *et al.* 1992). The North Fork of the Apple River originates in southwestern Wisconsin flowing southeast for approximately 7.7 km before entering Illinois west of the town of Apple River (Figure 1); it continues flowing southeast for approximately 12.1 km uniting with the South Fork in Apple River Canyon State Park to form the Apple River proper. The South Fork originates near the Jo Daviess - Stephenson county line southeast of the town of Nora flowing west for approximately 17.2 km before meeting with the North Fork. The main stem of the river then flows southwesterly for approximately 44.3 km to the dam in Hanover, Illinois. The river continues flowing southwest for approximately 23.2 km entering the Mississippi River north of the town of Savanna.

The majority of the Apple River watershed lies within the Wisconsin Driftless Natural Division of Illinois, except for the lower approximately 6.4 km which lie within the Upper Mississippi and Illinois River Bottomlands Division, and the upper 4.8 km of the South Fork which lie within the Freeport Section of the Rock River Hill Country Division (Schwegman 1973). The Wisconsin Driftless Division is part of an area extending from northwestern Illinois into Wisconsin, Iowa, and Minnesota that apparently escaped Pleistocene glaciation (Schwegman 1973). This division is one of the most maturely developed land surfaces in Illinois and is characterized by rugged terrain that originally was mostly forested. While the Apple River canyon area was not subjected to the "leveling effects" of the most recent upper Midwest glaciations and resultant glacial drift (e.g., the "driftless area"), the area has been shaped to some extent by the glaciers. Prior to the Illinoian glaciation, the upper Apple and the South Fork were a separate river flowing southeast. During and at the end of the "Illinoian" a combination of glacial drift blocking the flow of that river and a tremendous volume of glacial melt water forced the flow of both forks southwesterly, reversing the flow of the South Fork, cutting through a ridge of dolomite (forming the canyon), and into the Apple River (IDOC 1977). This is the only such formed canyon of this nature in Illinois.

As described above, much of the course of the Apple River upstream of a point about 5 km northeast of Elizabeth flows through a narrow valley, with steep bluffs or bedrock cliffs rising as high as 85 m above the valley floor (Wetzel *et al.* 1995). The middle reaches of the river flow

