# Freshwater mussel (Bivalvia: Unionidae) survey of four river basins in the Wisconsin Driftless Area of Wisconsin and Illinois

Prepared by:

Jeremy S. Tiemann

Illinois Natural History Survey
Division of Biodiversity and Ecological Entomology
1816 South Oak Street
Champaign, Illinois 61820
Telephone: (217) 244-4594
Fax: (217) 333-4949
Email: jtiemann@inhs.uiuc.edu

ILLINOIS NATURAL HISTORY SURVEY

15 December 2006

Report to:
Illinois Department of Natural Resources
One Natural Resources Way
Springfield, Illinois 62702

Illinois Natural History Survey
Technical Report 2006(7)

# TABLE OF CONTENTS

Chapter 1 – Spatial patterns of freshwater mussel assemblages in three adventitious streams in the Wisconsin Driftless Division ........ 1

Abstract ........ 2
Introduction ........ 2
Methods ........ 4
Results ........ 5
Discussion ........ 6
Acknowledgements ........ 9
Literature Cited ........ 9
Figures ........ 13
Figure 1 (Study area map) ........ 13
Figure 2 (Species area curves for study area) ........ 14
Tables ........ 15
Table 1 (List of unionids for study area) ........ 15
Appendices ........ 16
Appendix 1 (Collecting location from study area) ........ 16
Appendix 2 (Site specific data from study area) ........ 18

Chapter 2 – Freshwater mussel (Bivalvia: Unionidae) survey of the Galena River basin in Wisconsin and Illinois ........ 20

Abstract ........ 21
Introduction ........ 21
Methods ........ 22
Results and Discussion ........ 23
Acknowledgements ........ 28
Literature Cited ........ 28
Figure Legend ........ 31
Figure 1 (Study area map) ........ 31
Figure 2 (Species area curves for study area) ........ 32
Tables ........ 33
Table 1 (List of unionids for study area) ........ 33
Appendices ........ 34
Appendix 1 (Collecting location from study area) ........ 34
Appendix 2 (Site specific data from study area) ........ 36

Plates of Study Area and Study Specimens ........ 39
Plates of Study Area ........ 39
Plates of Study Specimens ........ 42

# SPATIAL PATTERNS OF FRESHWATER MUSSEL ASSEMBLAGES IN THREE ADVENTITIOUS STREAMS IN THE WISCONSIN DRIFTLESS DIVISION

JEREMY S. TIEMANN

*Illinois Natural History Survey, Division of Biodiversity and Ecological Entomology,*

*1816 South Oak Street, Champaign, IL 61820*

Telephone: 217-244-4594 – e-mail: jtiemann@inhs.uiuc.edu

Key Words:

Mollusca, Unionidae, unionids, bivalve, river continuum concept, Menominee River, Little Menominee River, Sinsinawa River

**<This chapter will be submitted to Walkerana>**

ABSTRACT.—The Menominee, Little Menominee, and Sinsinawa rivers are adventitious streams of the Mississippi River basin that occur in the Wisconsin Driftless Division of northwestern Illinois and southwestern Wisconsin. All three basins were sampled for freshwater mussels during 2005-2006 to determine the assemblage composition. Both extant and historic species richness increased with drainage area only in the Sinsinawa River. The interface areas in these three rivers were very diverse sites, and contained more than twice as many species as were found at all other sites. The data suggest that interface areas with their proximal stream influences cause adventitious stream to deviate from the usual river continuum concept.

## INTRODUCTION

Adventitious streams are small tributaries to larger streams that typically are of first to third order and differ in stream-order rank by at least three from the receiving or proximal streams (Vannote *et al.*, 1980; Gorman, 1986). Adventitious streams can “have localized effects of varying magnitude depending upon the volume and nature of the input” (Vannote *et al.*, 1980). The large change in stream order results in abrupt assemblage differences at the interface area and deviates from the river continuum concept (RCC). Specifically, the interface area between an adventitious stream and its proximal stream has macroinvertebrate (Harel and Dorris, 1968) and fish (Whiteside and McNatt, 1972) assemblages similar to those of the proximal stream. These areas usually stray away from the usual hierarchical RCC progression for aquatic life (Gorman, 1986). Although some data are available for macroinvertebrates and fishes in adventitious streams, data are sparse on freshwater mussel assemblage composition in these unique areas.

Freshwater mussels (Bivalvia: Unionidae) are vital component of stream ecosystems (Strayer and Smith, 2003). They act as biological indicators of stream integrity due to their sensitivity to stream disturbances, supply a food source for many animals, offer habitat for algae, aquatic insect larvae, and fishes, and stabilize stream substrate against the scouring effects of floods. However, North American freshwater mussels are among the most rapidly declining groups of organisms on Earth (Williams *et al*., 1993). During the past century, nearly two-thirds of the approximate 300 species have become extinct, federally–listed as endangered or threatened, or determined to be in need of conservation. Freshwater mussels are negatively affected by commercial harvest, anthropogenic disturbances to stream habitats, and invasion of exotic species.

The drastic alteration in freshwater mussel assemblages also is occurring in Illinois. For example, the live species count in the Mississippi River has dropped from its historical number of 51 to its post-1969 number of 32 (Cummings and Mayer, 1997). Although most of the larger river basins have been surveyed in Illinois, many smaller stream basins have not been adequately investigated to assess the fauna. Monitoring the remaining assemblages is vital for natural resource agencies to accurately portray the status of the assemblages (e.g., rare species) and provide baseline data to evaluate the effects of human activities. The freshwater mussel assemblages of the Menominee, Little Menominee, and Sinsinawa river basins were sampled to obtain data on the distribution and abundance of the assemblage; prior to these studies, no comprehensive surveys on the assemblage of these river basins have been conducted.

## METHODS

The Menominee, Little Menominee, and Sinsinawa river basins arise in Grant County, Wisconsin and flow southward before depositing their waters in the Mississippi River in Jo Daviess County, Illinois (Figure 1). Together these three adventitious streams drain approximately 300 $km^2$ of the Wisconsin Driftless Division (herein after Driftless area). The Driftless area encompasses an area of nearly 35,000 $km^2$, and was surrounded on three sides but never covered by late Pleistocene glacial ice. Today the region has undulating topography characterized by steep-sided rocky valleys dissecting uplands with dendritic patterns of small stream development. The headwaters of the river basins are spring-fed creeks that mostly flow through narrow upland limestone and sandstone bluffs with forested ridges; these ridges and escarpments of the larger valleys can have up to 150 m/km vertical relief. Situated between the tallgrass prairie to the west and the deciduous forest to the east, the Driftless area historically was dominated by tallgrass prairie, oak savanna, southern oak forest, and southern mesic forest. Today the region contains agricultural pastures used for grazing and/or row crop agriculture and have riparian areas composed of either grassy or wooded buffer strips. The valley floor is usually dominated by agriculture; stream habitat varies from clear-flowing gravel riffles to hard-packed gravel and cobble runs to silt-laden pools.

Freshwater mussels were collected at 6 to 10 sites in each river basin (Appendix 1) from August 2005 to May 2006. Stations were spaced nearly 2 km apart from the headwaters to the mouths of the basins. The below average water levels during the study period allowed for sampling at the interface areas between the adventitious streams and the Mississippi River. Live freshwater mussels and valves of dead specimens were collected by hand-grabbing while wading through all available habitats for one to four person-hours at each site depending upon the size of the stream and the amount of success. Shell material was classified as live, dead, or relict based on condition of best shell found. All live mussels and shells were identified to species using Cummings and Mayer (1992), with common and scientific names following Turgeon *et al*. (1998), except for the recognition of subspecies. Voucher specimens of each species were deposited in the INHS Mollusk Collection; all live mussels were returned to the stream reach where they were collected.

Extant species richness and historical species richness were calculated for each site in each basin (a species was considered extant if it was represented by live or dead, but not relict, shell material). Regression analysis was used to test whether extant species richness and historical species richness increased with drainage area for each basin. Statistical analyses were preformed with SAS (SAS Version 8, SAS Institute Inc., Cary, NC) and considered significant at $P \leq 0.05$.

## Results

One hundred fourteen individuals from 11 extant species were collected in 56 person hours in the Menominee, Little Menominee, and Sinsinawa river basins; an additional 5 species were collected only as dead or relict shell material (Table 1; Appendix 2). Extant species richness in the Sinsinawa River ranged from 0 to 8 per site and increased significantly ($r^2 = 0.62$, $P = 0.01$) with drainage area, whereas historical species richness ranged from 0 to 12 per site and increased significantly ($r^2 = 0.65$, P =

0.009) with drainage area (Figure 2). Species richness was not significantly related to drainage area for the Menominee or Little Menominee river basins.

## Discussion

A positive relationship has been shown to exist between species richness and drainage area for fishes (Edds, 1993) and freshwater mussels (Watters, 1992), including freshwater mussels in the Sinsinawa River basin. The data suggest that freshwater mussel assemblages were more abundant and species rich near the Mississippi River and extended upstream as far as fish hosts and habitat quality allowed. Longitudinal variations in aquatic assemblages are related to the abundance of their preferred habitats (Vannote *et al*., 1980). Species richness for both fish and freshwater mussels typically increases as a function of enlarging drainage area, which usually offers decreased gradients and expanded habitat complexities; freshwater mussels are further benefited by the increase in fish diversity to offer suitable glochidia hosts. Streams in the Driftless area are typically dominated by a high diversity of cyprinids, catostomids, ictalurids, centrarchids, and percids (Lyons, 1996).

