THIS THESIS HAS BEEN EXAMINED AND APPROVED:

Name ____________________
Timothy Spier
Chair, Examining Committee

Name ____________________
Richard Anderson
Member, Examining Committee

Name ____________________
Susan Romano
Member, Examining Committee

Date ____10/27/11_____

A SURVEY OF THE FRESHWATER MUSSELS (BIVALVIA: UNIONIDAE) OF THE LA MOINE AND SPOON RIVER BASINS, ILLINOIS

A THESIS

PRESENTED TO THE FACULTY OF

THE SCHOOL OF GRADUATE STUDIES OF

WESTERN ILLINOIS UNIVERSITY

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE

MASTER OF SCIENCE

BY

JOSHUA SHERWOOD

DR. TIMOTHY W. SPIER, ADVISOR

2011

ACKNOLEDGEMENTS

I would like to thank Dr. Timothy Spier for his assistance conducting this study as well as his suggestions while writing this manuscript. I would also like to thank Jeremy Tiemann and Kevin Cummings for subject expertise. For the loan of historical mussel and fish data, I would like to acknowledge the Illinois Natural History Survey's Mollusk and Fish Collections. This study could not have been performed with out the generous grants received from the Illinois Smallmouth Alliance Conservation Fund and the Illinois Department of Natural Resources Wildlife Preservation Fund. Finally, I am extremely grateful to Sarah Bales, Brandon Cheek, Stefanie Fitzsimons, Andrew Klinsky, Dan Knapp, Alison Price, Diane Shasteen, Jeremy Tiemann, Samantha Worthington, and the entire Illinois Natural History Survey mussel sampling crew for their sampling assistance.

ABSTRACT

Declines in freshwater mussel communities are being seen in North America and through out the world. Direct, large scale disturbances such as impoundments and channelization have been shown to have negative effects on mussel communities, but little is known about how watershed characteristics affect these organisms. The goals of this project were to (1) document the mussel communities of the La Moine and Spoon Rivers, (2) use geographic information systems (GIS) to determine the effects of watershed characteristics on these mussel communities and (3) compare the current mussel communities to historical records.

Forty sites on each river and their tributaries were sampled by four person hours of hand searching in 2009-2010. The mussel classification index (MCI) was then calculated for each site. The La Moine River basin produced 499 live individuals representing 20 species and 21 species and 1,308 live individuals were collected from the Spoon River basin. Mussel species richness showed a positive relationship to the natural log of basin size (y = 2.8ln(x)-28.1, Adj. R^2 = 0.50, p = 9.0 x 10^{-8}). Regression analyses of land use practices showed a significant negative relationship between site MCI and the proportion of forest and pasture in the basin (y = -8.83x + 8.86, Adj. R^2 = 0.11, p = 0.002; y = -25.99x + 10.49, Adj. R^2 = 0.18, p = 0.00004) and the proportion of row crop showed a significant positive relationship to site MCI (y = 6.42x + 3.47, Adj. R^2 = 0.12, p = 0.001). Mean basin slope showed no significant relationship to MCI.

Historical mussel data showed 28 species were known to be found in the La Moine River and 43 from the Spoon River basin. A major decline in the number of mussel species found in the Spoon River was seen at the time when row crop agriculture

increased in this area. The remaining mussel communities are composed of species that are considered tolerant and thus are likely able to survive in an agricultural landscape.

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INTRODUCTION

Freshwater mussels (Bivalvia: Unionidae) are a relatively crucial component of freshwater ecosystems (Howard and Cuffey 2006; Vaughn and Hakenkampf 2001). They improve water quality by filtering microscopic organisms and detritus from the water (Strayer and Smith 2003). Due to their feeding habits and relative inability to escape disturbances (e.g. pollutants and sedimentation), mussel populations are a good indicator of the 'health' of water bodies. Thus, lack of mussels in a stream often indicates poor water quality. In addition, mussels also are a food source for organisms such as muskrats, otters, minks, fish and some birds (Cummings and Mayer 1992).

Eastern North America has some of the most diverse freshwater mussel populations in the world (Cummings and Mayer 1992), but mussel populations throughout the United States have declined drastically over the past century. Of the approximately 300 species historically found in the United States, only 70 species are considered to have stable populations (Williams et al. 1993). The rivers of Illinois once provided habitat for 80 species of mussels, but like the rest of the United States these rivers have seen a decline in mussel populations. Of the 80 historical species, 17 are no longer found in Illinois (6 due to extinction) and only 27 species are considered stable (Cummings and Mayer 1997).

Anthropogenic disturbances account for many of the declines we are seeing in mussel populations. Watters (1999) provides examples of how specific disturbances negatively affect the distribution of freshwater mussels, such as stream impoundment (Tiemann et al. 2007a; Vaughn and Taylor 1999), channelization and basin land use practices (Brainwood et al. 2006; McRae et al. 2004). Impoundment and channelization clearly influence stream habitat directly, but watershed land use affects a stream ecosystem in many different ways (Allan 2004). And, although impoundment and channelization vary little, land use can change annually.

Watershed land use can be difficult to quantify and study due to its scale. But Geographic Information Systems (GIS) can now be used to analyze the effects of land use on mussel populations (Poole and Downing 2004; Andersen 2002; Arbuckle and Downing 2002; Diamond et al. 2002) as well as fish (Wang et al. 1997) and instream habitat (Zigler et al. 2008; Allan 1997). Comparing mussel populations to the land use practices and the watershed's geologic features is one step towards understanding the relationships between the two and can be an important tool in the conservation of freshwater mussels.

The area around Western Illinois University is drained mostly by two large rivers, the La Moine River and the Spoon River. Each river drains a basin of similar size (La Moine; 3,497 km^2,Spoon River; 4,805 $km.^2$), is similar in length (La Moine; 203 km, Spoon; 260 km), and empties into the La Grange Pool of the Illinois River (IDNR 2001; IDNR 1998). The Spoon River has a greater diversity of freshwater mussels than the La Moine River. A total of 41 species have been collected from the Spoon River and only 23 in the La Moine. Since 1969, these numbers have dropped; only 20 species have been found alive in the Spoon River basin and only 16 in the La Moine river basin (Cummings and Mayer 1997; Tiemann et al. 2007b). Current trends in the mussel numbers of these rivers are unknown because neither river has had a basin-wide survey in recent years. The last mussel survey of the Spoon River was in 1971, and a survey of the La Moine was performed between 1989-91, but only in McDonough and Hancock counties.

This study was designed to accomplish three goals: 1) To perform basin-wide mussel surveys of both the La Moine and Spoon Rivers; 2) To use GIS to determine the effects that basin land use practices and basin geology have on mussel communities; and 3) To compare current mussel populations in both basins to historical data.

METHODS

Mussel Survey

Forty sites were sampled from both the La Moine (Table 1, Figure 1) and Spoon (Table 2, Figure 2) River basins. Sites were chosen because historical data were available for the site, the site was scheduled to be sampled by the Illinois Natural History Survey (INHS) statewide mussel sampling crew, or because there was a lack of data from that portion of the stream. All 40 sites on the Spoon River, as well as 37 in the La Moine River, were sampled for four person hours of hand searching. The remaining three sites (Site Numbers 38-40, Table 1) on the La Moine River were sampled using a mussel brail due to high water levels.

Live individuals and deceased mussel shells were collected. Live individuals were indentified to the species level and total lengths were taken at the site. One representative of each species was kept from each location and sent to the INHS Mollusk Collection for vouchering (dead individuals took precedent over live individuals when vouchering). The remaining live individuals were returned to the stream.

GIS Analysis

Watershed analyses were done using *ArcGIS 9.3* (ESRI, Redlands, CA). Topographic data was gathered from the United States Geological Survey Seamless Data Warehouse (www.seamless.usgs.gov, accessed November 2010) and the 2007 USDA-NASS Cropland Data layer was downloaded from the Illinois Natural Resources Geospatial Data Clearinghouse website (www.isgs.illinois.edu/nsdihome/, accessed November 2010).

Table 1. Sites in the La Moine River Basin surveyed for freshwater mussels (*Indicates sites also sampled by INHS mussel crew.**Indicates sites sampled with mussel brail.)