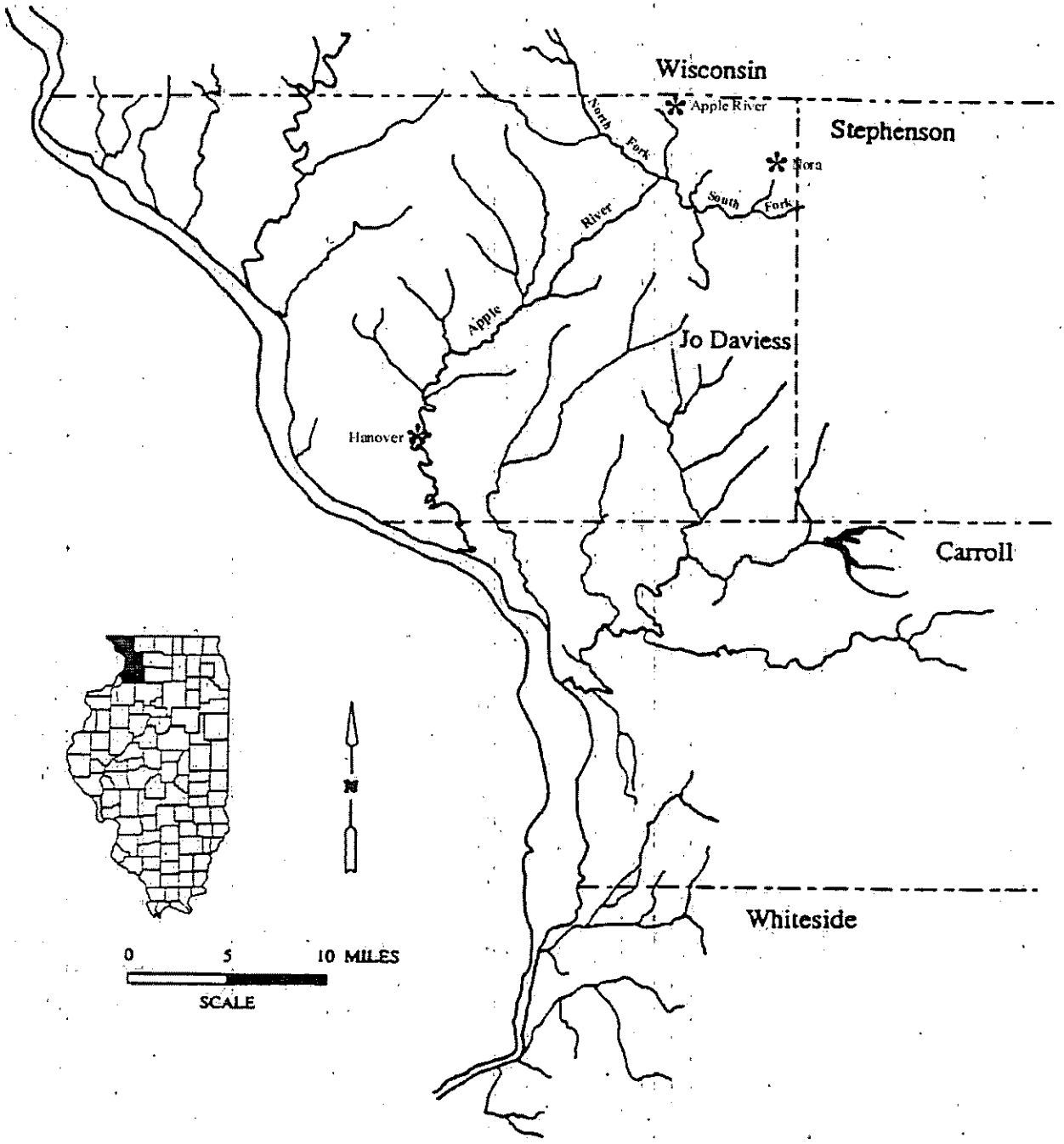


Figure 1. Project location - Upper Apple River above Hanover; Jo Daviess County, Illinois.

through a moderately broad floodplain before reaching the Mississippi River floodplain a few kilometers before its confluence. Soils on the steep slopes of the uplands of the Apple River watershed are generally well drained, silt soils formed from underlying dolomitic residue and wind blown loess (another indirect glacial impact), and are of the Dubuque - Lacrescent - Dunbarton association (Tegler 1996). The bottomlands of the middle reaches are generally sandy or clayey deposits of the Wakeland - Dorchester - Birds association. The longest tributary of the river has an overall gradient of 2.3 m/km, but numerous Order 1 tributaries flow from adjacent uplands with mean gradients of nearly 80 m/km (Weasel *et al.* 1995). At its confluence with the Mississippi River, the Apple River is an Order 6 stream (Weasel *et al.* 1995). The average width of the Apple River is 18.3 m with a substrate consisting of a combination of silt, gravel, rubble, and bedrock (Page *et al.* 1992).

Agriculture, both crops and pasture, accounts for the majority of the land use in the watershed. Page *et al.* (1992) indicated that silt was the number one stream pollutant in the basin, particularly on the lower reaches. Effluents from sewage treatment plants were identified as a localized problem. In 1998, the Apple River was named the ninth most endangered river in the country by American Rivers, the nation's leading river conservation group. The proposed construction of factory hog farms in the Apple River watershed was cited as a primary reason for this listing. Potential manure spills from such farms and the spreading of vast amounts of hog manure on farm fields were identified as potential threats to the water quality and fish habitat of the river. Regardless, the Apple River supports a high diversity of fish and was referred to as the best stream in the region by Smith (1971). The river (Figure 2) from Wolf Creek (on the South Fork) to Furnace Creek and a portion of the West Fork near the Wisconsin state line are classified as Class B stream segments (i.e., Highly Valued Aquatic Resources) by the IEPA Biological Stream Characterization (Hite and Bertrand 1989). In addition, most of the same length of the river (from Wolf Creek downstream to Mill Creek...and the West Fork) is designated as a Biologically Significant Illinois Stream (Figure 3), based on the occurrence of two rare fish species, the Ozark Minnow (*Notropis nubilus*) and the largescale stoneroller (*Campostoma oligolepis*) (Page *et al.* 1992).

A notable structure along the Apple River is the approximately 9-meter tall concrete dam at Hanover. The history of Hanover, including developments such as the dam, has been described by Miller (1976). In the spring of 1828, the first dam was erected at Hanover in conjunction with a saw mill and grist mill. The river's flow over an eleven-foot natural rock fall at this location