The longitudinal pattern did not exist for freshwater mussels in the Menominee and Little Menominee river basins and appeared to be the result of habitat within the headwaters of the basins. Mathiak (1979) suggested that the Driftless area of southwestern Wisconsin lacks freshwater mussels because of poor habitat. Very little sand, gravel, or pebble existed in the Menominee and Little Menominee river basins, which seems to have accounted for the dearth of headwater species (e.g., lilliput *Toxolasma parvus*) in the upstream portions of these basins. The majority of the habitat in these areas was clay/silt-laden cobble and boulder with patches of bare bedrock or clay hardpan. Even though freshwater mussels can colonize these habitats (Sietman *et al*., 1999), it is sub-optimal habitat. The Sinsinawa River had small patches of sand, gravel, and pebble throughout the basin, which might explain why a few individuals were collected throughout the basin.

Site-specific conditions can alter aquatic assemblage structure and confound efforts to obtain an accurate holistic view of the stream continuum concept (Minshall *et al*., 1985). This pattern has been stated for macroinvertebrates (Harel and Dorris, 1968) and fishes (Whiteside and McNatt, 1972) in adventitious streams, and was evident for freshwater mussels at the interface areas between the Sinsinawa River and the Mississippi River. Schaefer and Kerfoot (2004) suggested that species richness is affected by events that occur at larger spatial scales (e.g., interactions between the proximal river fauna and the adventitious stream fauna). Both the proximal riverine fish and freshwater mussel faunas affected the freshwater mussel assemblage at the interface area in the Sinsinawa River. This area contained what Cummings and Mayer (1992) described as large river species (e.g., threehorn wartyback *Obliquaria reflexa* and hickorynut *Obovaria olivaria*), and many of these species use riverine fishes (e.g., shovelnose sturgeon *Scaphirhynchus platorynchus*, flathead catfish *Pylodictis olivaris,* and freshwater drum *Aplodinotus grunniens*) as hosts (Watters, 1994). A similar pattern was observed for the interface areas in the Menominee and Little Menominee rivers, and has been described in other stream systems (van der Schalie, 1938). Therefore, proximal riverine fishes probably moved into and out of these interface areas from the Mississippi River and dropped glochidia. Possible explanations for this hypothesis include 1) tributaries are often used as spawning nursery areas by the riverine fishes (Schaefer and Kerfoot, 2004), 2) interface areas offer low velocity refuges for riverine fishes (Barko *et al*., 2000), and 3) fish vagility is high and assemblage composition is seasonally dynamic in areas where habitat heterogeneity is low (Gorman, 1986). Also, the interface areas between these three adventitious streams and Mississippi River was fairly uniform (sand with patches of mud) and appeared stable, and therefore offered suitable habitat for freshwater mussels. This pattern of habitat has been observed for other adventitious streams (Gorman, 1986).

Several anthropogenic disturbances, including dredging, mining, poor agricultural practices, bridge construction, and logging were occurring throughout the Menominee, Little Menominee, and Sinsinawa river basins. Species richness of macroinvertebrates (Weigel, 2003) and fishes (Wang *et al*., 1997) in the Driftless area has been shown to respond to watershed conditions; these groups of animals were negatively linked to organic pollution and siltation (e.g., increases in cattle grazing, barnyard runoff, intensive row-crop farming, urban areas, and mine tailings, and reductions in wetlands and riparian cover). These types of disturbances also have been shown to alter stream habitat (e.g., Tiemann, 2004) and change freshwater mussel assemblages (e.g., Aldridge, 2000). However, after anthropogenic disturbances have subsided in adventitious streams, flash floods, which are common in the Driftless area (Mathiak, 1979), can restore habitat to pre-disturbance conditions (Tiemann, 2004).

Conservation work is underway to preserve and restore the streams in the Driftless area. If the anthropogenic disturbances are reduced or eliminated, and suitable habitat is created, then freshwater mussels have a chance to colonize the upstream portions of the Menominee, Little Menominee, and Sinsinawa river basins from nearby areas. The Lost Mound Unit of the Upper Mississippi River National Wildlife and Fish Refuge, located downstream of the study area, was reported to have 26 extant species (37 historic species) of freshwater mussels (Sietman *et al*., 2004). Many of these species (e.g., *T. parvus*) are found in the Mississippi River at the confluences of the Menominee, Little Menominee, and Sinsinawa rivers (Tiemann, unpublished data), and also are commonly found in small streams (Cummings and Mayer, 1992). Therefore, given proper conditions (e.g., optimal habitat and extant fish hosts), these species could serve as source populations for the Menominee, Little Menominee, and Sinsinawa river basins.

The streams in the study area are relatively small (a total of 300 $km^2$ for the three streams) compared to other adventitious stream studies (e.g., 320 $km^2$ for one stream in Schaefer and Kerfoot [2004]). The freshwater mussel assemblage dynamics appeared to be the result of the stream's drainage area size and habitat characteristics. Additional studies are underway to address the freshwater mussel assemblage dynamics of adventitious stream basins with varying drainage area sizes and habitat characteristics.

*Acknowledgments*.— The Illinois Department of Natural Resources (IL-DNR) partially funded the project through an Illinois Wildlife Preservation Fund Grant (#06-34W), whereas other funding was provided by the Illinois Department of Transportation. The Wisconsin Department of Natural Resources issued a Wisconsin collecting permit. F. Hutto (INHS) assisted in map creation. K.S. Cummings (INHS), G.A. Levin (INHS), R.E. Szafoni (IL-DNR), D.L. Thomas (INHS), and B.L. Tiemann offered constructive comments.

## LITERATURE CITED

ALDRIDGE, D.C. 2000. The impacts of dredging and weed cutting on a population of freshwater mussels (Bivalvia: Unionidae). Biological Conservation 95:247-257.

BARKO, V.A., M.W. PALMER, AND D.P. HERZOG. 2004. Influential environmental gradients and spatiotemporal patterns of fish assemblages in the unimpounded upper Mississippi River. American Midland Naturalist 152:369-385.

CUMMINGS, K.S. AND C.A. MAYER. 1992. Field guide to freshwater mussels of the Midwest. Manual 5. Illinois Natural History Survey, Champaign. 194 pp.

CUMMINGS, K.S. AND C.A. MAYER. 1997. Distributional checklist and status of Illinois freshwater mussels (Mollusca: Unionacea). pp. 129-145 *in* K.S. Cummings, A.C. Buchanan, C.A. Mayer, and T.J. Naimo, eds. Conservation and management of freshwater mussels II: initiatives for the future. Proceedings of a UMRCC Symposium, 16-18 October 1995, St. Louis, Missouri. Upper Mississippi River Conservation Committee, Rock Island, Illinois. 293 pp.

EDDS, D.R. 1993. Fish assemblage and environmental correlates in Nepal's Gandaki River. Copeia 1993:48-60.

GORMAN. O.T. 1986. Assemblage organization of stream fishes: the effect of rivers on adventitious streams. American Naturalist 128:611-616.

HAREL, R.C. AND T.C. DORRIS. 1968. Stream order, morphometry, physio-chemical conditions and community structure of benthic macroinvertebrates in an intermittent stream system. American Midland Naturalist 80:220-251.

LYONS, J. 1996. Patterns in the species composition of fish assemblages among Wisconsin streams. Environmental Biology of Fishes 45(4):329-341.

MATHIAK, H.A. 1979. A river survey of the Unionid mussels of Wisconsin 1973-1977. Sand Shell Press. Horicon, Wisconsin. 75 pp.

MINSHALL, G.W., K.W. CUMMINS, R.C. PETERSEN, C.E. CUSHING, D.A. BRUNS, J.R.

SEDELL, AND R.L. VANNOTE. 1985. Developments in stream ecosystem theory. Canadian Journal of Fisheries and Aquatic Sciences 42:1045-1055.

SCHAEFER, J.F. AND J.R. KERFOOT. 2004. Fish assemblage dynamics in an adventitious stream: a landscape perspective. American Midland Naturalist 151:134-145.

SIETMAN, B.E., E.A. ANDERSON, R. NŸBOER, AND F.R. HUTTO. 2004. Native freshwater mussels (Bivaliva: Unionidae) and infestation by zebra mussels at the Lost Mound Unit of the Upper Mississippi River Nation al Wildlife and Fish Refuge. Transactions of the Illinois State Academy of Science 97:234-254.

SIETMAN, B.E., M.A. FURMAN, AND F.A. PURSELL. 1999. Colonization of bedrock by freshwater mussels (Bivalvia: Unionidae). American Midland Naturalist 141:209-211.

STRAYER, D.L. AND D.R. SMITH. 2003 A guide to smapling freshwater mussel populations. American Fisheries Society, Monograph 8, Bethesda, Maryland. 103 pp.

TIEMANN, J.S. 2004. Short-term effects of logging and bridge construction on habitat in two Kansas streams. Transactions of the Kansas Academy of Science 107(3/4):136-142.