Site #	Date	Stream	Location	Latitude	Longitude
1	8/12/2009	Grindstone Creek	E 1200th St Bridge, 3.9 mi WSW of Industry	40.31088	-90.67768
2	8/13/2009	E. Fork La Moine	Glenwood Park, Macomb	40.47966	-90.67085
3	8/14/2009	E. Fork La Moine	Rt. 136 Bridge, 6.4 mi W of Colchester	40.40971	-90.91195
4	8/25/2009	Spring Creek	Spring Lake Park below dam	40.50336	-90.72372
5	9/1/2009	Camp Creek	800 E. Bridge 3.4 mi. S of Fandon	40.31982	-90.75475
6	9/1/2009	Troublesome Creek	875 E. Bridge 1.9 mi. NE of Fandon	40.39003	-90.73969
7	9/3/2009	Grindstone Creek	350 N. Bridge 0.7 mi W of Industry	40.32924	-90.62038
8	9/3/2009	Camp Creek	1525 E. Bridge 3.4 mi. N of Industry	40.37637	-90.61893
9	9/15/2009	Grindstone Creek	806 E Bridge 4.6 mi S. of Fandon	40.30195	-90.75377
10	9/17/2009	E. Fork La Moine	700 E Bridge 1.8 mi NNE of Colchester	40.44874	-90.77574
11	9/23/2009	E. Fork La Moine	1650 N Bridge 3.6 mi SW of Bushnell	40.52098	-90.55953
12	9/30/2009	Troublesome Creek	450 N Bridge 4.9 mi WSW of Fandon	40.34929	-90.85093
13	6/10/2010	Bronson Creek	2900 E Bridge 1.8 mi. NW of Plymouth	40.31128	-90.94049
14	6/10/2010	Williams Creek*	Williams Cr. Rd 4.6 mi E of Augusta	40.23685	-90.86316
15	6/10/2010	Flour Creek	Flour Cr. Rd. 5.6 mi ESE of Plymouth	40.25952	-90.82179
16	6/29/2010	Little Missouri Creek	IL Route 99 Bridge 3.1 mi S of Camden	40.10864	-90.76776
17	7/2/2010	La Harpe Creek	2750 E. Crossing 2.8 mi S of La Harpe	40.54345	-90.97353
18	7/2/2010	Little Creek*	2300 N Bridge 3.4 mi S of La Harpe	40.53386	-90.96469
19	7/2/2010	La Harpe Creek*	1950 N Bridge 7.5 mi NE of Carthage	40.48019	-91.02036
20	7/2/2010	Rock Creek*	2250 E Bridge 4.9 mi NE of Carthage	40.46807	-91.07177
21	7/3/2010	Drowning Fork*	1900 N Bridge 2.0 mi WSW of Bushnell	40.54228	-90.54090
22	7/3/2010	Farmer's Fork*	1700 N Bridge 3.7 mi WSW of Bushnell	40.52825	-90.56884
23	7/3/2010	E. Fork La Moine	Waco Rd. Bridge 4.3 mi E of Good Hope	40.55933	-90.59185
24	7/4/2010	La Moine River	IL Route 94 Bridge 1.6 mi NNW of La Harpe	40.60457	-90.98255
25	7/5/2010	Cedar Creek	IL Route 99 Bridge 0.6 mi NNW of Camden	40.16235	-90.77389
26	7/5/2010	Cedar Creek*	250 E Bridge 4.8 mi WNW of Camden	40.17438	-90.85672
27	7/6/2010	Missouri Creek	Avery Rd Bridge 4.0 mi SE of Camden	40.11061	-90.71930
28	7/6/2010	Missouri Creek*	Missouri Cr. Rd 3.1 mi SW of Camden	40.12390	-90.81475
29	7/6/2010	Camp Creek	50 N Bridge 5.7 mi SSW of Fandon	40.28836	-90.78874
30	7/6/2010	Stony Branch	Rattlesnake Ranch Rd 5.6 mi WNW of Rushville	40.15178	-90.66133
31	7/12/2010	Kepple Creek	2000 E Bridge 2.9 mi SSW of Bushnell	40.51266	-90.52395
32	8/24/2010	La Moine River	1800 E Bridge 5.4 mi ENE of Carthage	40.45864	-91.04984
33	9/9/2010	La Moine River	1420 E Bridge 7.9 mi NNW of Plymouth	40.40265	-90.95272
34	9/9/2010	La Moine River	75 N Bridge 4.4 mi E of Plymouth	40.29360	-90.83582
35	10/7/2010	La Moine River*	St. Mary's Rd 3.6 mi N of Plymouth	40.34367	-90.91380
36	10/10/2010	La Moine River*	2300 N Bridge 5.2 mi SW of La Harpe	40.53181	-91.04113
37	10/11/2010	La Moine River*	Guinea Rd 5.7 mi N of Camden	40.23538	-90.78243
38	10/15/2010	La Moine River**	Down Stream of La Grange Lock Rd, 4.2 mi SE of Ripley	39.98056	-90.58070
39	10/15/2010	La Moine River**	Between La Grange Lock Rd and Mouth	39.98214	-90.55869
40	10/15/2010	La Moine River**	Between La Grange Lock Rd and Mouth	39.98180	-90.54808

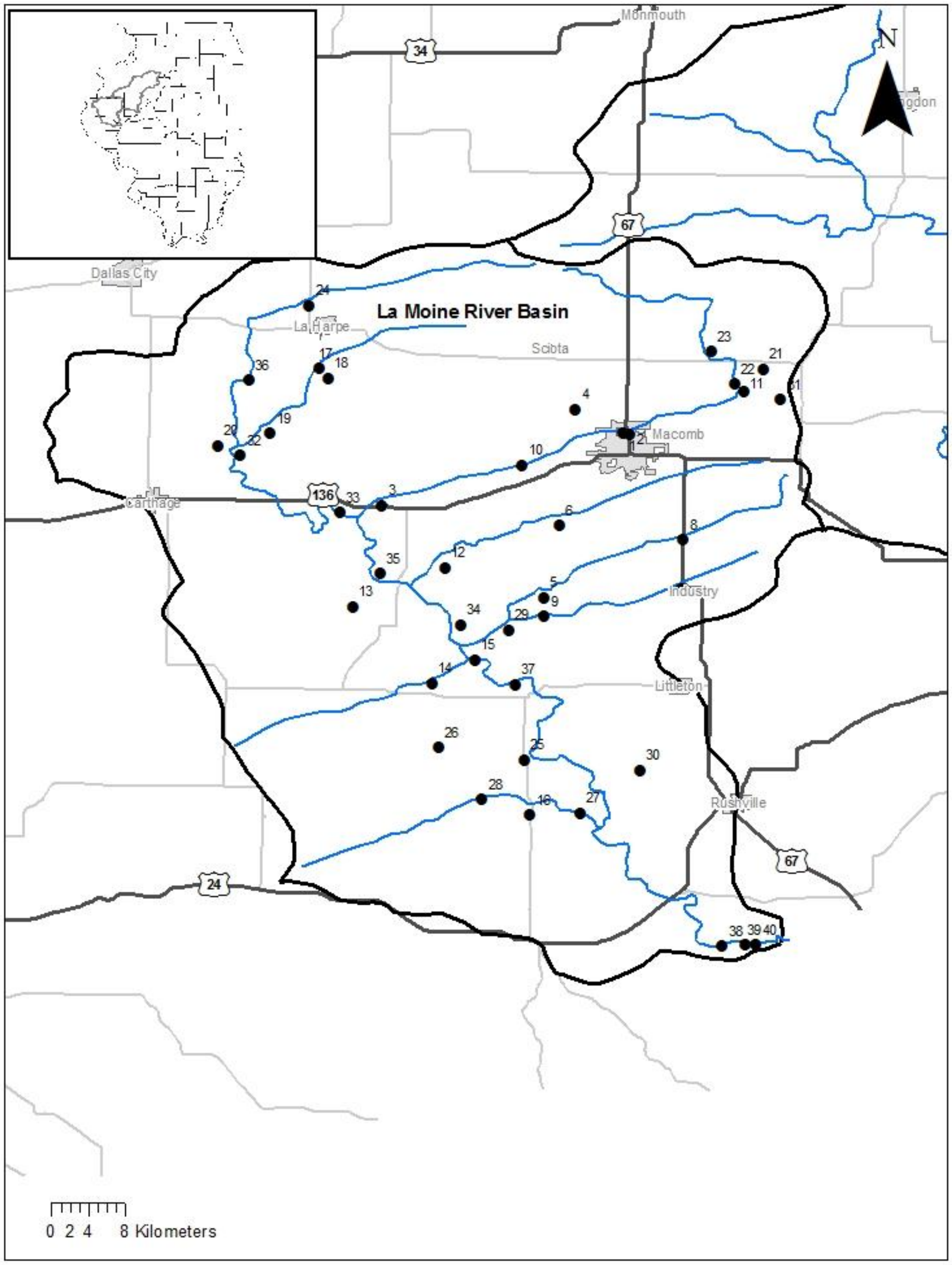

Figure 1. Map of mussel sampling sites in the La Moine River Basin.

Table 2. Sites in the Spoon River Basin surveyed for freshwater mussels (*Indicates sites also sampled by INHS mussel crew.)