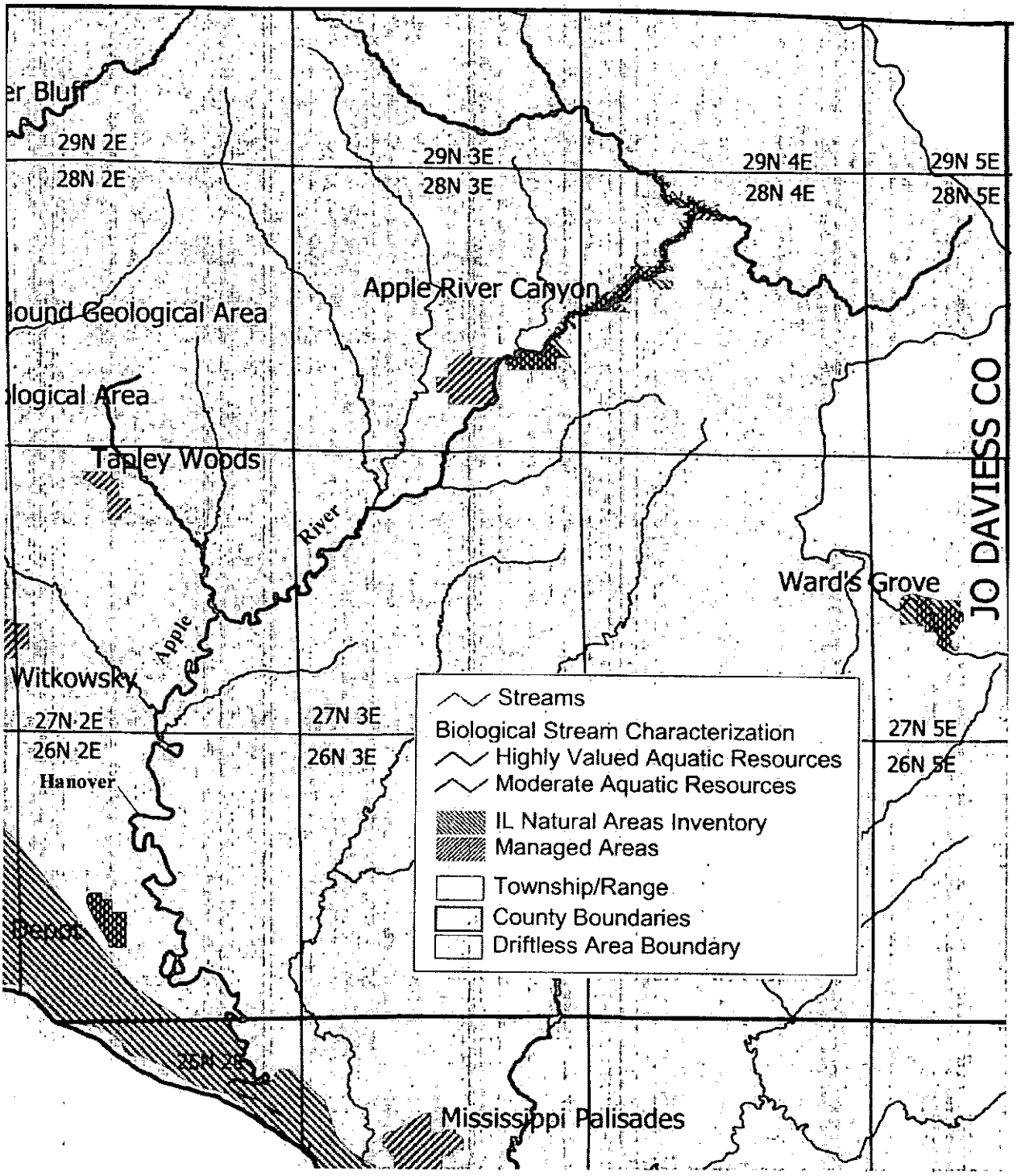
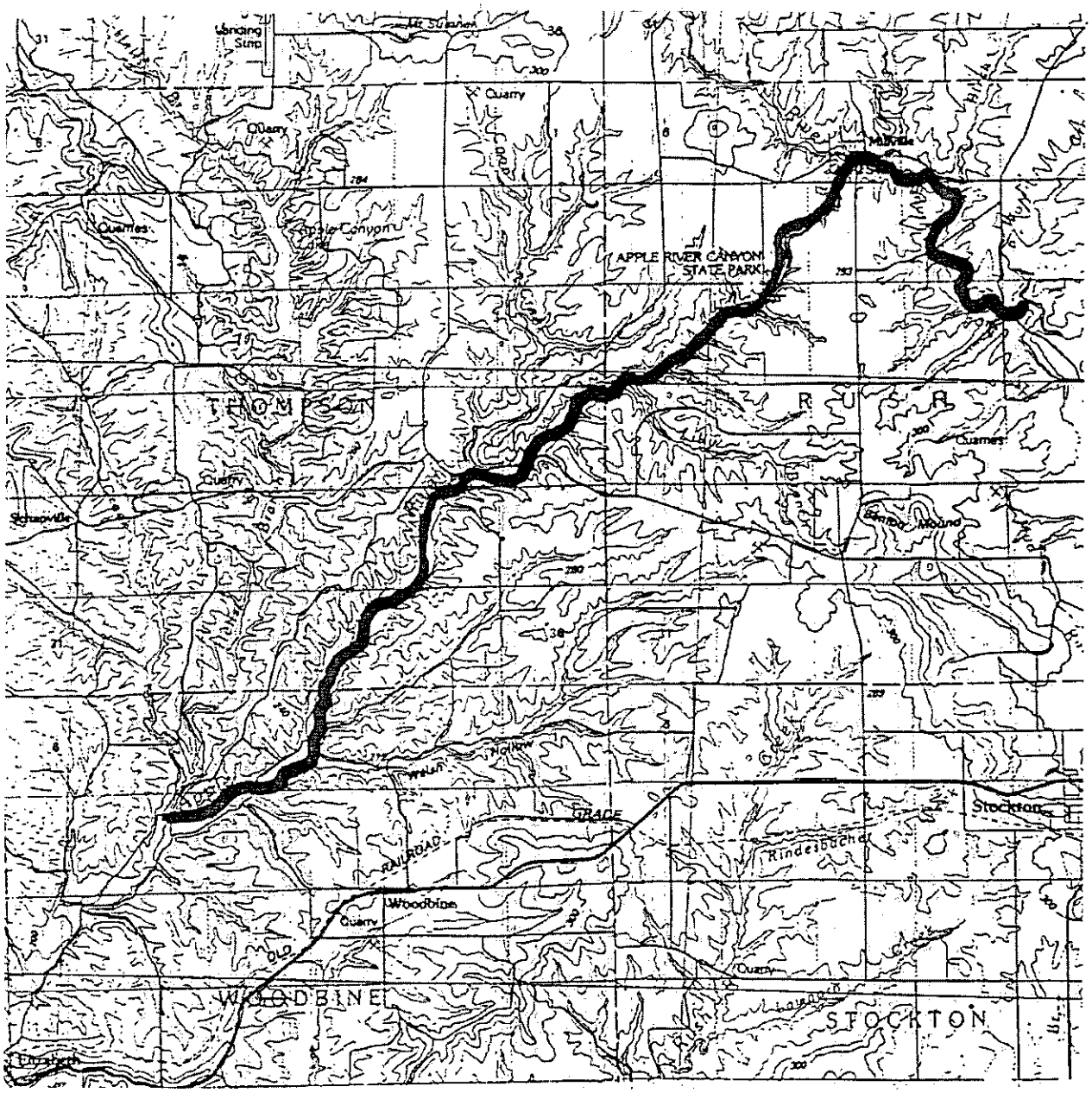