TURGEON, D.D., A.E. BOGAN, E.V. COAN, F.G. HOCHBERG, W.G. LYONS, P.M. MIKKELSEN, J.F. QUINN, JR., C.F.E. ROPER, G. ROSENBERG, B. ROTH, A. SCHELTEMA, M.J. SWEENEY, F.G. THOMPSON, M. VECCHIONE AND J.D. WILLIAMS. 1998. Common And Scientific Names Of Aquatic Invertebrates From The United States And Canada: Mollusks. 2nd Edition. American Fisheries Society, Special Publication 26, Bethesda, Maryland. 526 pp.

VAN DER SCHALIE, H. 1938. The naiad fauna of the Huron River, in southeastern Michigan. Miscellaneous Publications, Museum of Zoology, University of Michigan 40:1-83.

VANNOTE, R.L., G.W. MINSHALL, K.W. CUMMINS, J.R. SEDELL, AND C.E. CUSHING. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

WANG, L. J. LYONS, P. KANEHL, AND R. GATTI. 1997. Influences of watershed land use on habitat quality and biotic integrity in Wisconsin streams. Fisheries 22(6):6-12.

WATTERS, G.T. 1992. Unionids, fishes, and the species-area curve. Journal of Biogeography 19:481-490.

WATTERS, G.T. 1994. An annotated bibliography of the reproduction and propagation of the Unionoidea (primarily of North American). Ohio Biological Survey Miscellaneous Contributions Number 1.

WEIGEL, B.M. 2003. Development of stream macroinvertebrate models that predict watershed and local stressors in Wisconsin. Journal of North American Benthological Society 22(1):123-142.

WHITESIDE, B.G. AND R.M. MCNATT. 1972. Fish species diversity in relation to stream order and physiochemical conditions in the Plum Creek drainage basin. American Midland Naturalist 88:90-101.

WILLIAMS, J.D., M.L. WARREN, K.S. CUMMINGS, J.L. HARRIS, AND R.J. NEVES. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18(9):6-22.

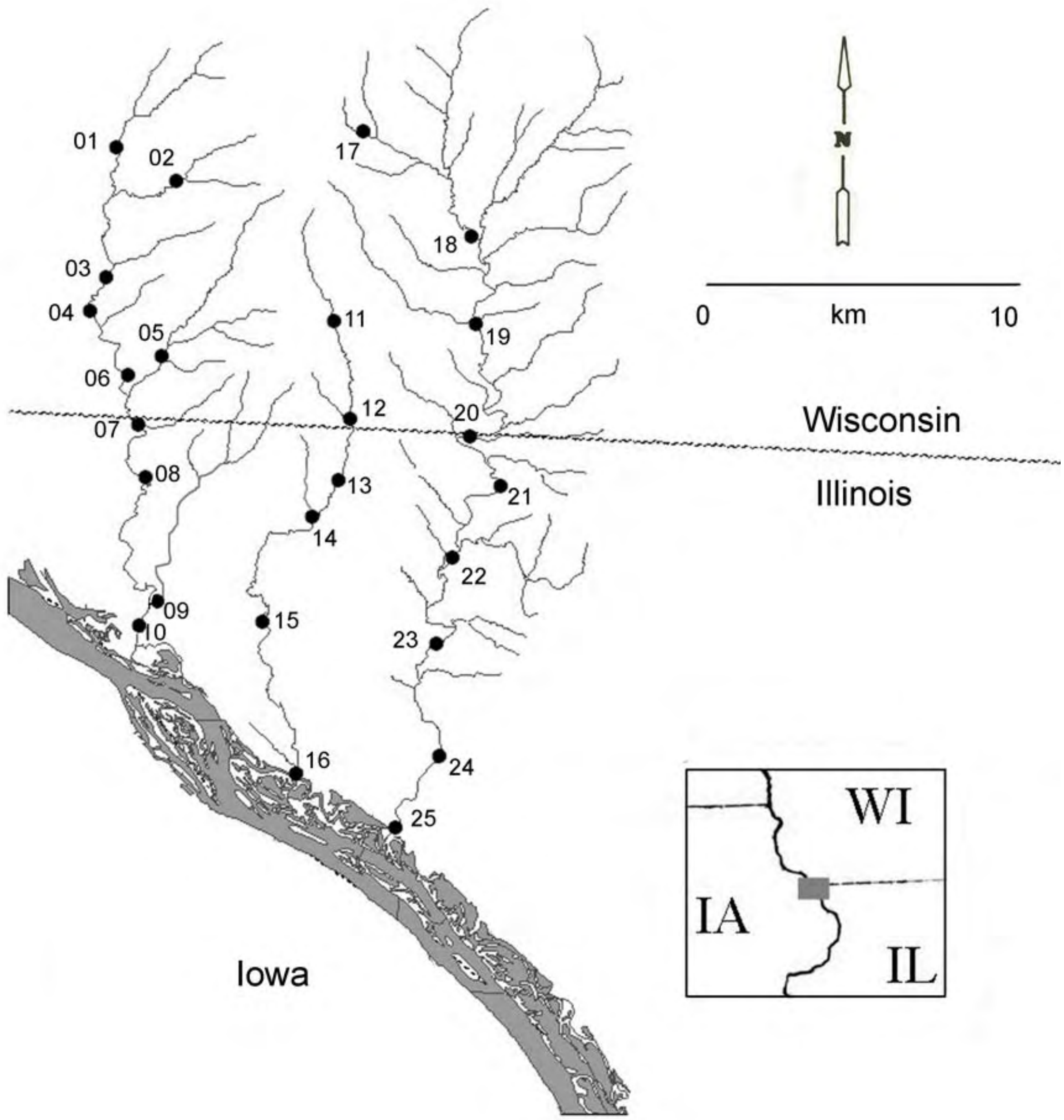



FIGURE 1.—Map of the Menominee (Sites 1-10), Little Menominee (Sites 11-16), and Sinsinawa (Sites 17-25) river basins.

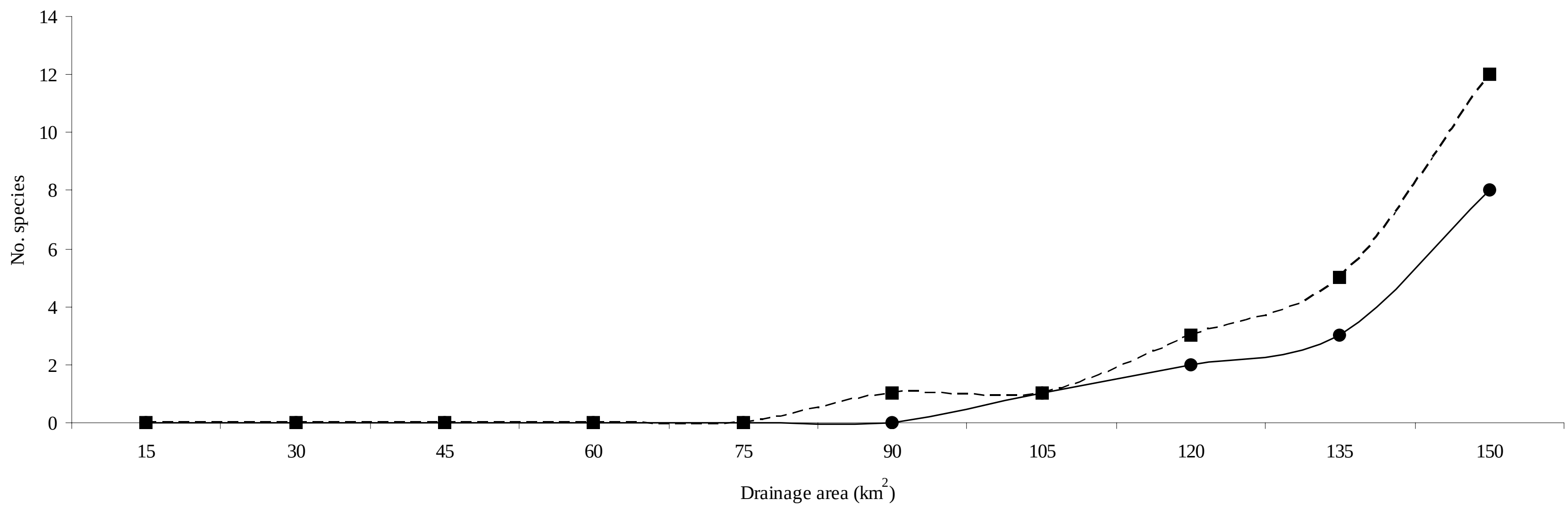



FIGURE 2.—Extant (solid line with circles) and historic (dashed line with squares) species richness area curves for freshwater mussels in the Sinsinawa River.