Site #	Date	Stream	Location	Latitude	Longitude
1	7/16/2010	Cedar Creek*	147th St. Bridge, 3.5 Mi SSE Berwick	40.75771	-90.52924
2	7/16/2010	Cedar Fork*	90th Ave. Bridge, 4 mi SE Berwick	40.75945	-90.46819
3	7/16/2010	Negro Creek*	105th St Bridge, 4.2 Mi NE Roseville	40.74968	-90.58697
4	7/19/2010	W Fork Spoon River*	IL Route 93 Br 2 Mi E Elmira	41.18065	-89.78837
5	7/19/2010	E Fork Spoon River*	Co Rd 1300E Br 4 Mi SW Bradford	41.16085	-89.73506
6	7/20/2010	Coopers Defeat Creek*	Co Rd 1300E Br 1.8 Mi NE Modena	41.14961	-89.73500
7	7/20/2010	Camp Creek*	Co Rd 1300E 4 Mi SSE Wyoming	41.00930	-89.73512
8	7/20/2010	Prince Run*	Co Rd 22300N Br 2 Mi N Of Princeville	40.95981	-89.77207
9	7/21/2010	Indian Creek*	Co Rd 450N Br 3.5 Mi SW Wyoming	41.04054	-89.83424
10	7/21/2010	Walnut Creek*	Co Rd 2350E 4.6 mi NW of West Jersey	41.06178	-89.99446
11	7/21/2010	French Creek*	Co Rd 2000E Br 4 Mi NW Yates City	40.80846	-90.06201
12	7/21/2010	Court Creek*	Co Rd 1600E Br 1.5 Mi W Dahinda	40.92954	-90.13942
13	7/21/2010	North Creek*	Co Rd 1700N, 5 Mi ENE East Galesburg	40.96148	-90.20965
14	7/22/2010	Brush Creek*	600 N Br 4 Mi E Abingdon	40.80115	-90.31751
15	7/22/2010	Haw Creek*	Co Rd 400N Br, 3.5 Mi SW Maquon	40.77229	-90.22214
16	7/22/2010	Littlers Creek*	Co Rd 1300E Br 2 Mi NW Rapatee	40.73599	-90.20030
17	7/22/2010	Haw Creek*	Co Rd 950E Br, 3 Mi S Knoxville	40.84972	-90.26139
18	7/23/2010	Negro Creek	IL 116 Bridge 6.3 mi E of Roseville	40.73058	-90.54464
19	7/23/2010	Swan Creek*	Co Rd 1500E 2.5 Mi SE Greenbush	40.68472	-90.50152
20	8/2/2010	Coal Creek*	Co Rd 1100E Br 4 Mi SE London Mills	40.65774	-90.23334
21	8/2/2010	Cedar Creek*	Co Rd 3400N, 3.5 Mi SW London Mills	40.69073	-90.33635
22	8/3/2010	Spoon River*	IL Route 17 Br, 2 Mi W Wyoming	41.06287	-89.79532
23	8/3/2010	Spoon River*	US Route 150 Br 2.5 Mi SE Dahinda	40.90750	-90.08680
24	8/3/2010	Spoon River*	Co Hwy 17 Br 5 Mi Ne Maquon	40.85652	-90.10975
25	8/3/2010	Spoon River*	2Nd St Br N Edge London Mills	40.71364	-90.26585
26	8/4/2010	Turkey Creek*	900N, 1 mi SE Blyton	40.55671	-90.26046
27	8/4/2010	Put Creek*	Co Rd 2300N, 3 Mi S Blyton	40.52406	-90.26891
28	8/4/2010	Shaw Creek*	Co Rd 325E, 1.5 Mi NW Marietta	40.51964	-90.38065
29	8/5/2010	Barker Creek*	Co Rd 250E, 1.8 Mi S Marietta	40.47119	-90.39285
30	8/5/2010	Big Creek*	1650 E 2 Mi SW Bryant	40.45872	-90.13343
31	8/5/2010	Tater Creek*	Mile Load Rd, 1.5 Mi NW Duncan Mills	40.34722	-90.21250
32	8/26/2010	Spoon River	Mt. Pisgah Rd at Ellisville	40.62672	-90.30212
33	8/30/2010	Spoon River*	Near Elmore	40.95670	-89.97706
34	8/30/2010	Spoon River	650 N Bridge 1.8 mi ENE of Maquon	40.80796	-90.13407
35	8/30/2010	Spoon River*	Co Rd 2350N 3.5 Mi NW Smithfield	40.53186	-90.31078
36	9/1/2010	Spoon River	At Bernadotte	40.40265	-90.32453
37	9/1/2010	Spoon River*	Waterford Rd 3 Mi S Lewistown	40.33723	-90.12958
38	9/22/2010	Francis Creek	E Holler Rd 4.5 mi NW of Ipava	40.39879	-90.38259
39	9/24/2010	Big Creek	Co Rd 14 3.3 mi W of Lewistown	40.39745	-90.21638
40	9/25/2010	Put Creek	Co Rd 2 5.8 mi WNW of Cuba	40.52659	-90.29105

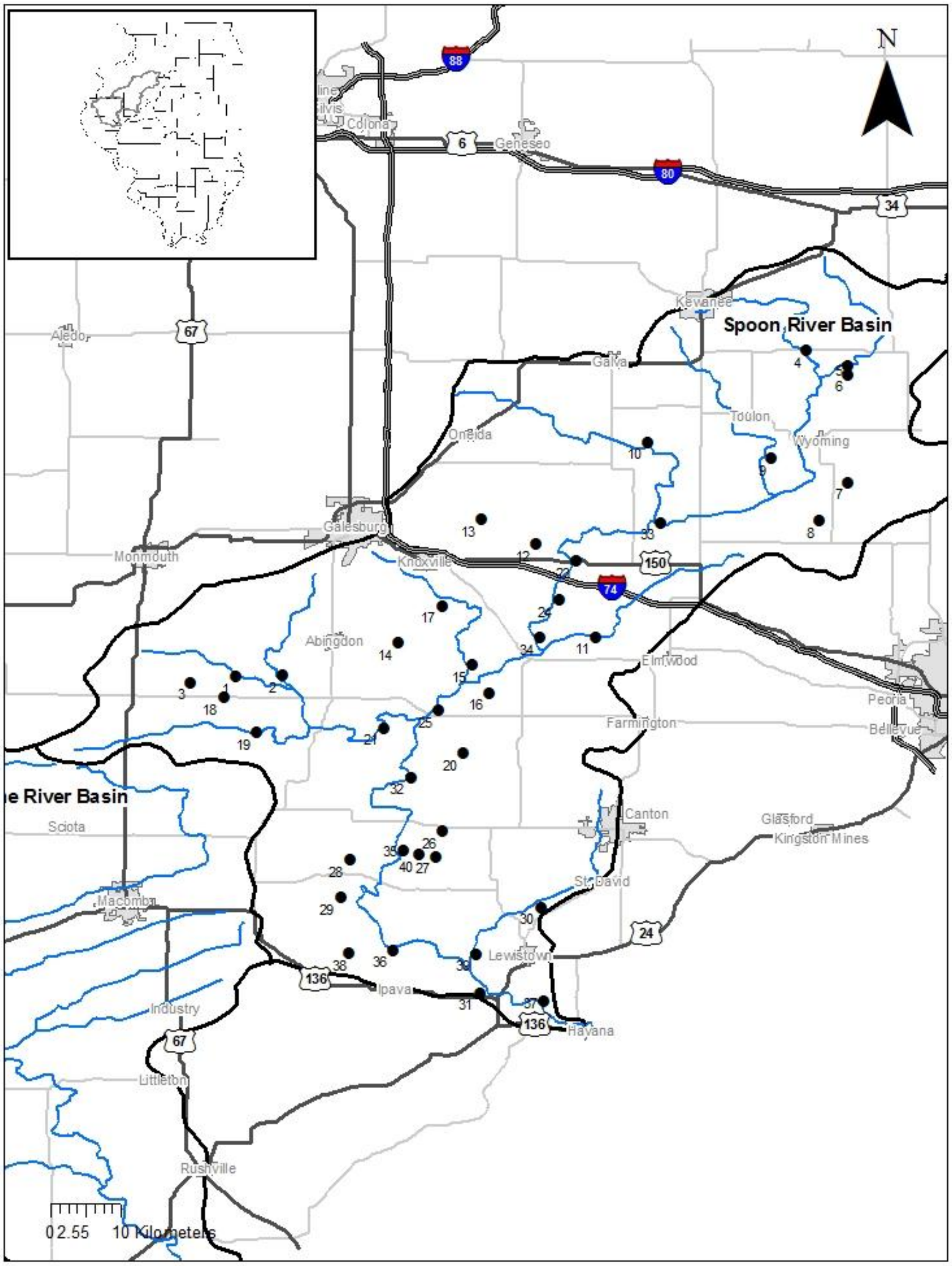

Figure 2. Map of mussel sampling sites in the Spoon River Basin.

I used GIS to determine watersheds, summarize land use within the watersheds, and obtain mean slope for each watershed. Watersheds were found for each stream within both basins, and watersheds were also defined for each individual sample site. Site land use was determined using the 2007 USDA-NASS Cropland Data layer. The cropland data were summarized into 3 categories: row crop (corn and soybeans), forest, and pasture. The remaining land use categories were found to cover a limited area and thus were left out of the analysis. For each site, I used Spatial Analyst to extract the portion of the land use raster that was unique to that site's watershed, and then I determined the proportion of row crop, forest, and pasture for each site. Mean basin slope was also calculated using Spatial Analyst. A slope layer (in percent rise) was created using the Slope tool, and then site specific basin layers were once again used to extract a portion of the slope layer that corresponded to each site.

Fish species data for the La Moine River were gathered from the INHS Fish Collection Database, Western Illinois University Fish Collection and Carney (2007). Spoon River fish species data was collected from Burns Jr. (2000), the INHS Fish Collection Database and the Western Illinois University Fish Collection.