Figure 2. Biologically stream characterization of Apple River; Jo Daviess and Carroll counties, Illinois (From: Hite and Bertrand 1989).



Galena, Apple, and Plum River Systems (Dubuque South 1:100,000)
Apple River, Wolf Creek to Mill Creek, Jo Daviess County, Illinois; based on occurrence of Ozark Minnow and largescale stoneroller.

Figure 3. Biologically Significant Illinois Stream (From: Page *et al.* 1992).

was harnessed to produce energy for the mills. The grist mill was replaced with a large flour mill in 1842 which was subsequently destroyed by fire only six weeks after construction. In 1845, the water power site was purchased by a new owner, who constructed a new dam, saw mill, and flour mill. On March 9, 1868, after 48 hours of steady rain, the Apple River flooded destroying the bridge and a portion of the dam. A third dam was completed in 1868 to again provide energy for the mills at Hanover. This dam was an improvement over its predecessors being a frame structure and made of solid oak; however, by 1887, the need for a new dam was recognized and a fourth dam was constructed. This dam functioned until 1918 when the fifth and present day dam was constructed. The dam provided water power for a large woolen mill, known as Hanover Manufacturing Company, until the mill closed in May 1949. For purposes of this study, the reach of the Apple River above the dam is considered the upper Apple River.

There was relatively little data on the present species composition and abundance of freshwater mussels in the Apple River drainage in Illinois. This prompted a survey by the Illinois Natural History Survey (INHS) of the lower Apple River, i.e., the reach below the dam at Hanover, in summer 2001, which yielded 29 species of freshwater mussels, 22 of which were found live (Sietman *et al.* 2002). Three of these species, i.e., purple wartyback (*Cyclonaias tuberculata*), spike (*Elliptio dilatata*), and black sandshell (*Ligumia recta*), are listed as Threatened in Illinois (Herkert 1992, IESPB 1999). While only dead specimens of *C. tuberculata* and *E. dilatata* were collected, 27 live individuals of *L. recta* were found, including one young specimen (Sietman *et al.* 2002).

Recent surveys (1992-1994) at proposed bridge sites in the upper Apple River, i.e., the reach above Hanover, recorded only 11 unionid species (Wetzel *et al.* 1995 and 1996), which likely reflects the few sites sampled. These collections included live specimens of five species and dead specimens of six species, including the Illinois Threatened *E. dilatata*, suggesting this species was widely distributed in the drainage. There is a 1941 record of slippershell mussel (*Alasmidonta viridis*) from the region, i.e., Galena River (Page *et al.* 1992, INHS Mollusk Collection). *A. viridis* is a headwater species, and *E. dilatata* is often found in low order stream reaches (Cummings and Mayer 1992), thus it was believed that the upper Apple River may harbor extant populations of these species.

The objectives of this study were to determine: 1) the overall species composition of unionids, 2) the distribution and abundance of unionid communities, and 3) the status of Illinois listed

unionids in the upper Apple River above Hanover. This data will provide baseline data to allow future comparison for monitoring of unionid communities, and provide information to resource managers on which to base management and protection goals for the river.

MATERIALS AND METHODS

Unionids were sampled using timed searches to provide a measure of abundance per unit effort at each sample site. This method of sampling not only gives a semi-quantitative measure of unionid abundance for future comparisons, but it is also the best method to measure species richness of unionid communities (Strayer *et al.* 1997, Vaughn *et al.* 1997, Obermeyer 1998).