TABLE 1.—Native freshwater mussels collected in the Wisconsin Driftless Division during the 2005-2006 surveys of the Menominee River (Men), the Little Menominee River (Lil), and the Sinsinawa River (Sin) basins in Illinois and Wisconsin. See appendices for site-specific data. Numbers within a given species row represent the number of individuals that species was collected alive, "D" indicates those species collected only as dead specimens, "R" signifies those species collected only as relict specimens.

| Scientific name | Common name | Men | Lil | Sin |
|---|---|---|---|---|
| Anodontinae | | | | |
| *Arcidens confragosus* (Say, 1829) | Rock pocketbook | | R | |
| *Lasmigona complanata* (Barnes, 1823) | White heelsplitter | | R | 3 |
| *Pyganodon grandis* (Say, 1829) | Giant floater | 3 | 8 | 14 |
| *Utterbackia imbecillis* (Say, 1829) | Paper pondshell | D | D | |
| Ambleminae | | | | |
| *Amblema plicata* (Say, 1817) | Threeridge | 2 | 5 | 3 |
| *Fusconaia flava* (Rafinesque, 1820) | Wabash pigtoe | 1 | 4 | R |
| *Quadrula pustulosa* (Lea, 1831) | Pimpleback | 1 | 6 | 1 |
| *Quadrula quadrula* (Rafinesque, 1820) | Mapleleaf | 2 | 12 | 3 |
| *Tritogonia verrucosa* (Rafinesque, 1820) | Pistolgrip | | | R |
| Lampsilinae | | | | |
| *Lampsilis cardium* Rafinesque, 1820 | Plain pocketbook | | R | R |
| *Leptodea fragilis* (Rafinesque, 1820) | Fragile papershell | 2 | 4 | 10 |
| *Obliquaria reflexa* (Rafinesque, 1820) | Threehorn wartyback | 4 | 10 | 7 |
| *Obovaria olivaria* (Rafinesque, 1820) | Hickorynut | | 1 | |
| *Potamilus alatus* (Say, 1817) | Pink heelsplitter | | 1 | |
| *Toxolasma parvus* (Barnes, 1823) | Lilliput | D | D | 7 |
| *Truncilla truncata* Rafinesque, 1820 | Deertoe | | | R |

APPENDIX 1.—Collecting locations for the 2005-2006 freshwater mussel surveys of Wisconsin Driftless Division rivers in Illinois and Wisconsin. "FWM" is native freshwater mussel material, if any, collected at that site during this survey, with "L" signifying number of species collected alive and "V" referring to number of species collected only as valves during this survey. Effort is in person-hours.

| Site | Drainage | State: County | Stream | Common location | Latitude, Longitude | FWM | Effort |
|---|---|---|---|---|---|---|---|
| 01 | Menominee | WI: Grant | Kieler Creek | 6 km SSW Dickeyville | 42.5735, -90.6010 | L (0), V (0) | 1 |
| 02 | | | Louisburg Creek | 7 km SSE Dickeyville | 42.5663, -90.5811 | L (0), V (0) | 1 |
| 03 | | | Menominee River | 10 km SSW Dickeyville | 42.5426, -90.6026 | L (0), V (0) | 2 |
| 04 | | | Menominee River | 11 km SSW Dickeyville | 42.5342, -90.6073 | L (0), V (0) | 2 |
| 05 | | | Hollow Branch | 11 km SSE Dickeyville | 42.5242, -90.5836 | L (0), V (0) | 1 |
| 06 | | | Menominee River | 12 km S Dickeyville | 42.5193, -90.5943 | L (0), V (0) | 2 |
| 07 | | IL: Jo Daviess | Menominee River | 5 km NE East Dubuque | 42.5074, -90.5902 | L (0), V (0) | 2 |
| 08 | | | Menominee River | 5 km E East Dubuque | 42.4950, -90.5871 | L (0), V (0) | 2 |
| 09 | | | Dixon Creek | 6 km SE East Dubuque | 42.4653, -90.5818 | L (0), V (0) | 1 |
| 10 | | | Menominee River | 5 km SE East Dubuque | 42.4651, -90.5839 | L (7), V (2) | 4 |
| 11 | Little Menominee | WI: Grant | Little Menominee River | 2 km NE Sinsinawa | 42.5341, -90.5283 | L (0), V (0) | 2 |
| 12 | | | Little Menominee River | 3 km SE Sinsinawa | 42.5110, -90.5218 | L (0), V (0) | 2 |
| 13 | | IL: Jo Daviess | Little Menominee River | 2 km NE Menominee | 42.4963, -90.5247 | L (0), V (0) | 2 |
| 14 | | | Little Menominee River | Menominee | 42.4871, -90.5324 | L (0), V (0) | 2 |
| 15 | | | Little Menominee River | 3 km SW Menominee | 42.4616, -90.5473 | L (0), V (0) | 2 |
| 16 | | | Little Menominee River | 7 km S Menominee | 42.4255, -90.5344 | L (9), V (5) | 4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 17 | Sinsinawa | WI: Grant | Sinsinawa River | 8 km NW Hazel Green | 42.5800, -90.5211 | L (0), V (0) | 2 |
| 18 | | | Sinsinawa River | 5 km NW Hazel Green | 42.5559, -90.4847 | L (0), V (0) | 2 |
| 19 | | | Sinsinawa River | 4 km W Hazel Green | 42.5349, -90.4821 | L (0), V (0) | 2 |
| 20 | | | Sinsinawa River | 5 km WSW Hazel Green | 42.5079, -90.4826 | L (0), V (1) | 2 |
| 21 | | IL: Jo Daviess | Sinsinawa River | 10 km NNW Galena | 42.4962, -90.4723 | L (1), V (0) | 2 |
| 22 | | | Sinsinawa River | 9 km NNW Galena | 42.4788, -90.4868 | L (2), V (0) | 2 |
| 23 | | | Sinsinawa River | 7 km NW Galena | 42.4579, -90.4906 | L (2), V (1) | 4 |
| 24 | | | Sinsinawa River | 5.5 km WNW Galena | 42.4311, -90.4884 | L (3), V (2) | 4 |
| 25 | | | Sinsinawa River | 6 km W Galena | 42.4135, -90.5017 | L (8), V (4) | 4 |

APPENDIX 2.—Site-specific data for only those locations where freshwater mussels were collected during the 2005-2006 freshwater mussel surveys of Wisconsin Driftless Division rivers in Illinois and Wisconsin. "Site No." is the site number, which is referenced in Appendix 1. Numbers within a given species row represent the number of individuals that species was collected alive, "D" indicates those species collected only as dead specimens, and "R" signifies those species collected only as relict specimens. Abundance is the total number of live unionids, extant species richness is the number of species represented by live or dead shell material, and historical species richness is the total number of species found. Effort is in person-hours.

| | Site No. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species | 10 | 16 | 20 | 21 | 22 | 23 | 24 | 25 |
| Anodontinae | | | | | | | | |
| *Arcidens confragosus* | | R | | | | | | |
| *Lasmigona complanata* | | R | | | | 1 | 1 | 1 |
| *Pyganodon grandis* | 3 | 8 | | | 2 | 2 | 2 | 8 |
| *Utterbackia imbecillis* | D | D | | | | | | |
| Ambleminae | | | | | | | | |
| *Amblema plicata* | 2 | 5 | | | | | R | 3 |
| *Fusconaia flava* | 1 | 4 | | | | | | R |
| *Quadrula pustulosa* | 1 | 6 | | | | | | 1 |
| *Quadrula quadrula* | 2 | 12 | | | | | | 3 |
| *Tritogonia verrucosa* | | | | | | | | R |
| Lampsilinae | | | | | | | | |
| *Lampsilis cardium* | | R | | | | | R | R |
| *Leptodea fragilis* | 2 | 4 | | | | | 5 | 5 |
| *Obliquaria reflexa* | 4 | 10 | | | | | | 7 |
| *Obovaria olivaria* | | 1 | | | | | | |
| *Potamilus alatus* | | 1 | | | | | | |
| *Toxolasma parvus* | D | D | D | 3 | 1 | D | | 3 |
| *Truncilla truncata* | | | | | | | | R |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Abundance | 15 | 51 | 0 | 3 | 3 | 3 | 8 | 31 |
| Extant species richness | 7 | 9 | 0 | 1 | 2 | 2 | 3 | 8 |
| Historical species richness | 9 | 14 | 1 | 1 | 2 | 3 | 5 | 12 |
| Effort | 4 | 4 | 2 | 2 | 2 | 4 | 4 | 4 |

# Freshwater Mussel (Bivalvia: Unionidae) Survey of the Galena River Basin in Wisconsin and Illinois

**JEREMY S. TIEMANN**

Illinois Natural History Survey

Division of Biodiversity and Ecological Entomology

1816 South Oak Street, Champaign, Illinois 61820

Correspondence: jtiemann@inhs.uiuc.edu

**<This chapter will be submitted to Prairie Naturalist>**

**ABSTRACT --** The freshwater mussel assemblage of the Galena River basin in Wisconsin and Illinois was investigated during a 2005-2006 survey. Twenty-seven live individuals representing five species were collected during 47 person-hours of sampling at 28 stations; 20 additional species, including the state threatened slippershell mussel *Alasmidonta viridis* and spike *Elliptio dilatata*, also were found but only as valves. Freshwater mussels were evident at 18, or 64%, of the sites. Extant and historic species richness differed significantly ($t_{0.05(1), 27} = 2.87$, $P = 0.004$) suggesting that, over time, the freshwater mussel assemblage has been decimated. The results appear to be more drastic compared to other river basins in the Wisconsin Driftless division.