Data Analysis

I used the mussel classification index (MCI) (Szafoni 2002) to describe each site's mussel communities. The MCI takes into account species richness, number of intolerant species, abundance and reproduction to quantify the mussel community. These factors are used to describe communities as restricted, limited, moderate, highly valued or unique. Indentifying highly valued and unique mussel assemblages is important for the conservation of mussels, especially in highly disturbed watersheds. The mussel classification index was calculated for each site and a mussel resource value was determined (Szafoni 2002). Linear regression analyses were performed to compare site MCI to proportion of row crop, forest and pasture land use categories, as well as mean basin slope in each site's basin.

Historical Data

Historical mussel sampling data were collected for both basins to compare current mussel communities to past communities (Figures 3 and 4). Much of the historical data for both basins were gathered from the INHS Mollusk Collection as well as Cummings and Mayer (1997) and Tiemann et al. (2007b). Additional Spoon River data was found in Strode (1892) and an unpublished INHS survey performed by W.C. Starret in 1971. Further La Moine River data was collected from a survey of the La Moine River basin across McDonough and Hancock counties from 1989-1991 (Baumgardner 1995).

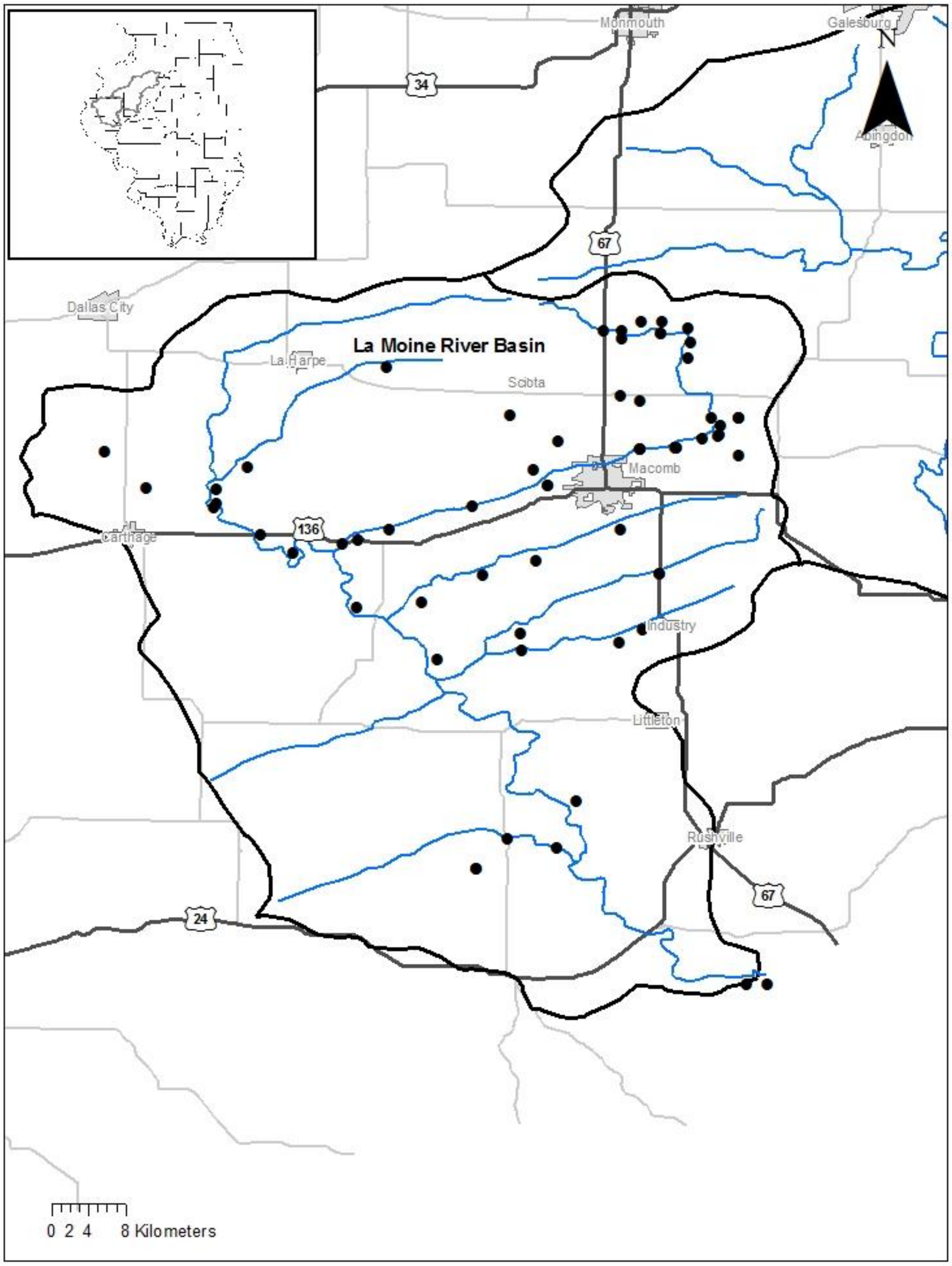

Figure 3. Map of historical mussel sampling sites in the La Moine River basin.

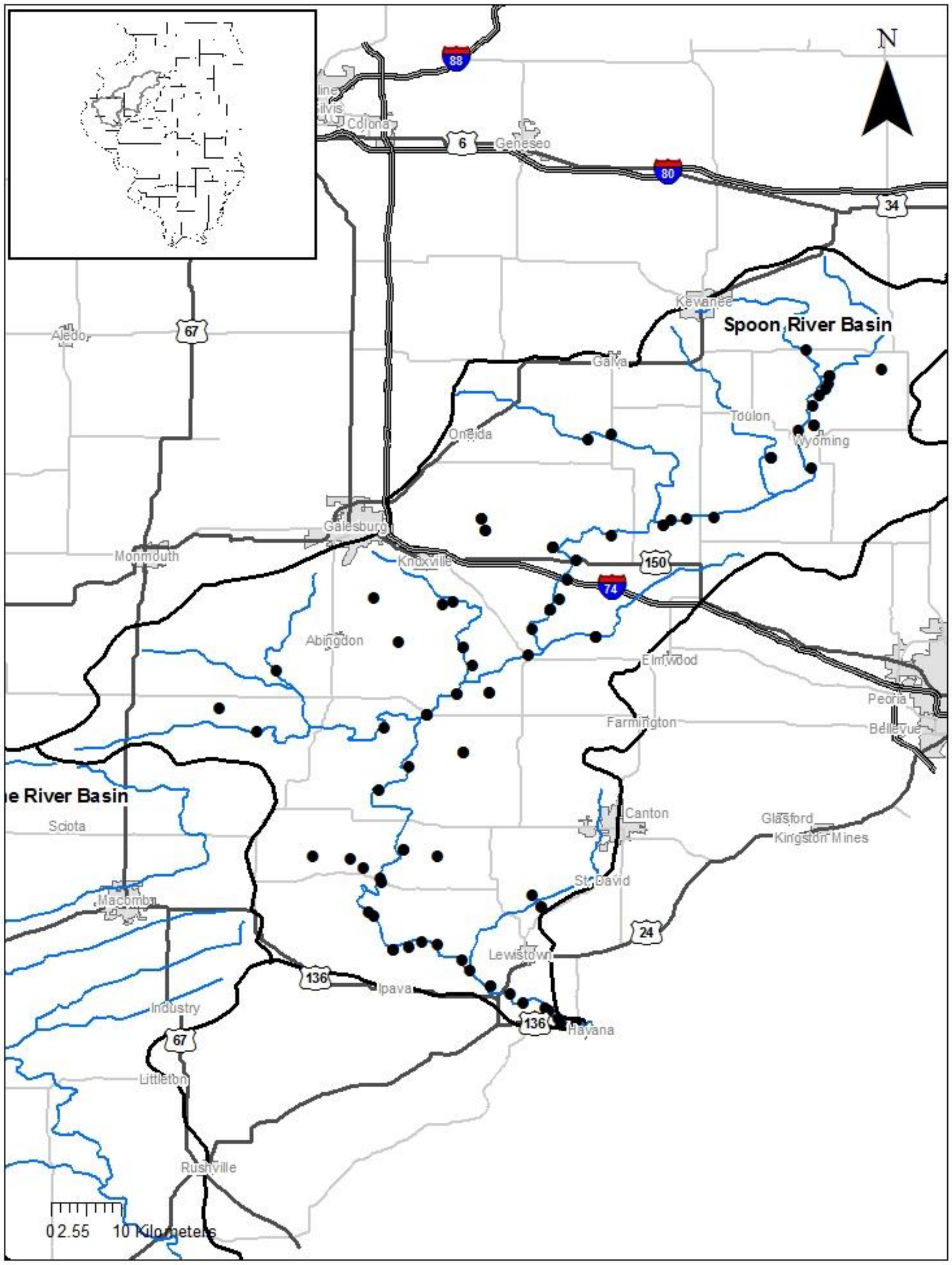

Figure 4. Map of historical mussel sampling sites in the Spoon River basin.