Unionids were sampled at 16 sites in the upper Apple River basin above Hanover, Jo Daviess County, from 16 to 19 September 2002 and on 6 and 8 May 2003 (Figure 4). One to three people collected unionids by hand during timed searches while wading, snorkeling, and/or with SCUBA. Due to turbid conditions at most sites, searches for unionids were conducted by sweeping hands back and forth on the substrate surface and by probing the substrate to find buried individuals. If habitat at a site was variable, an effort was made to search different habitats. Sites were sampled for 20 to 540 minutes (mean = 130 min). The length of river searched at each site varied from 100 to 760 m. Locations of sampling sites were marked on a map. In addition, UTM coordinates (NAD83, Zones 15-16) were recorded at the approximate center of each site with a Magellan GPS Tracker unit (Appendix 1).

All live, and most dead unionids encountered were placed in a mesh bag until the end of the search period. Dead unionids with dried or decaying tissue, or shiny nacre and intact periostracum were categorized as fresh (recently) dead, those with chalky nacre and worn periostracum, other than normal umbonal erosion, were categorized as weathered dead, and those with extreme wear, little to no periostracum, and often fragmented were categorized as subfossil. The length (anterior-posterior axis) to the nearest millimeter of all live unionids was recorded. Listed species were sexed if possible, and most females were checked to determine if they were gravid. Although they were not targeted in sampling, we also collected aquatic snails, and fingernail clams (Sphareidae) when they were encountered (snails and fingernail clams were not identified, but were vouchered). Unionid nomenclature follows Turgeon et al. (1998), and voucher specimens were deposited in the Illinois Natural History Survey Mollusk Collection,