**Key Words:** Mollusca, unionids, bivalve, Wisconsin Driftless Division

The Wisconsin Driftless Division (herein after Driftless area), an area of nearly 35,000 km$^2$, was surround but never covered by late Pleistocene glacial ice. Today, the area has rolling topography characterized by steep-sided (up to150 m/km vertical relief) limestone/sandstone valleys, forested ridges, and streams that have spring-fed headwaters. Situated between the tallgrass prairie to the west and the deciduous forest to the east, the Driftless area historically was dominated by tallgrass prairie, oak savanna, southern oak forest, and southern mesic forest. Today, the region has agricultural fields (e.g., row crops or grazing pastures) that have riparian areas composed of either grassy or woody buffer strips.

The Galena River, one of the streams in the Driftless area, drains nearly 525 km$^2$. The stream originates in Grant and Lafayette counties, Wisconsin, and flows south-

southwest through Jo Daviess County, Illinois, until reaching the Mississippi River (Figure 1). The Galena River basin contains a unique fish assemblage, including Ozark minnow *Notropis nubilus* and longnose dace *Rhinichthys cataractae*, which only are found in a few basins in Wisconsin and Illinois. Monitoring aquatic assemblages is vital for natural resource agencies to accurately assess their statuses (e.g., rare species) and provide baseline data to evaluate the effects of human activities. However, not all aquatic assemblages, including the freshwater mussel (Bivalvia: Unionidae) assemblage, in the basin have been adequately sampled. Freshwater mussels of the Galena River basin were sampled to determine distribution and structure of the assemblage. Prior to this study, no comprehensive survey on the freshwater mussel assemblage of the Galena River basin had been conducted. Data collected will allow future comparisons for monitoring the assemblage and provide information on which to base management goals for the river basin.

## METHODS

Freshwater mussels were collected at 28 sites in the Galena River basin (Figure 1; Appendix 1) during August 2005 and August 2006. Live freshwater mussels and valves of dead specimens were collected by hand-grabbing for one to two person-hours at each site depending upon the size of the stream and the amount of success; this technique allowed for greater coverage of the study area. Sampling occurred while wading through all available habitats but primarily took place in areas that appeared likely to support freshwater mussels. No effort was made to sample ponds/lakes or wetlands in the basin. Below average water levels during summer 2005 allowed sampling in the channelized, lower portions of the basin. Global Positioning System coordinates were obtained at each site using a Garmin GPS 12 XL (Garmin International, Romsey, Hampshire, United Kingdom). Shell material was classified as live, fresh dead (shiny nacre), or relict (chalky nacre) based on condition of best specimen found. All specimens were identified to species using Cummings and Mayer (1992), with common and scientific names following Turgeon et al. (1998), except for the recognition of subspecies. All live individuals were counted and then returned to the stream reach from which they came.

Extant species richness, historical species richness, and assemblage abundance were calculated for each site. Extant species richness was figured as the number of species represented by live or fresh dead shell material, historical species richness was determined as the total number of species found, including museum records (e.g., Illinois Natural History Survey [INHS] Mollusk Collection, Champaign), and abundance was calculated as catch-per-unit-effort (CPUE). Regression analysis was used to test if extant species richness, historical species richness, and assemblage abundance increased from upstream to downstream in the basin, and a *t*-test was applied to determine if extant species richness was significantly lower than historic species richness in the basin. Statistical analyses were preformed with SAS (SAS Version 8, SAS Institute Inc., Cary, NC) and considered significant at $P \leq 0.05$.

## RESULTS AND DISCUSSION

A total of 27 live individuals representing five species was collected in 47 person-hours in the Galena River; 20 additional species, including the state threatened slippershell mussel *Alasmidonta viridis* and spike *Elliptio dilatata* (IESBP 2005), also were found but only as valves (Table 1, Appendix 2). Freshwater mussels were evident at 18, or 64%, of the 28 sites (Appendix 1). CPUE in the Galena River basin ranged from zero to three individuals per hour per station (Appendix 2), and did not increase significantly ($r^2$ = 0.06, $F_{0.05(2), 1, 27}$ = 1.53, $P$ = 0.23) from upstream to downstream (Figure 2a). Giant floater *Pyganodon grandis* was the most abundant and widely distributed species (12 individuals from six sites) followed by white heelsplitter *Lasmigona complanata* (five individuals from five sites), plain pocketbook *Lampsilis cardium* (five individuals from three sites), creek heelsplitter *Lasmigona compressa* (three individuals from two sites), and lilliput *Toxolasma parvus* (two individuals from two sites) (Appendix 2). Excluding *L. compressa*, the species found live are widespread and common throughout streams in the Midwest; *L. compressa* occasionally is found in small streams in the region (Cummings and Mayer 1992). Most of the specimens found were relict valves (Table 1, Appendix 2). Based on historical records, there appeared to be distribution gaps for most species (e.g., *A. viridis*, *T. parvus*, and ellipse *Venustaconcha ellipsiformis*) in the basin, whereas other species (e.g., pistolgrip *Tritogonia verrucosa*, pink heelsplitter *Potamilus alatus*, and threehorn wartyback *Obliquaria reflexa*) probably were not widely distributed (e.g., found only in the lower portions). The extant species in the basin are in small, isolated populations, which could hinder reproduction and recolonization efforts.

No live threatened or endangered species were found; however, two state-threatened species, *A. viridis* and *E. dilatata* (IESBP 2005), were found throughout the basin. Both *A. viridis* and *E. dilatata* were once widely distributed in the Midwest, but now are sporadic in their distributions (Cummings and Mayer 1992).

The number of extant species in the Galena River basin ranged from zero to three species per station, whereas the number of historic species varied from zero to 11 species (Appendix 1; Appendix 2). The difference in species richness between historic and extant ranged from zero to 11 species. Extant species richness and historic species richness differed significantly ($t_{0.05(1), 27} = 2.87$, $P = 0.004$) suggesting that the freshwater mussel assemblage has drastically declined. There was a linear increase in extant species richness ($r^2 = 0.21$, $F_{0.05(2), 1, 27} = 6.97$, $P = 0.02$) and historic species richness ($r^2 = 0.58$, $F_{0.05(2), 1, 27} = 36.21$, $P < 0.0001$) from upstream to downstream (Figure 2b). This positive relationship between species richness and drainage area has been shown to exist for fishes (Edds 1993) and freshwater mussels (Watters 1992). Expanding drainage areas usually offer decreased gradients, more habitat complexities, and higher fish diversity to serve as glochidia hosts (Vannote et al. 1980; Watters 1992). No evidence of freshwater mussels was found in the middle portions of the basin, and likely is the result of sub-optimal habitat (e.g., silt-laden cobble) in the area.

The temporal decline in species richness in the Galena River basin (80%) is substantially greater than other basins in the Driftless area region. The Apple River basin (Wisconsin and Illinois) has a 16% reduction in historic species richness (Anderson and Sietman 2004), whereas the upper Iowa and Turkey river basins (Iowa) together have a 23% reduction (Eckblad et al. 2002), and the Menominee, Little Menominee, and Sinsinawa river basins (Wisconsin and Illinois) have a 23%, 36%, and 33% reduction, respectively (Tiemann unpublished data). The Lost Mound Unit of the Upper Mississippi River National Wildlife and Fish Refuge, an area of the Mississippi River that lies on the southeastern edge of the Driftless area, has a 30% reduction (26 extant species out of 37 historic species) in historic species richness (Sietman et al. 2004). Twenty-six of the 31 species known from the Apple River have been recorded live since post-1969 (Anderson and Sietman 2004), whereas ten of 13 have been collected live for the upper Iowa and Turkey river basins (Eckblad et al. 2002), and seven of nine, nine of 14, and eight of 12 have been reported live for the Menominee, Little Menominee, and Sinsinawa rivers, respectively (Tiemann unpublished data). In the Apple, Menominee, Little Menominee, and Sinsinawa river basins, the majority (> 80%) of live individuals and species richness were found within the lower quarter of their respective basins (Anderson and Sietman 2004; Tiemann unpublished data), whereas in the upper Iowa and Turkey river basins, the majority (> 85%) of live individuals and species richness were found in the headwaters (Eckblad et al. 2002). A similar pattern of downstream distribution as seen in the Apple, Menominee, Little Menominee, and Sinsinawa river basins was seen in the Galena River for historic species richness but not extant species richness or abundance, perhaps because the lower portion of the river has been dredged and now offers unsuitable habitat. The distribution of freshwater mussel in the Apple River basin (Anderson and Sietman 2004), the upper Iowa and Turkey river basins (Eckblad et al. 2002), and the Menominee, Little Menominee, and Sinsinawa river basins (Tiemann unpublished data) were attributed to the complexity and amount of available habitat at a given site. It appears this trend is evident for the Galena River basin.