RESULTS

Mussel Survey

In 149 person-hours of sampling, 499 live individuals were collected from the La Moine River and its tributaries representing 20 species (Table 3). Eighteen of the 40 sites sampled in the La Moine produced live individuals. Two sites on the East Fork of the La Moine River (Site 2 and Site 10) received an MCI score of Highly Valued (Figure 5). Plain Pocketbook (*Lampsilis cardium*) was the most common species in the La Moine basin, comprising 19% of all live individuals. Wabash Pigtoe (*Fusconia flava*) and Creeper (*Strophitus undulatus*) made up 15% and 14% of live individuals, respectively.

The Spoon River and tributaries produced a total of 1,308 live individuals and 21 species (Table 4) in 160 person-hours of sampling. Live individuals were collected from 34 of the 40 Spoon River basin sites. Six sites from the Spoon received a MCI of Highly Valued (Sites 10, 21, 23, 24, 33 and 34) (Figure 5). *L. cardium* was also the most common species found in the Spoon basin and accounted for 21% of live individuals. *F. flava* accounted for 14% of live individuals and White Heelsplitter (*Lasmigona complanata*) accounted for 13%.

No threatened or endangered mussel species were collected alive during this survey although relic shells were collected. A relic shell of the state endangered Snuffbox (*Epioblasma triquetra*) was found at Spoon River site 24. Relic shells of the state threatened Slippershell (*Alasmidonta viridis*), Spike (*Elliptio dilatata*) and Black sandshell (*Ligumia recta*) were also found in the Spoon River basin.

Table 3. All mussels collected and site MCI from La Moine River basin survey. Only sites where live individuals and shell were collected are represented. Number indicates the live individuals collected at each site, D indicates that species was only represented by recently deceased shell and R indicates that species was only represented by relic shell. (*Indicates a MRV of Highly Valued)

		Site							
Species	**Common Name**	2	3	4	7	9	10	11	12
Subfamily Ambleminae									
Amblema plicata	Threeridge						R		
Fusconia flava	Wabash pigtoe	40	4				10	6	
Pleurobema sintoxia	Round pigtoe		D						
Quadrula pustulosa	Pimpleback	18	12				9		1
Quadrula quadrula	Mapleleaf	30	2	12			3	2	2
Tritogonia verrucosa	Pistolgrip	9	2	R		6	5		
Uniomerus tetralasmus	Pondhorn								
Subfamily Anodontinae									
Lasmigona complanata	White heelsplitter	1	1	7		3	1	1	4
Pyganodon grandis	Giant floater	2		6					3
Strophitus undulatus	Creeper	30	5			2	7	4	12
Utterbackia imbecillis	Paper pondshell	1	D	10					
Subfamily Lampsilinae									
Lampsilis cardium	Plain pocketbook	11	9	R		3	71		
Lampsilis siliquoidea	Fatmucket	5		1			11		
Lampsilis teres	Yellow sandshell		1						
Leptodea fragilis	Fragile papershell	2	2			1	1		D
Ligumia subrostrata	Pondmussel			R		2		1	
Obliquaria reflexa	Threehorn wartyback								
Potamilus alatus	Pink heelsplitter								
Potamilus ohiensis	Pink papershell								
Toxolasma parvus	Lilliput		1	D	D	D			
Truncilla donaciformes	Fawnsfoot								
Truncilla truncata	Deertoe	2	2				2		
Number of Live Individuals		151	41	36	0	17	120	14	22
MCI		13*	11	7	5	8	12*	9	8
*Indicates MCI value of Highly Valued									

Table 3. (continued)

		Site							
Species	**Common Name**	15	16	17	19	21	22	25	26
Subfamily Ambleminae									
Amblema plicata	Threeridge								
Fusconia flava	Wabash pigtoe						17		
Pleurobema sintoxia	Round pigtoe				1				
Quadrula pustulosa	Pimpleback					1	1		
Quadrula quadrula	Mapleleaf					R	1		
Tritogonia verrucosa	Pistolgrip								
Uniomerus tetralasmus	Pondhorn	D		D		D			4
Subfamily Anodontinae									
Lasmigona complanata	White heelsplitter	D			1	D	2		
Pyganodon grandis	Giant floater					1	11		
Strophitus undulatus	Creeper					D	7		
Utterbackia imbecillis	Paper pondshell								
Subfamily Lampsilinae									
Lampsilis cardium	Plain pocketbook				1				
Lampsilis siliquoidea	Fatmucket								
Lampsilis teres	Yellow sandshell				1				
Leptodea fragilis	Fragile papershell				1	D			
Ligumia subrostrata	Pondmussel					D	2		
Obliquaria reflexa	Threehorn wartyback								
Potamilus alatus	Pink heelsplitter								
Potamilus ohiensis	Pink papershell								
Toxolasma parvus	Lilliput		D	1	1	D	D	D	
Truncilla donaciformes	Fawnsfoot								
Truncilla truncata	Deertoe								
Number of Live Individuals		0	0	1	6	2	41	0	4
MCI		5	5	6	7	8	11	5	6
*Indicates MCI value of Highly Valued									

Table 3. (continued)

		Site						
Species	**Common Name**	27	29	31	32	33	34	35
Subfamily Ambleminae								
Amblema plicata	Threeridge							
Fusconia flava	Wabash pigtoe							
Pleurobema sintoxia	Round pigtoe							
Quadrula pustulosa	Pimpleback					D	1	D
Quadrula quadrula	Mapleleaf				D	1	1	
Tritogonia verrucosa	Pistolgrip					8	3	2
Uniomerus tetralasmus	Pondhorn							
Subfamily Anodontinae								
Lasmigona complanata	White heelsplitter	D		D				
Pyganodon grandis	Giant floater		D			1		
Strophitus undulatus	Creeper						1	D
Utterbackia imbecillis	Paper pondshell							
Subfamily Lampsilinae								
Lampsilis cardium	Plain pocketbook		1			1		R
Lampsilis siliquoidea	Fatmucket							
Lampsilis teres	Yellow sandshell				1	D	3	D
Leptodea fragilis	Fragile papershell					2	9	D
Ligumia subrostrata	Pondmussel		1	D	D			
Obliquaria reflexa	Threehorn wartyback						1	
Potamilus alatus	Pink heelsplitter	R						
Potamilus ohiensis	Pink papershell						1	
Toxolasma parvus	Lilliput							
Truncilla donaciformes	Fawnsfoot						3	
Truncilla truncata	Deertoe							
Number of Live Individuals		0	2	0	1	13	23	2
MCI		5	6	5	5	8	10	7
*Indicates MCI value of Highly Valued								

Table 3. (continued)

		Site		
Species	**Common Name**	36		**Total Live**
Subfamily Ambleminae				
Amblema plicata	Threeridge			0
Fusconia flava	Wabash pigtoe			77
Pleurobema sintoxia	Round pigtoe			1
Quadrula pustulosa	Pimpleback			43
Quadrula quadrula	Mapleleaf			54
Tritogonia verrucosa	Pistolgrip			35
Uniomerus tetralasmus	Pondhorn	R		4
Subfamily Anodontinae				
Lasmigona complanata	White heelsplitter	3		24
Pyganodon grandis	Giant floater			24
Strophitus undulatus	Creeper			68
Utterbackia imbecillis	Paper pondshell			11
Subfamily Lampsilinae				
Lampsilis cardium	Plain pocketbook			97
Lampsilis siliquoidea	Fatmucket			17
Lampsilis teres	Yellow sandshell			6
Leptodea fragilis	Fragile papershell	D		18
Ligumia subrostrata	Pondmussel			6
Obliquaria reflexa	Threehorn wartyback			1
Potamilus alatus	Pink heelsplitter			0
Potamilus ohiensis	Pink papershell			1
Toxolasma parvus	Lilliput			3
Truncilla donaciformes	Fawnsfoot			3
Truncilla truncata	Deertoe			6
Number of Live Individuals		3		499
MCI		6		
*Indicates MCI value of Highly Valued				

Table 4. All mussels and site MCI collected from Spoon River basin survey. Only sites where live individuals and shell were collected are represented. Number indicates the live individuals collected at each site, D indicates that species was only represented by recently deceased shell and R indicates that species was only represented by relic shell. (* indicates a MRV of Highly Valued)

		Site							
Species	**Common Name**	1	2	3	4	5	6	7	8
Subfamily Ambleminae									
Amblema plicata	Threeridge					R		R	
Elliptio dilatata	Spike						R	R	
Fusconia flava	Wabash pigtoe		14			19		R	
Pleurobema sintoxia	Round pigtoe								
Quadrula metanevra	Monkeyface								
Quadrula pustulosa	Pimpleback					2			
Quadrula quadrula	Mapleleaf								
Tritogonia verrucosa	Pistolgrip		1			7			
Uniomerus tetralasmus	Pondhorn								
Subfamily Anodontinae									
Alasmidonta viridis	Slippershell mussel								
Anodontoides ferussacianus	Cylindrical papershell				D	R	10	6	25
Lasmigona complanata	White heelsplitter	1	D	D	7	2			133
Lasmigona compressa	Creek heelsplitter	3				2			6
Lasmigona costata	Fluted-shell								
Pyganodon grandis	Giant floater					D			
Strophitus undulatus	Creeper		3		2	1			1
Utterbackia imbecillis	Paper pondshell								
Subfamily Lampsilinae									
Actinonaias ligmentina	Mucket								
Epioblasma triquetra	Snuffbox								
Lampsilis cardium	Plain pocketbook	3	1			45	D	R	
Lampsilis siliquoidea	Fatmucket	D	5	1		9		R	
Lampsilis teres	Yellow sandshell								
Leptodea fragilis	Fragile papershell	D	D		D	D			
Ligumia recta	Black sandshell								
Ligumia subrostrata	Pondmussel								
Obliquaria reflexa	Threehorn wartyback								
Potamilus alatus	Pink heelsplitter								
Potamilus ohiensis	Pink papershell								
Toxolasma parvus	Lilliput	1	D						D
Truncilla donaciformes	Fawnsfoot								
Truncilla truncata	Deertoe								
Venustaconcha ellipsiformes	Ellipse								
Number of Live Individuals		8	24	1	9	87	10	6	165
MCI		8	8	5	7	10	7	6	10
*Indicates MCI value of Highly Valued									