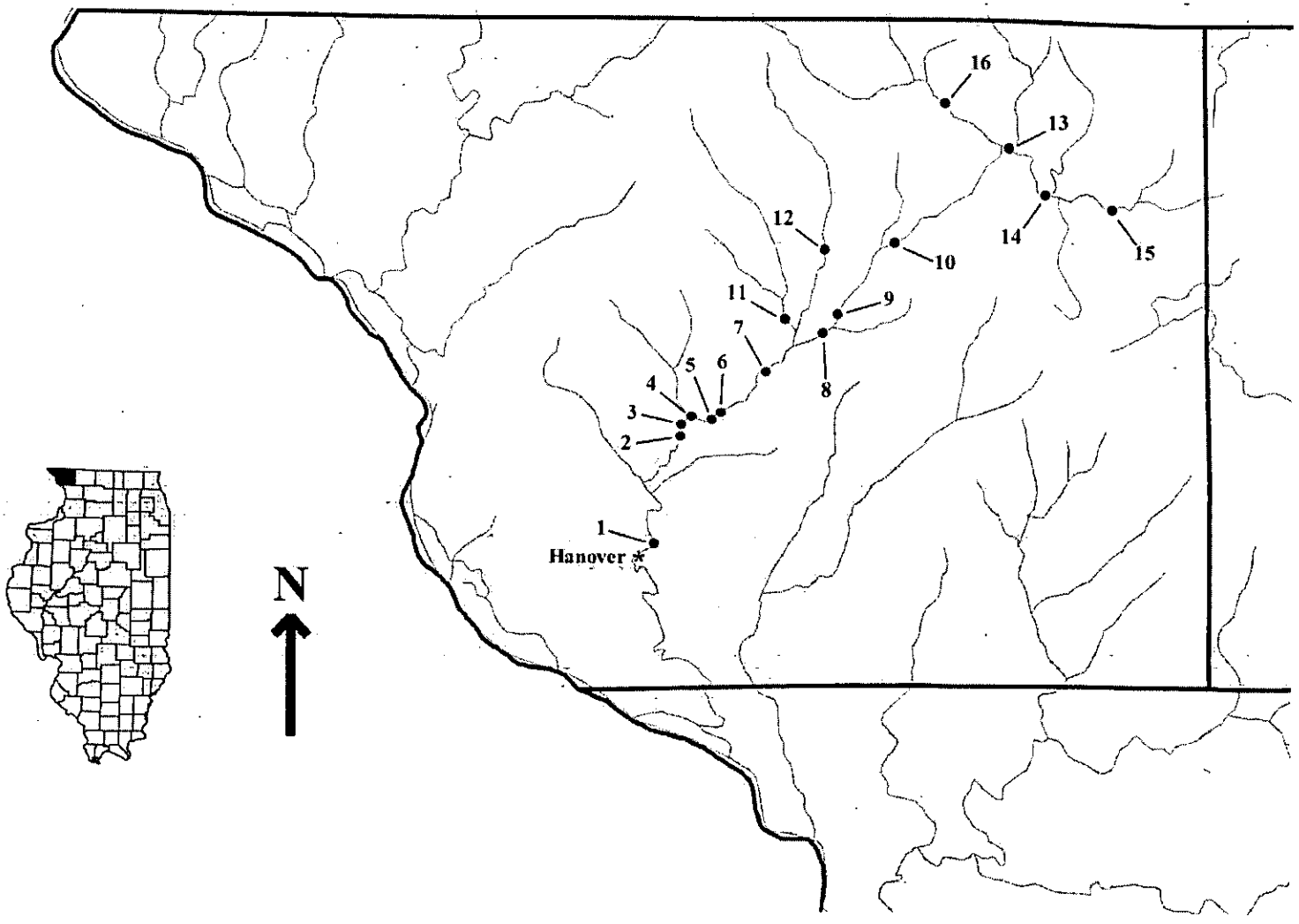


Figure 4.
ionid sampling sites in the upper Apple River, Jo Daviess County, Illinois; 2002-2003.

Un

Champaign, Illinois.

RESULTS AND DISCUSSION

Upper Apple River

In all, 124 live individuals representing 10 species were collected, and an additional three species were collected as weathered shells (Table 1). There is a record of one additional species (*Leptodea fragilis),* from the upper Apple River (Table 1) (Wetzel *et al.* 1996). Live unionids were found at seven of the 16 sites sampled (Table 2, Figure 4). Two of the species (*A. viridis* and *E. dilatata*) are listed as Threatened in Illinois (Herkert 1992, IESPB 1999). *A. viridis* was collected at one site (Site 14) and comprised 1.6% of the community (Tables 1-2). Only weathered shells of *E. dilatata* were collected (Sites 3, 6, 8, and 9). *Lampsilis cardium* (23.4%), *Pyganodon grandis* (16.1%), *Strophitus undulatus* (16.1%), and *Anodontoides ferussacianus* (15.3%) were the most abundant species.

There were gaps in the distribution of unionids along the upper Apple River and composition and abundance were variable where unionids occurred. Catch Per Unit Effort (CPUE) at sites ranged from 0.0 to 14.0 unionids/hour, and species richness ranged from 0 to 8 live species (0 to 10 including dead species). Unionids were more species rich and generally more abundant at Sites 2 - 7 (Figure 4, Table 2). These differences may be due to the complexity and amount of available habitat, especially suitable substrate, at a given site. As noted, the middle reaches of the Apple River flow through a moderately broad floodplain which, along with the bottomland soils, was reflected in the river substrate. The dam at Hanover has likely negatively affected unionids for some distance upstream, as none were found at Site 1 and the river was, for the most part, pooled to just downstream of Site 2. Substrate at Site 1 was firm mud with a thin layer of silt, while substrates at Sites 2 - 7 were generally a mix of areas of silt, sand, gravel, and cobble. The course of the river upstream of a point about 5 km northeast of Elizabeth flows through a narrow valley, with steep bluffs or bedrock cliffs. Sites 8 - 13, and Site 16 lie within this stretch of the river. The substrate of the river along this stretch was generally rock cobble, gravel, or

Table 1. Species composition and relative abundance of unionids in the upper Apple River, Illinois; 16-19 September 2002 and 6 and 8 May 2003. wd = weathered dead, sf = subfossil.

Species	Museum [a]	No. live	% Relative abundance	% Occurrence (live only)	% Occurrence (live + dead)
Subfamily Ambleminae					
Amblema plicata (Threeridge)	wd	10	8.06	12.5	18.8
Elliptio dilatata (Spike) [ST]	wd	wd	0.0	0.0	25.0
Fusconaia flava (Wabash Pigtoe)	wd	12	9.68	25.0	31.3
Pleurobema sintoxia (coccineum) (Round Pigtoe)		sf	0.0	0.0	6.3
Subfamily Anodontinae					
Alasmidonta viridis (Slippershell Mussel) [ST]		2	1.61	6.3	6.3
Anodontoides ferussacianus (Cylindrical Papershell)	wd	19	15.32	12.5	25.0
Lasmigona compressa (Creek Heelsplitter)	wd	5	4.03	18.8	43.8
Pyganodon grandis (Giant Floater)	live	20	16.13	12.5	37.5
Strophitus undulatus (Squawfoot)	live	20	16.13	31.3	37.5
Subfamily Lampsilinae					
Lampsilis cardium (Plain Pocketbook)	live	29	23.39	31.3	37.5
Lampsilis siliquoidea (Fatmucket)	wd	4	3.23	25.0	37.5
Leptodea fragilis (Fragile Papershell)	live	----	----	----	----
Toxolasma parvus (Lilliput)	wd	sf	0.0	0.0	6.3
Venustaconcha ellipsiformis (Ellipse)		3	2.42	12.5	37.5
No. live individuals		124			
No. live species			10	100.0	
Total no. species	11 14			100.0	
CPUE (unionids / hour)			3.6		
Effort (minutes)		2075			

[a] Illinois Natural History Survey Mollusk Collection; specimens collected in upper Apple River.
[ST] = State (Illinois) threatened species.