Habitat appears to be the limiting factor for freshwater mussels in the Driftless area. Mathiak (1979) suggested that the Driftless area lacks freshwater mussels because of poor habitat. Very little sand, gravel, or pebble existed in the Galena River basin. The majority of the habitat in these areas was silt-laden cobble / boulder with patches of bare bedrock or clay hardpan. Even though freshwater mussels can colonize bedrock, it is sub-optimal habitat (Sietman et al. 1999). Silt, the number one pollutant in streams in the Driftless area (Page et al. 1992), has been shown to decrease species richness of macroinvertebrates (Weigel 2003) and fishes (Wang et al. 1997) in this area. Several anthropogenic disturbances that cause siltation, including dredging, mining, unrestricted livestock access in stream, and cutting of riparian areas, were occurring in the Galena River basin. These types of disturbances, along with organic pollution (e.g., effluents from sewage treatment plants), have been shown to alter stream habitat and change the freshwater mussel assemblage (e.g., Aldridge 2000; Hoke 1997). Unless mitigated, these disturbances will continue to threaten the existing, decimated assemblage and might prevent the expansion/recolonization of future species.

The dramatic reduction in freshwater mussel species richness in the Galena River basin is a cause of concern. Of the approximate 40 species found in the Driftless area and portion the Mississippi River that borders the Driftless area, only 13%, or five species (fluted shell *Lasmigona costata*, elephantear *Elliptio crassidens*, ebonyshell *Fusconaia ebena*, sheepnose *Plethobasus cyphyus*, and mucket *Actinonaias ligamentina*), are extirpated from the area (Eckblad et al. 2002; Anderson and Sietman 2004; Sietman et al. 2004; Tiemann unpublished data; INHS Mollusk Collection data); however, all except *L. costata* are still extant in the Mississippi River in Illinois downstream of the Driftless area (Cummings and Mayer 1997). The apparent loss of 80% of a taxonomic group in a basin might result in the loss of valuable genetic diversity. Imlay (1973) suggested that the Driftless area be protected as a possible “seed area” for the redistribution of species.

## ACKNOWLEDGMENTS

R.E. Szafoni of the Illinois Department of Natural Resources (IL-DNR) provided the idea for this project. The IL-DNR partially funded the project through an Illinois Wildlife Preservation Fund Grant (#06-34W), whereas other funding was provided by the Illinois Department of Transportation. The Wisconsin Department of Natural Resources (WI-DNR) issued a Wisconsin collecting permit. Hutto (INHS) assisted in map creation. E.A. Anderson (IL-DNR) and B.E. Sietman (Minnesota Department of Natural Resources) shared their Apple River data. K.S. Cummings (INHS), G.A. Levin (INHS), R.E. Szafoni (IL-DNR), D.L. Thomas (INHS), B.L. Tiemann, and C. Warrick (INHS) offered constructive comments.

## LITERATURE CITED

Aldridge, D.C. 2000. The impacts of dredging and weed cutting on a population of freshwater mussels (Bivalvia: Unionidae). Biological Conservation 95:247-257.

Anderson, E.A. and B.E. Sietman. 2004. Unionid mussel fauna of the Apple River above Hanover, Illinois. Technical Report to the Illinois Department of Natural Resources, Springfield, Illinois. 23 pp + appendix.

Cummings, K.S. and C.A. Mayer. 1992. Field guide to freshwater mussels of the Midwest. Manual 5. Illinois Natural History Survey, Champaign, Illinois. 194 pp.

Cummings, K.S. and C.A. Mayer. 1997. Distributional checklist and status of Illinois freshwater mussels (Mollusca: Unionacea). pp. 129-145 *in* K.S. Cummings, A.C. Buchanan, C.A. Mayer, and T.J. Naimo, eds. Conservation and Management of

Freshwater Mussels II: Initiatives for the Future. Proceedings of a UMRCC Symposium, 16-18 October 1995, St. Louis, MO. Upper Mississippi River Conservation Committee, Rock Island, IL. 293 pp.

Eckblad, J., B. Ostby, and K. Tenneson. 2002. The unionid mussels of the upper Iowa and Turkey river watersheds. Journal of the Iowa Academy of Science 109:43-49.

Edds, D.R. 1993. Fish assemblage and environmental correlates in Nepal's Gandaki River. Copeia 1993:48-60.

Hoke, E. 1997. The unionid mollusks of the upper Kansas basin of northwestern Kansas and southwestern Nebraska. Transactions of the Nebraska Academy of Science 24:35-62.

Illinois Endangered Species Protection Board (IESPB). 2005. Checklist of endangered and threatened animals and plants of Illinois. Illinois Endangered Species Protection Board, Springfield, Illinois. ii + 16 pp.

Imlay, M.J. 1973. A case for protecting the Driftless area of the upper Midwest. Malacological Review 6:64-65.

Mathiak, H.A. 1979. A river survey of the Unionid mussels of Wisconsin 1973-1977. Sand Shell Press. Horicon, Wisconsin. 75 pp.

Page, L. M., K. S. Cummings, C. A. Mayer, S. L. Post and M. E. Retzer. 1992. Biologically significant Illinois streams - an evaluation of the streams of Illinois based on aquatic biodiversity. Center for Biodiversity Technical Report 1992(1), Illinois Natural History Survey, Champaign, Illinois. vi + 479 pp + appendices.

Sietman, B.E., E.A. Anderson, R. Nÿboer, and F.R. Hutto. 2004. Native freshwater mussels (Bivaliva: Unionidae) and infestation by zebra mussels at the Lost Mound Unit of the Upper Mississippi River National Wildlife and Fish Refuge. Transactions of the Illinois State Academy of Science 97:234-254.

Sietman, B.E., M.A. Furman, and F.A. Pursell. 1999. Colonization of bedrock by freshwater mussels (Bivalvia: Unionidae). American Midland Naturalist 141:209-211.

Turgeon, D.D., A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelsen, J.F. Quinn, Jr., C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, M.J. Sweeney, F.G. Thompson, M. Vecchione and J.D. Williams. 1998. Common And Scientific Names Of Aquatic Invertebrates From The United States And Canada: Mollusks. 2nd Edition. American Fisheries Society, Special Publication 26, Bethesda, Maryland. 526 pp.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

Wang, L. J. Lyons, P. Kanehl, and R. Gatti. 1997. Influences of watershed land use on habitat quality and biotic integrity in Wisconsin streams. Fisheries 22(6):6-12.

Watters, G.T. 1992. Unionids, fishes, and the species-area curve. Journal of Biogeography 19:481-490.

Weigel, B.M. 2003. Development of stream macroinvertebrate models that predict watershed and local stressors in Wisconsin. Journal of North American Benthological Society 22:123-142.

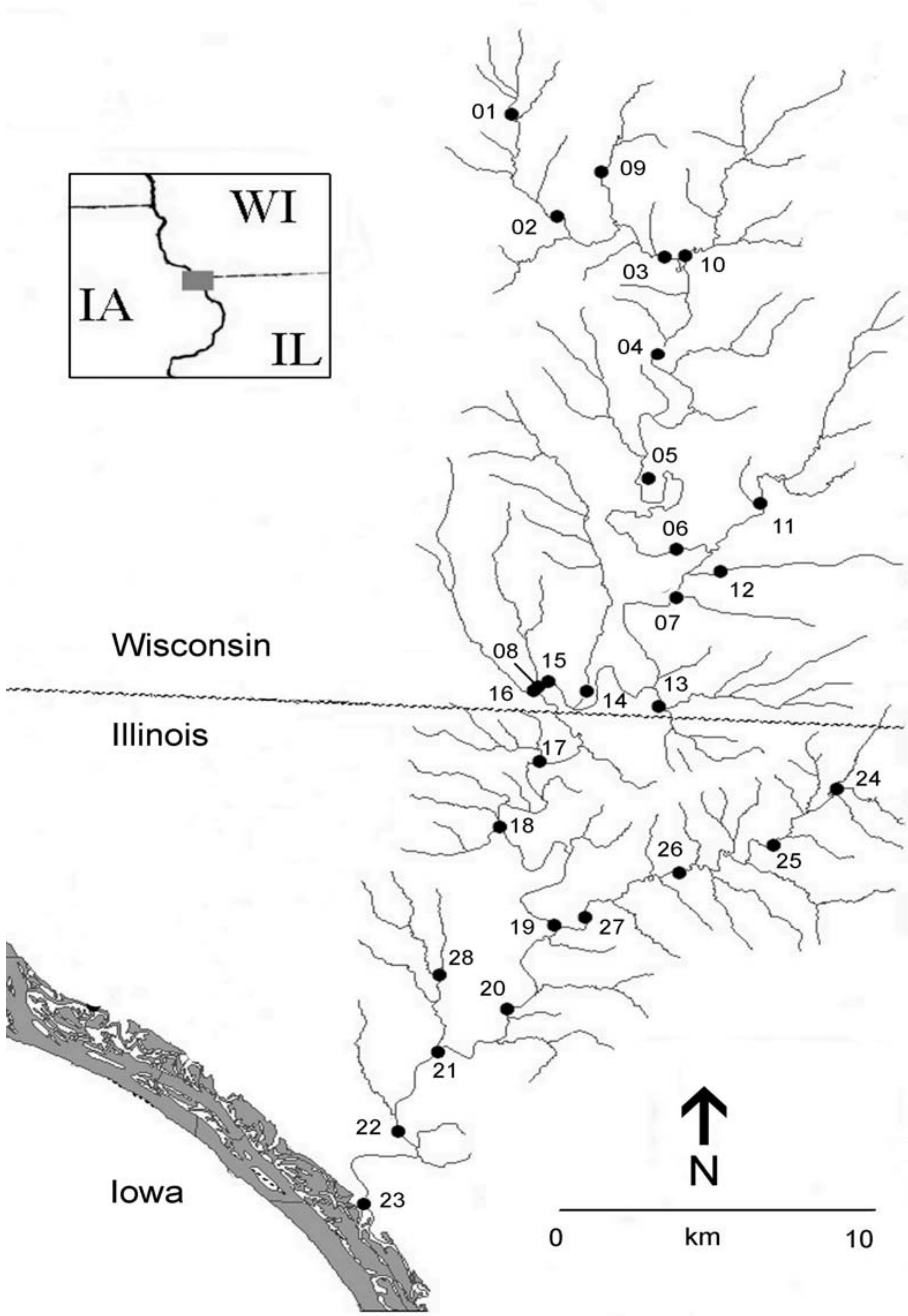
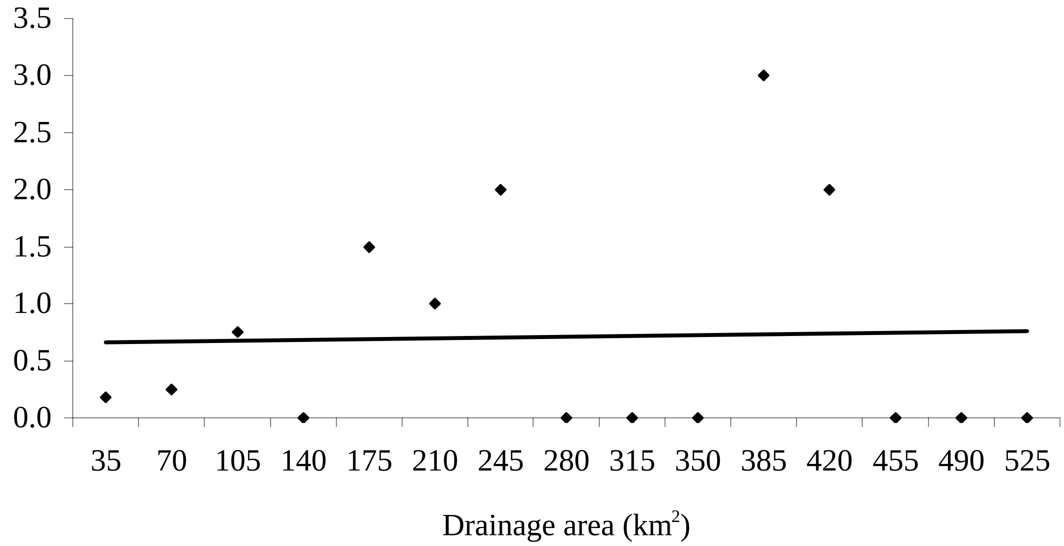