Table 4. (continued)

		Site							
Species	**Common Name**	9	10	11	12	13	14	15	16
Subfamily Ambleminae									
Amblema plicata	Threeridge	R							
Elliptio dilatata	Spike	11	R						
Fusconia flava	Wabash pigtoe		33	8				12	
Pleurobema sintoxia	Round pigtoe	1	10					3	
Quadrula metanevra	Monkeyface		1						
Quadrula pustulosa	Pimpleback	4	23	4				14	D
Quadrula quadrula	Mapleleaf							7	
Tritogonia verrucosa	Pistolgrip								
Uniomerus tetralasmus	Pondhorn								
Subfamily Anodontinae									
Alasmidonta viridis	Slippershell mussel	R	R						
Anodontoides ferussacianus	Cylindrical papershell		4	16		1			
Lasmigona complanata	White heelsplitter			2		D	D		7
Lasmigona compressa	Creek heelsplitter		D	9		D	D		D
Lasmigona costata	Fluted-shell								
Pyganodon grandis	Giant floater		R						6
Strophitus undulatus	Creeper	1	7	12	1	D		1	3
Utterbackia imbecillis	Paper pondshell								
Subfamily Lampsilinae									
Actinonaias ligmentina	Mucket								
Epioblasma triquetra	Snuffbox								
Lampsilis cardium	Plain pocketbook	42	8	12	15	3	D		3
Lampsilis siliquoidea	Fatmucket	2	6		2		1		1
Lampsilis teres	Yellow sandshell								
Leptodea fragilis	Fragile papershell		D						
Ligumia recta	Black sandshell								
Ligumia subrostrata	Pondmussel								
Obliquaria reflexa	Threehorn wartyback								
Potamilus alatus	Pink heelsplitter								
Potamilus ohiensis	Pink papershell								
Toxolasma parvus	Lilliput	D	R	1				1	1
Truncilla donaciformes	Fawnsfoot								
Truncilla truncata	Deertoe								
Venustaconcha ellipsiformes	Ellipse								
Number of Live Individuals		61	92	64	18	4	1	38	21
MCI		9	14*	11	6	7	6	9	10
*Indicates MCI value of Highly Valued									

Table 4. (continued)

Species	Common Name	Site 17	18	19	20	21	22	23	24
Subfamily Ambleminae									
Amblema plicata	Threeridge					R	1	D	R
Elliptio dilatata	Spike					R	R	R	R
Fusconia flava	Wabash pigtoe		5	7		23	D	6	28
Pleurobema sintoxia	Round pigtoe						1	7	13
Quadrula metanevra	Monkeyface					3	2	14	91
Quadrula pustulosa	Pimpleback			4		17	1	2	19
Quadrula quadrula	Mapleleaf					2		3	19
Tritogonia verrucosa	Pistolgrip			1		12	D		
Uniomerus tetralasmus	Pondhorn	1	1						
Subfamily Anodontinae									
Alasmidonta viridis	Slippershell mussel								
Anodontoides ferussacianus	Cylindrical papershell				D				
Lasmigona complanata	White heelsplitter	2	4	3	R	1	3		2
Lasmigona compressa	Creek heelsplitter		4	2		1	D		
Lasmigona costata	Fluted-shell								R
Pyganodon grandis	Giant floater								
Strophitus undulatus	Creeper	2	5	1	D	11	D	D	4
Utterbackia imbecillis	Paper pondshell								
Subfamily Lampsilinae									
Actinonaias ligmentina	Mucket								R
Epioblasma triquetra	Snuffbox								R
Lampsilis cardium	Plain pocketbook			22		13	6	34	D
Lampsilis siliquoidea	Fatmucket	1	1	14		R	R	R	1
Lampsilis teres	Yellow sandshell								
Leptodea fragilis	Fragile papershell					2	D	D	1
Ligumia recta	Black sandshell								
Ligumia subrostrata	Pondmussel								
Obliquaria reflexa	Threehorn wartyback								
Potamilus alatus	Pink heelsplitter								
Potamilus ohiensis	Pink papershell								
Toxolasma parvus	Lilliput				D				
Truncilla donaciformes	Fawnsfoot								1
Truncilla truncata	Deertoe								
Venustaconcha ellipsiformes	Ellipse						R	R	
Number of Live Individuals		6	20	54	0	85	14	66	179
MCI		7	7	9	5	14*	11	13*	13*

*Indicates MCI value of Highly Valued

Table 4. (continued)

Species	Common Name	Site 25	26	27	28	29	30	31	32
Subfamily Ambleminae									
Amblema plicata	Threeridge				R				R
Elliptio dilatata	Spike								
Fusconia flava	Wabash pigtoe		R						
Pleurobema sintoxia	Round pigtoe	2							D
Quadrula metanevra	Monkeyface	3							D
Quadrula pustulosa	Pimpleback				R				1
Quadrula quadrula	Mapleleaf	1		5	1		D		D
Tritogonia verrucosa	Pistolgrip			1			1		
Uniomerus tetralasmus	Pondhorn		D			D		D	
Subfamily Anodontinae									
Alasmidonta viridis	Slippershell mussel								
Anodontoides ferussacianus	Cylindrical papershell				R				
Lasmigona complanata	White heelsplitter				1		1	R	
Lasmigona compressa	Creek heelsplitter								
Lasmigona costata	Fluted-shell								
Pyganodon grandis	Giant floater						D		
Strophitus undulatus	Creeper	D	D		D		D		D
Utterbackia imbecillis	Paper pondshell								
Subfamily Lampsilinae									
Actinonaias ligmentina	Mucket								
Epioblasma triquetra	Snuffbox								
Lampsilis cardium	Plain pocketbook	3		D	2	D	D		3
Lampsilis siliquoidea	Fatmucket		R	D					
Lampsilis teres	Yellow sandshell								
Leptodea fragilis	Fragile papershell	D		D			D		D
Ligumia recta	Black sandshell								
Ligumia subrostrata	Pondmussel								
Obliquaria reflexa	Threehorn wartyback								
Potamilus alatus	Pink heelsplitter								
Potamilus ohiensis	Pink papershell						1		
Toxolasma parvus	Lilliput		D		D	D		D	
Truncilla donaciformes	Fawnsfoot								1
Truncilla truncata	Deertoe								
Venustaconcha ellipsiformes	Ellipse		R						
Number of Live Individuals		9	0	6	4	0	3	0	5
MCI		9	5	7	7	5	8	5	10
*Indicates MCI value of Highly Valued									

Table 4. (continued)

		Site				
Species	**Common Name**	33	34	35	36	37
Subfamily Ambleminae						
Amblema plicata	Threeridge	R	R	R		R
Elliptio dilatata	Spike	R			R	
Fusconia flava	Wabash pigtoe	19	14	D		
Pleurobema sintoxia	Round pigtoe	27	3	R		
Quadrula metanevra	Monkeyface	34	D	D		
Quadrula pustulosa	Pimpleback	31	16	2		R
Quadrula quadrula	Mapleleaf	3	8	2	1	D
Tritogonia verrucosa	Pistolgrip	4				
Uniomerus tetralasmus	Pondhorn					
Subfamily Anodontinae						
Alasmidonta viridis	Slippershell mussel					
Anodontoides ferussacianus	Cylindrical papershell	R	1			
Lasmigona complanata	White heelsplitter	1	D	2	D	
Lasmigona compressa	Creek heelsplitter	D				
Lasmigona costata	Fluted-shell	R				
Pyganodon grandis	Giant floater					
Strophitus undulatus	Creeper	2	D	R	R	
Utterbackia imbecillis	Paper pondshell					
Subfamily Lampsilinae						
Actinonaias ligmentina	Mucket		R	R	R	
Epioblasma triquetra	Snuffbox					
Lampsilis cardium	Plain pocketbook	59	1	3	R	
Lampsilis siliquoidea	Fatmucket	1		R		
Lampsilis teres	Yellow sandshell				R	
Leptodea fragilis	Fragile papershell	D	D	D	D	1
Ligumia recta	Black sandshell	R				
Ligumia subrostrata	Pondmussel					
Obliquaria reflexa	Threehorn wartyback					1
Potamilus alatus	Pink heelsplitter					D
Potamilus ohiensis	Pink papershell				1	4
Toxolasma parvus	Lilliput					
Truncilla donaciformes	Fawnsfoot			D		
Truncilla truncata	Deertoe	1				
Venustaconcha ellipsiformes	Ellipse				R	
Number of Live Individuals		182	43	9	2	6
MCI		15*	12*	10	7	7
*Indicates MCI value of Highly Valued						