Table 2. Species composition and abundance of freshwater mussels at sample sites in the upper Apple River, Illinois; 16-19 September 2002 and 6 and 8 May 2003. f d = fresh (recently) dead, wd = weathered dead, sf = subfossil.

	Apple River - Main Stem										Mill Ck.	Hell's Br.	South Fork			North Fork
Species **Site / Station:**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Subfamily Ambleminae																
Amblema plicata (Threeridge)		1	wd			9										
Elliptio dilatata (Spike) [ST]			sf			wd		sf	sf							
Fusconaia flava (Wabash Pigtoe)		1		1	1	9	sf									
Pleurobema sintoxia (coccineum) (Round Pigtoe)			sf													
Subfamily Anodontinae																
Alasmidonta viridis (Slippershell Mussel) [ST]														2		
Anodontoides ferussacianus (Cylindrical Papershell)		fd				1	wd							18		
Lasmigona compressa (Creek Heelsplitter)		2	wd	1	wd	2	wd							fd		
Pyganodon grandis (Giant Floater)		wd	wd	wd	2	wd								18		
Strophitus undulatus (Squawfoot)		6		5	3	5	1							fd		
Subfamily Lampsilinae																
Lampsilis cardium (Plain Pocketbook)		7	wd	8	4	7	3									
Lampsilis siliquoidea (Fatmucket)		1	1	1	wd	1								wd		
Toxolasma parvus (Lilliput)														sf		
Venustaconcha ellipsiformis (Ellipse)				wd		1	2	sf	sf					wd		
Number live individuals	**0**	**18**	**1**	**16**	**10**	**35**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**38**	**0**	**0**
Number live species	**0**	**6**	**1**	**5**	**4**	**8**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**
Total number species	**0**	**8**	**7**	**7**	**6**	**11**	**6**	**2**	**2**	**0**	**0**	**0**	**0**	**8**	**0**	**0**
CPUE (mussels/hour)	**0**						**0**			**0**	**0**	**0**	**0**	**0**	**0**	**0**
Effort (minutes)	**20**	**105**	**120**	**160**	**270**	**150**	**225**	**120**	**55**	**135**	**30**	**45**	**30**	**540**	**30**	**40**

bedrock with no silt or sand. The absence of unionids at these sites may, in large part, be due to the lack of suitable habitat. The middle reach of the South Fork flows through a widening floodplain where once again the river substrates included areas of silt, sand, gravel, and cobble. The presence of unionids at Site 14 likely reflects the suitable habitat found there (Table 2). It is also possible the unionid communities were influenced by changes in the fish community along the course of the river. More diverse or abundant fish communities, especially specific unionid host species, may exist in response to habitat structure, thus having a positive affect on the unionid community.

Several of the species found live had recent recruits to their populations. Length-frequency distributions (Table 3) show that young individuals (≤5 years) were present for 31% of the species found live. This is based on species with individuals <40 mm, including small sized species with individuals <20 mm (i.e., *A. viridis*).

Lower Apple River

Sietman *et al.* 2002, reported 559 live individuals representing 22 species were collected along the lower Apple River, i.e., the reaches below the dam at Hanover. An additional seven species were collected as weathered shells. The addition of 19 species found during that study raised the total number recorded for the Apple River to 30 species. *Lasmigona complanata* (19%) and *Tritogonia verrucosa* (18.6%) were the most abundant species, whereas *Lampsilis siliquoidea, Megalonaias nervosa, Obliquaria reflexa, Quadrula nodulata, Quadrula pustulosa, Toxolasma parvus,* and *Utterbackia imbecillis* were uncommon and represented by only one or two individuals (<1% of the community each)(Sietman *et al.* 2002).

Upper vs. Lower Apple River

There were distinctions in the mussel community between the upper and lower reaches of the Apple River. There were considerably fewer species in the upper river, and mussel community

Table 3. Length frequency (%) distributions for live unionids collected from the upper Apple River, Illinois; 16-19 September 2002 and 6 and 8 May 2003.

Species	Length category (mm)																
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	121-130	131-140	(n)	Mean	Min.	Max.
Subfamily Ambleminae																		
Amblema plicata (Threeridge)	----	----	----	----	----	----	----	----	30.3	50.0	10.0	10.0	----	----	10	93.7	82	111
Ellitptio dilatata (Spike) [ST]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0	----	----	----
Fusconaia flava (Wabash Pigtoe)	----	----	----	8.3	----	16.7	41.7	8.3	25.0	----	----	----	----	----	12	66.8	37	86
Pleurobema sintoxia (coccineum) (Round Pigtoe)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0	----	----	----
Subfamily Anodontinae																		
Alasmidonta viridis (Slippershell Mussel) [ST]	----	50.0	50.0	----	----	----	----	----	----	----	----	----	----	----	2	35.0	30	40
Anodontoides ferussacianus (Cylindrical Papershell)	----	----	----	----	26.3	5.3	36.8	31.6	----	----	----	----	----	----	19	62.8	44	80
Lasmigona compressa (Creek Heelsplitter)	----	----	----	----	----	----	----	----	80.0	----	20.0	----	----	----	5	89.4	83	103
Pyganodon grandis (Giant Floater)	----	----	----	5.0	----	5.0	20.0	30.0	35.0	5.0	----	----	----	----	20	74.9	34	92
Strophitus undulatus (Squawfoot)	----	----	----	----	----	10.0	15.0	30.0	35.0	10.0	----	----	----	----	20	76.9	58	95
Subfamily Lampsilinae																		
Lampsilis cardium (Plain Pocketbook)	----	----	----	3.5	3.5	3.5	3.5	10.3	24.1	6.9	13.8	6.9	13.8	10.3	29	95.6	39	139
Lampsilis siliquoidea (Fatmucket)	----	----	----	----	----	25.0	----	50.0	----	----	----	25.0	----	----	4	82.3	60	118
Toxolasma parvus (Lilliput)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0	----	----	----
Venustaconcha ellipsiformis (Ellipse)	----	----	----	----	----	33.3	66.7	----	----	----	----	----	----	----	3	61.7	56	65