**Figure 1.** Map of the Galena River basin and sampling stations, Wisconsin and Illinois.

(a)




(b)

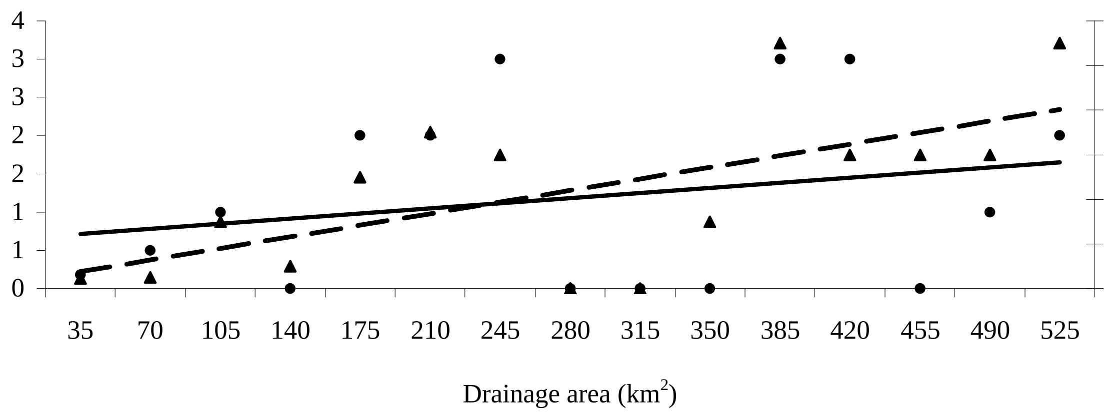



**Figure 2.** (a) Freshwater mussel abundance ($r^2$ = 0.06, $F_{0.05(2), 1, 27}$ = 1.53, $P$ = 0.23) and (b) extant species richness ($r^2$ = 0.21, $F_{0.05(2), 1, 27}$ = 6.97, $P$ = 0.02) (left y-axis; circles with solid line) and historic species richness ($r^2$ = 0. 58, $F_{0.05(2), 1, 27}$ = 36.21, $P$ < 0.0001) (right y-axis; triangles with dashed line) versus drainage area in the Galena River basin, Wisconsin and Illinois.

**Table 1.** Freshwater mussels collected during the 2005-2006 survey of the Galena River basin, Wisconsin and Illinois. See appendices for site-specific data. Numbers within a given species row represent the number of individuals that species was collected alive, D indicates those species collected only as fresh dead specimens, R signifies those species collected only as relict specimens, and * indicates those species not found during survey but an INHS Mollusk Collection record exits for the basin. [IL-ST] = IL state-threatened.

| Sub-family | Scientific name | Common name | Status |
|---|---|---|---|
| Anodontinae | *Alasmidonta viridis* [IL-ST] | Slippershell mussel | R |
| | *Anodontoides ferussacianus* | Cylindrical papershell | D |
| | *Lasmigona complanata* | White heelsplitter | 5 |
| | *Lasmigona compressa* | Creek heelsplitter | 3 |
| | *Lasmigona costata* | Flutedshell | R |
| | *Pyganodon grandis* | Giant floater | 12 |
| | *Strophitus undulatus* | Creeper | R |
| | *Utterbackia imbecillis* | Paper pondshell | D |
| Ambleminae | *Amblema plicata* | Threeridge | R |
| | *Elliptio dilatata* [IL-ST] | Spike | R |
| | *Fusconaia flava* | Wabash pigtoe | R |
| | *Quadrula nodulata* | Wartyback | R |
| | *Quadrula pustulosa* | Pimpleback | R |
| | *Quadrula quadrula* | Mapleleaf | R |
| | *Tritogonia verrucosa* | Pistolgrip | R |
| Lampsilinae | *Lampsilis cardium* | Plain pocketbook | 5 |
| | *Lampsilis siliquoidea* | Fatmucket | * |
| | *Leptodea fragilis* | Fragile papershell | D |
| | *Obliquaria reflexa* | Threehorn wartyback | D |
| | *Potamilus alatus* | Pink heelsplitter | R |
| | *Potamilus ohiensis* | Pink papershell | R |
| | *Toxolasma parvus* | Lilliput | 2 |
| | *Truncilla donaciformis* | Fawnsfoot | R |
| | *Truncilla truncata* | Deertoe | R |
| | *Venustaconcha ellipsiformis* | Ellipse | R |

**Appendix 1.** Collecting locations for the 2005-2006 freshwater mussel survey of the Galena River basin, Wisconsin and Illinois. FWM is freshwater mussel material collected at that site. L is number of species collected alive and V is number of species collected only as valves.

| Site | State: County | Stream | Common location | Latitude, Longitude | FWM |
|---|---|---|---|---|---|
| 01 | WI: Lafayette | Galena River | 4.0 mi NNE Cuba City | 42.6673, -90.4134 | |
| 02 | | Galena River | 3.0 mi NE Cuba City | 42.6405, -90.3969 | |
| 03 | | Galena River | 0.5 mi SE Jenkynsville | 42.6308, -90.3621 | L (2) |
| 04 | | Galena River | 3.0 mi E Cuba City | 40.6092, -90.3602 | |
| 05 | | Galena River | 1.5 mi E Benton | 42.5714, -90.3639 | L (2), V (3) |
| 06 | | Galena River | 2.5 SE Benton | 42.5529, -90.3537 | L (2), V (5) |
| 07 | | Galena River | 3.0 mi SSE Benton | 42.5428, -90.3578 | L (3), V (3) |
| 08 | | Galena River | 2.5 mi ESE Hazel Green | 42.5161, -90.3931 | |
| 09 | | Pats Creek | 4.0 mi NE Cuba City | 42.6528, -90.3836 | L (1) |
| 10 | | Madden Branch | 1.0 mi ESE Jenkynsville | 42.6311, -90.3552 | |
| 11 | | Shullburg Branch | 2.5 mi E Benton | 42.5659, -90.3277 | V (1) |
| 12 | | Ellis Branch | 3.0 mi SE Benton | 42.5473, -90.3395 | V (1) |
| 13 | | Kelsey Branch | 4.0 mi ESE Hazel Green | 42.5108, -90.3575 | |
| 14 | | Coon Branch | 2.5 mi ESE Hazel Green | 42.5136, -90.3781 | V (1) |
| 15 | | Bull Branch | 2.0 mi SE Hazel Green | 42.5146, -90.3965 | L (1) |
| 16 | | Scrabble Branch | 2.0 mi SE Hazel Green | 42.5136, -90.3978 | |