Table 4. (continued)

		Site			
Species	**Common Name**	39	40		**Total Live**
Subfamily Ambleminae					
Amblema plicata	Threeridge				1
Elliptio dilatata	Spike				0
Fusconia flava	Wabash pigtoe				188
Pleurobema sintoxia	Round pigtoe				67
Quadrula metanevra	Monkeyface				148
Quadrula pustulosa	Pimpleback	1			141
Quadrula quadrula	Mapleleaf	2			54
Tritogonia verrucosa	Pistolgrip				27
Uniomerus tetralasmus	Pondhorn				2
Subfamily Anodontinae					
Alasmidonta viridis	Slippershell mussel				0
Anodontoides ferussacianus	Cylindrical papershell				63
Lasmigona complanata	White heelsplitter	D			172
Lasmigona compressa	Creek heelsplitter				27
Lasmigona costata	Fluted-shell				0
Pyganodon grandis	Giant floater		R		6
Strophitus undulatus	Creeper				57
Utterbackia imbecillis	Paper pondshell				0
Subfamily Lampsilinae					
Actinonaias ligmentina	Mucket				0
Epioblasma triquetra	Snuffbox				0
Lampsilis cardium	Plain pocketbook	3			281
Lampsilis siliquoidea	Fatmucket				45
Lampsilis teres	Yellow sandshell				0
Leptodea fragilis	Fragile papershell	D			4
Ligumia recta	Black sandshell				0
Ligumia subrostrata	Pondmussel				0
Obliquaria reflexa	Threehorn wartyback				1
Potamilus alatus	Pink heelsplitter				0
Potamilus ohiensis	Pink papershell				6
Toxolasma parvus	Lilliput				4
Truncilla donaciformes	Fawnsfoot				2
Truncilla truncata	Deertoe				1
Venustaconcha ellipsiformes	Ellipse				0
Number of Live Individuals		6	0		1308
MCI		7	4		
*Indicates MCI value of Highly Valued					

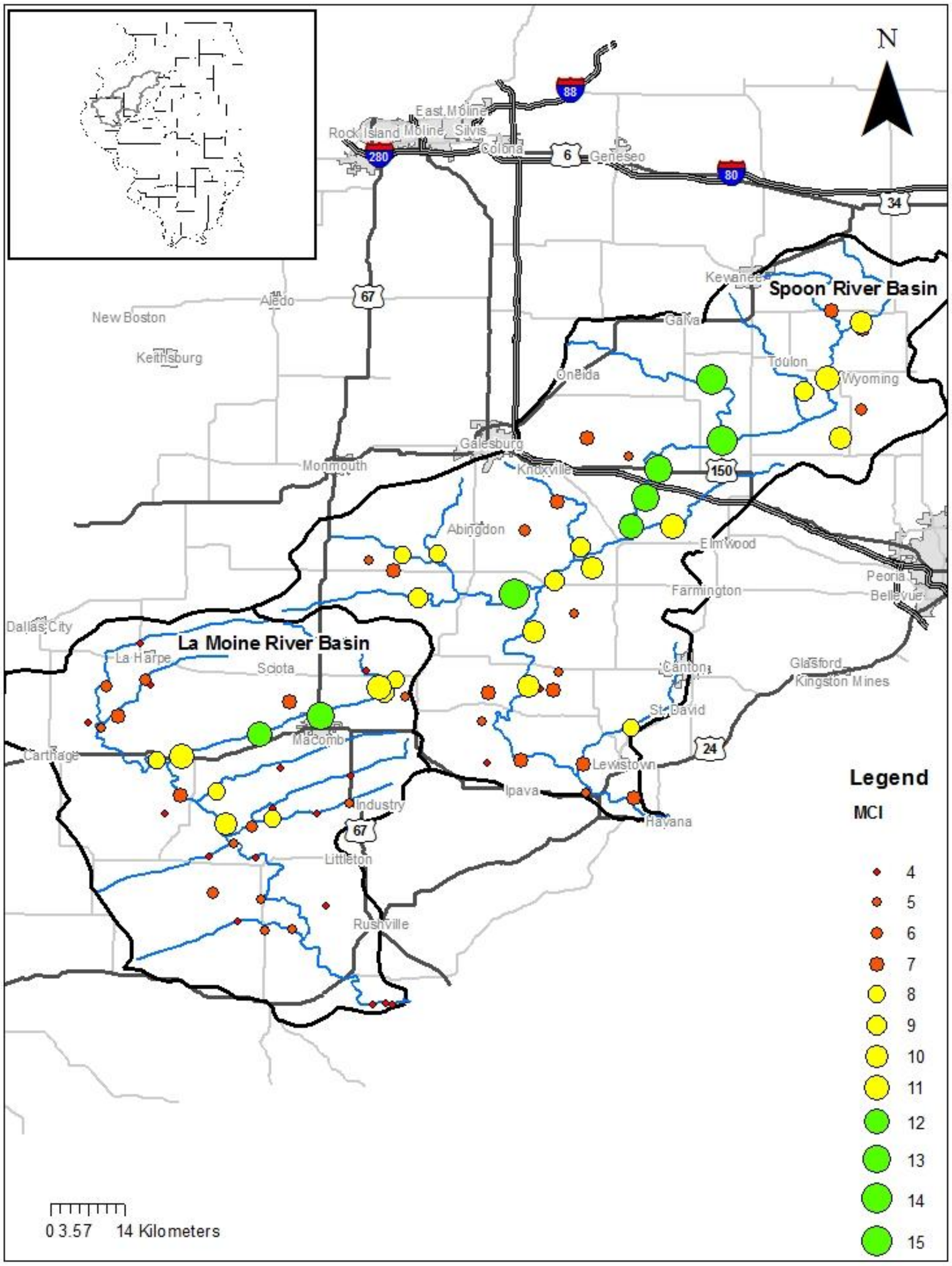

Figure 5. Map of sampled sites on both the La Moine and Spoon Rivers and corresponding Mussel Classification Index scores.

GIS Analysis

The number of fish and mussel species found in a basin was found to have a significant positive relationship to the size of the basin. The sample area was divided into 45 smaller sub-basins and fish data were available for 38 of these sub-basins. As basin size increases, the number of fish (*fish species* = 6.8ln(*basin size(km²)*) – 12.1, $p < 0.0001$, *Adj.* $R^2 = 0.67$) and mussel (*mussel species* = 2.8ln(*basin size(km²)*) – 8.49, $p < 0.0001$, *Adj.* $R^2 = 0.50$) species also increase (Table 5, Figure 6). This corresponds to a similar comparison done by Watters (1993) and Myers-Kinzie et al. (2001).

Just 3 land use categories (row crop, pasture and forest) comprised between 70 - 95% of total land use in each site specific basin. Land use varied greatly between basins. Row crop accounted for 23 – 84% of land use, forest < 1 – 47% and pasture < 1 – 30%. When a regression analysis was performed comparing proportion of each land use category to site MCI, all three categories showed a significant relationship. Proportion of row crop in a site's basin showed a positive relationship to site MCI (*MCI* = 6.42*(proportion row crop)* + 3.47, $p = 0.001$, *Adj.* $R^2 = 0.12$) (Figure 7). Both proportion of pasture and forest showed a significant negative relationship to MCI (*MCI* = -25.99*(proportion pasture)* + 10.49, $p = 0.0004$, *Adj.* $R^2 = 0.18$ and *MCI* = -8.83(*proportion forest)* + 8.86, $p = 0.002$, *Adj.* $R^2 = 0.11$) (Figures 8 and 9).

Mean percent basin slope had no significant effect on site MCI (*MCI* = -0.41(*% slope)* + 8.44, $p = 0.13$, *Adj.* $R^2 = 0.02$) (Figure 10). Although mean basin slope showed no significant relationship to site MCI, it was found that slope showed a significant relationship to the proportion of each land use category with in the basin. As mean basin slope increased, the proportion of row crop in the basin decreased ((*Proportion row crop)*

= -0.10*(% slope)* + 0.88, p = 3.4 x 10^{-15}, *Adj.* R^2 = 0.54) (Figure 11) and proportion of forest (*(proportion forest)* = 0.08*(% slope)* – 0.04, p = 9.4 x 10^{-20}, *Adj,* R^2 = 0.65) (Figure 12) and pasture (*(proportion pasture)* = 0.02*(% slope)* + 0.06, p = 1.7 x 10^{-7}, *Adj.* R^2 = 0.29) (Figure 13) increased.