composition differed from that of the lower river. Species such as *A. ferruscianus*, *A. viridis*, *L. compressa*, *L. siliquoidea*, *S. undulatus*, and *V. ellipsiformis* were either exclusively found in the upper river or were relatively more abundant there. *A. plicata* was found in both stream reaches, but individuals in the upper river were characteristically compressed and highly plicated type found in headwaters, whereas those downstream (including just below the dam), were more inflated and had fewer placations. Live specimens of several species, such as *Quadrula quadrula*, *T. verrucosa*, *L. complanata*, *L. recta*, and *Potamilus alatus*, were found just below the dam at Hanover, but were not present, either live or as shells, above there. Also, as noted, *L. complanata* and *T. verrucosa* were the most abundant species found in the lower Apple River. Mussel communities change along the course of streams from headwaters to lower reaches. It is possible, therefore, that there was a more gradual change in the mussel community below and above Hanover historically, but over time however, the dam has apparently created a more abrupt change in the mussel community here.

Listed Species of the Apple River

Live or dead specimens of four Illinois listed species were collected during this study of the upper Apple River and the earlier study of the lower reaches (Sietman *et al.* 2002). The following are brief accounts for each of these species.

Alasmidonta viridis (Illinois Threatened)

The slippershell mussel is a species of creeks and the headwaters of large rivers (Cummings and Mayer 1992). It was found during the present study as live and weathered specimens at Site 14 in the South Fork of the Apple River (Table 2, Figure 4). The slippershell mussel (*A. viridis*) was reported live from one location on the Galena River in 1941 (Page *et al.* 1992, INHS Mollusk Collection). Note: a map in Page *et al.* 1992 (Figure 1-4, Page 22) incorrectly shows the location for this *A. viridis* collection in the Apple River. This species may occur in other nearby stretches of the South Fork.

Cyclonaias tuberculata (Illinois Threatened)

A species of medium and large rivers (Cummings and Mayer 1992), historically the purple wartyback was widely distributed, although not abundant, in the upper Mississippi River, but now is rarely found (van der Schalie and van der Schalie 1950, Havlik and Sauer 2000). No specimens were collected in the upper Apple River, and only a single weathered valve was found in the lower Apple River (Sietman *et al.* 2002). It is unlikely that this species is extant in the river.

Elliptio dilatata (Illinois Threatened)

The spike is a widespread species found in small streams as well as large rivers (Cummings and Mayer 1992). It was apparently well distributed along much of the Apple River as it was collected as weathered shells at four sites (Sites 3, 6, 8, and 9) during this study of the upper reaches (Table 2, Figure 4), and additionally, it was found at four sites in the lower portion of the river (Sietman *et al.* 2002). The lack of recently dead shells of this species suggests it may be extirpated from the Apple River.

Ligumia recta (Illinois Threatened)

A widespread species of medium and large rivers (Cummings and Mayer 1992), the black sandshell presently occurs in only a third of the drainages it historically occupied in Illinois (Cummings and Mayer 1997). *L. recta* was not found in the upper Apple River. However, the species was relatively common along the 8.5-km (5.3-mile) reach immediately below the dam in the lower Apple River; at the four sites sampled along this stretch it accounted for 4.8% of the overall community (Sietman *et al.* 2002).

Summary

The Apple River is home to diverse unionid communities. The addition of four species found live during this study raises the total number of extant species for the Apple River to 26. The addition of *A. viridis* raises the total number of species (live + dead) recorded from the river to 31

species.

As a result of the 2001 study of the lower Apple River (Sietman *et al.* 2002), the 8.5 km stretch of the river below the dam was added to the Illinois Natural Areas Inventory in January 2003, being recognized as a high mussel diversity stream. This was due to the presence of and specific suitable habitat for the Illinois threatened *L. recta* and the presence of 18 species of live unionids found in this section during the study. Also found along this stretch were an additional 11 species that were either recently dead (10) or weathered dead (1).

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