| | | | | | |
|---|---|---|---|---|---|
| 17 | IL: Jo Daviess | Galena River | 5.0 mi N Galena | 42.4947, -90.3947 | |
| 18 | | Galena River | 4.0 mi N Galena | 42.4768, -90.4066 | V (3) |
| 19 | | Galena River | 3.0 mi NE Galena | 42.4511, -90.3879 | L (3), V (8) |
| 20 | | Galena River | 1.0 mi NE Galena | 42.4285, -90.4017 | L (3), V (3) |
| 21 | | Galena River | Galena | 42.4163, -90.4237 | V (6) |
| 22 | | Galena River | 1.5 mi S Galena | 42.4012, -90.4366 | V (6) |
| 23 | | Galena River | 4.0 mi S Galena | 42.3757, -90.4455 | V (11) |
| 24 | | East Fork Galena River | 2.5 mi WNW Scales Mound | 42.4901, -90.2991 | |
| 25 | | East Fork Galena River | 4.0 mi W Scales Mound | 42.4748, -90.3187 | L (1) |
| 26 | | East Fork Galena River | 5.0 mi NE Galena | 42.4665, -90.3483 | V (4) |
| 27 | | East Fork Galena River | 3.5 mi NE Galena | 42.4536, -90.3779 | V (2) |
| 28 | | Hughlett Branch | 1.0 mi N Galena | 42.4367, -90.4237 | |

**Appendix 2.** Site-specific data for only those locations where freshwater mussels were collected during the 2005-2006 freshwater mussel survey of the Galena River basin, Wisconsin and Illinois. Site No. is the site number, which is referenced in Appendix 1. Numbers within a given species row represent the number of individuals that species was collected alive at that site, D indicates those species collected only as fresh dead specimens, R signifies those species collected only as relict specimens, and * indicates those species represented by INHS Mollusk Collection records. Abundance is the total number of live unionids, extant species richness is the number of species represented by live or fresh dead shell material, and historical species richness is the total number of species found (including museum records). Effort is in person-hours. Note: stations 01, 02, 04, 08, 17, and 24 were sampled for two man-hours each and stations 10, 13, 16, and 28 were sampled for one man-hour each, but no evidence of freshwater mussels was found.

| | | | | | | | | Site | No | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 03 | 05 | 06 | 07 | 09 | 11 | 12 | 14 | 15 | 18 | 19 | 20 | 21 | 22 | 23 | 25 | 26 | 27 |
| Anodontinae | | | | | | | | | | | | | | | | | | |
| *Alasmidonta viridis* | | | R | | | | R | | | | * | | | | | | | R |
| *Anodontoides ferussacianus* | | | | | | R | | R | | | | | | | | | | |
| *Lasmigona complanata* | | 1 | 1 | 1 | | | | | | R | 1 | 1 | R | | | | | |
| *Lasmigona compressa* | 1 | | | 2 | | | | | | | | | | | | | | |
| *Lasmigona costata* | | | | | | | | | | | R | | | | | | R | |
| *Pyganodon grandis* | 2 | 2 | | 3 | | | | | | R | 2 | 2 | | | | 1 | | |
| *Strophitus undulatus* | | | R | | | | | | | | * | | | | | | | |
| *Utterbackia imbecillis* | | | | | | | | | | | | | | D | | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abundance | 3 | 3 | 2 | 6 | 1 | 0 | 0 | 0 | 1 | 0 | 6 | 4 | 0 | 0 | 0 | 1 | 0 | 0 |
| Extant species richness | 2 | 2 | 2 | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 3 | 0 | 1 | 2 | 1 | 0 | 0 |
| Historical species richness | 2 | 5 | 7 | 6 | 1 | 1 | 1 | 1 | 1 | 3 | 11 | 6 | 6 | 6 | 11 | 1 | 4 | 2 |
| Effort | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Catch-per-unit-effort | 1.5 | 1.5 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 2 | 0 | 0 | 0 | 0.5 | 0 | 0 |

# PLATES OF STUDY AREA AND STUDY SPECIMENS


Picture 1. Louisburg Creek (Menominee River basin), 4 mi SSE Dickeyville, Grant County, Wisconsin [42.5663°, -90.5811°]. Livestock in streams was a common occurrence in the area.

## PLATES OF STUDY AREA AND STUDY SPECIMENS (CONT.)


Picture 2. Little Menominee River, 1 mi NNE Menominee, Jo Daviess County, Illinois Wisconsin [42.4963°, -90.5247°]. The lack of woody riparian strips was a common occurrence in the area.

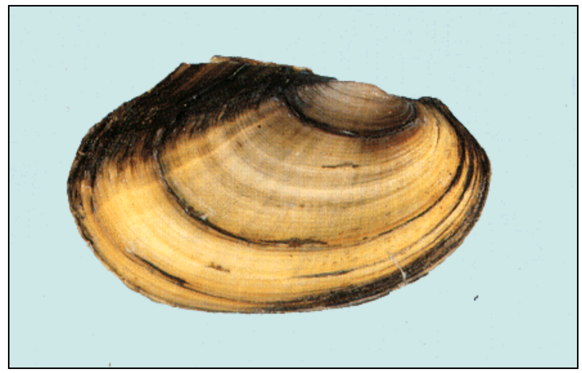
# PLATES OF STUDY AREA AND STUDY SPECIMENS (CONT.)


Picture 3. Galena River, 3 mi SSE Benton, Lafayette County, Wisconsin [42.5428°, -90.3578°]. The riparian area was actively being removed.

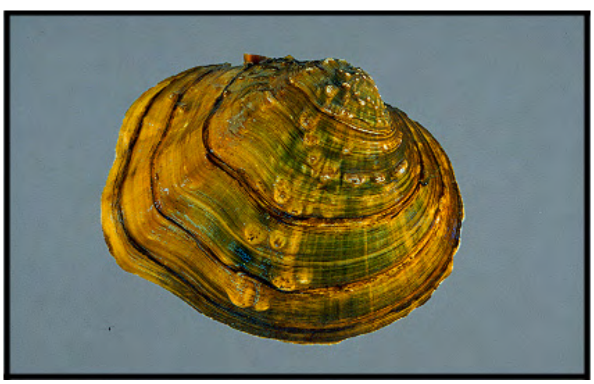
## Plates of Study Area and Study Specimens (cont.)

## Most Common Live Individuals Collected

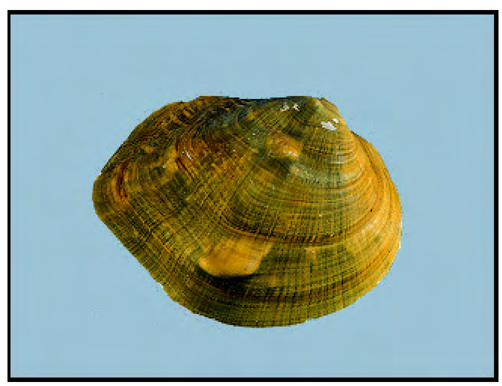
Picture 4. Giant floater *Pyganodon grandis* [INHS 10319 – Lone Tree Creek, Champaign County, Illinois] (photograph courteous of K.S. Cumming, Illinois Natural History Survey, Champaign).



Picture 6. Fragile papershell *Leptodea fragilis* [INHS 8019 – Henderson Creek, Henderson County, Illinois] (photograph courteous of K.S. Cumming, Illinois Natural History Survey, Champaign).



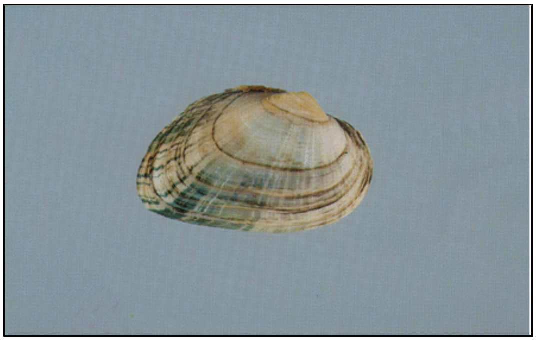
Picture 5. Mapleleaf *Quadrula quadrula* [INHS 4945 – Wabash River, Fountain County, Indiana] (photograph courteous of K.S. Cumming, Illinois Natural History Survey, Champaign).



Picture 7. Threehorn wartyback *Obliquaria reflexa* [INHS 3052 – Rock River, Rock Island County, Illinois] (photograph courteous of K.S. Cumming, Illinois Natural History Survey, Champaign).

## PLATES OF STUDY AREA AND STUDY SPECIMENS (CONT.)

## STATE-LISTED INDIVIDUALS COLLECTED



Picture 8. Slippershell mussel *Alasmidonta viridis* [INHS 7866 – Baker Creek, Kankakee County, Illinois] (photograph courteous of K.S. Cumming, Illinois Natural History Survey, Champaign).

Picture 9. Spike *Elliptio diliatata* [INHS 8505 – Big Kilbuck Creek, Madison County, Indiana] (photograph courteous of K.S. Cumming, Illinois Natural History Survey, Champaign).