Many of the sampled sites were downstream of other sampled sites. This causes their corresponding basins to 'overlap' and their subsequent land uses and slopes to be counted more than once (i.e. pseudoreplication and autocorrelation). In an attempt to examine whether multiple countings skewed the results of this study, 26 non-overlapping basins of various sizes and MCI scores were chosen for independent regression analysis. The results of this analysis showed very similar results concerning land use (*MCI* = 11.12*(proportion row crop)* + 1.62, p = 0.003, *Adj.* R^2 = 0.28: *MCI* = -15.17*(proportion forest)* + 10.95, p = 0.003, *Adj.* R^2 = 0.28: *MCI* = -42.01*(proportion pasture)* + 13.44, p = 0.001, *Adj.* R^2 = 0.34).

The non-overlapping basin regression analysis comparing mean percent basin slope to site MCI did show a significant negative relationship (*MCI* = -1.11*(% slope)* + 11.25, p = 0.034, *Adj.* R^2 = 0.14). The comparison of slope to land use in this analysis also were similar to the analysis comparing all basins.

Table 5. Number of live mussel species and fish species from each basin in La Moine and Spoon rivers and size of each basin.

Basin	Live Mussel Species	Fish Species[1]	Basin Size[2]
Spoon River Main Stem	19	45	5473
E. Fork La Moine River	16	46	635
La Moine River Main Stem	13	49	4122
Cedar Creek (Spoon)	11	30	903
Walnut Creek	10	25	551
E. Fork Spoon River	10	23	86
Camp Creek (LaMoine)	9	27	370
Haw Creek	9	30	367
Big Creek	9	16	204
Drowning Fork	9	23	119
Spring Creek	9	22	92
Cedar Fork	8	30	371
Swan Creek	8	26	284
French Creek	8	22	226
Grindstone Creek	8	32	167
Farmer's Fork	8	21	151
Littlers Creek	8	22	139
La Harpe Creek	7	21	305
Troublesome Creek	7	28	245
Indian Creek	7	28	223
Negro Creek	6	-	128
Put Creek	5	24	293
Shaw Creek	5	21	168
Prince Run	5	13	113
North Creek	5	25	97
Turkey Creek	4	-	140
Brush Creek	4	23	115
W.Fork Spoon River	4	21	44
Court Creek	3	22	321
Coal Creek	3	21	136
Barker Creek	3	23	76
Rock Creek	3	16	70
Missouri Creek	2	25	298
Flour Creek	2	-	209
Cedar Creek (LaMoine)	2	18	168
Williams Creek	2	25	126
Tater Creek	2	14	62
Kepple Creek	2	13	57
Coopers Defeat Creek	2	-	35

Table 5. (continued)

Little Creek	2	5	33
Camp Creek (Spoon)	1	22	230
Little Missouri Creek	1	15	118
Bronson Creek	0	-	210
Stoney Branch	0	-	88
Francis Creek	0	-	35

[1]Fish species data was gathered from IDNR basin reports and INHS Fish Collection data.
[2]Basin Size measured in square kilometers.

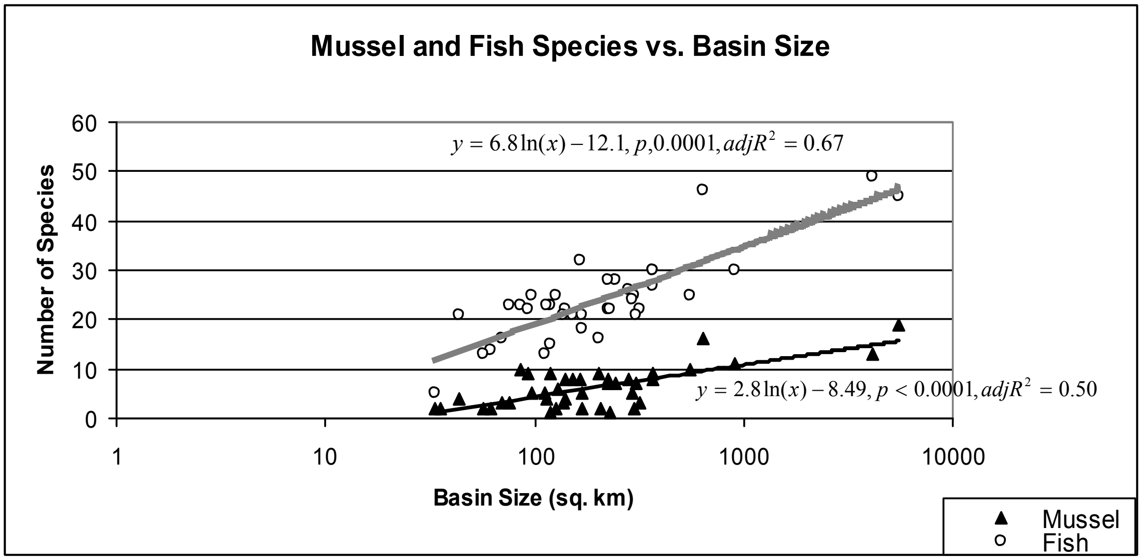

Figure 6. Regression analysis of number of mussel and fish species found in each basin of the Spoon and La Moine Rivers compared to basin size.

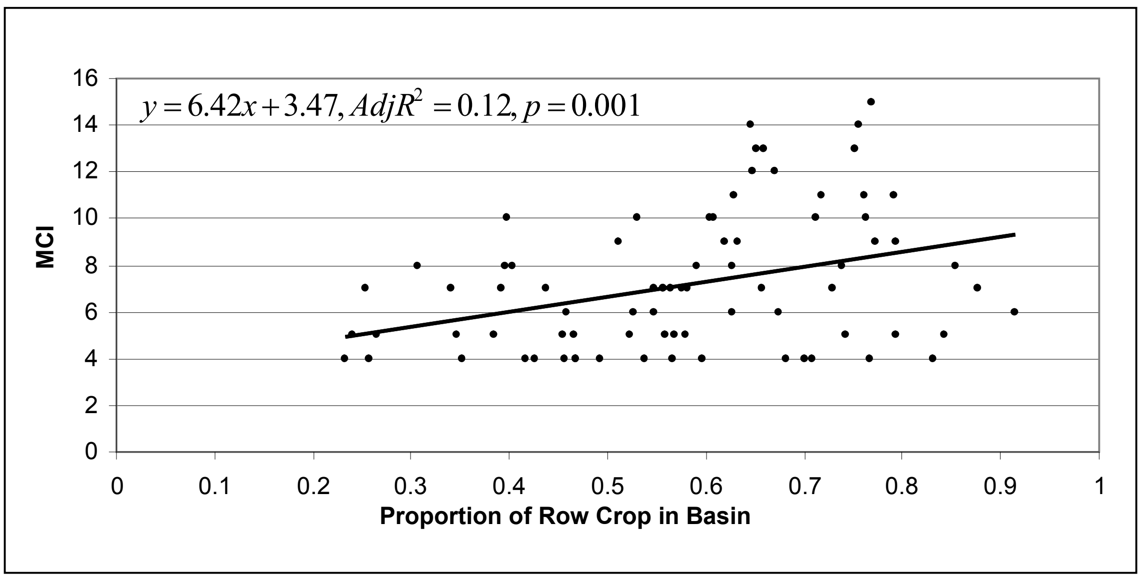

Figure 7. Comparison of site MCI versus the proportion of row crop in the site's watershed.

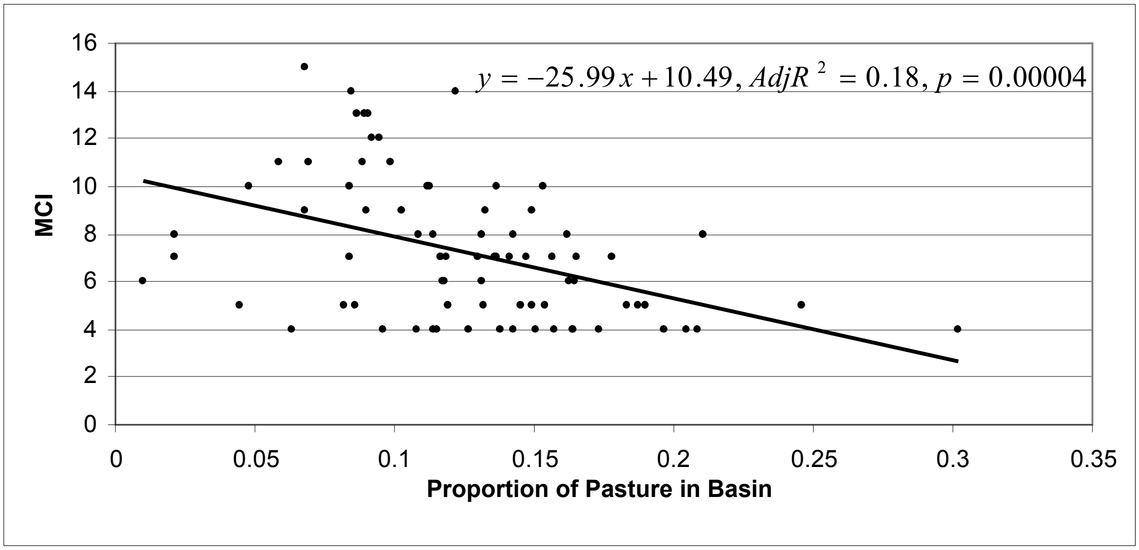

Figure 8. Comparison of site MCI versus the proportion of pasture land in the site's watershed.

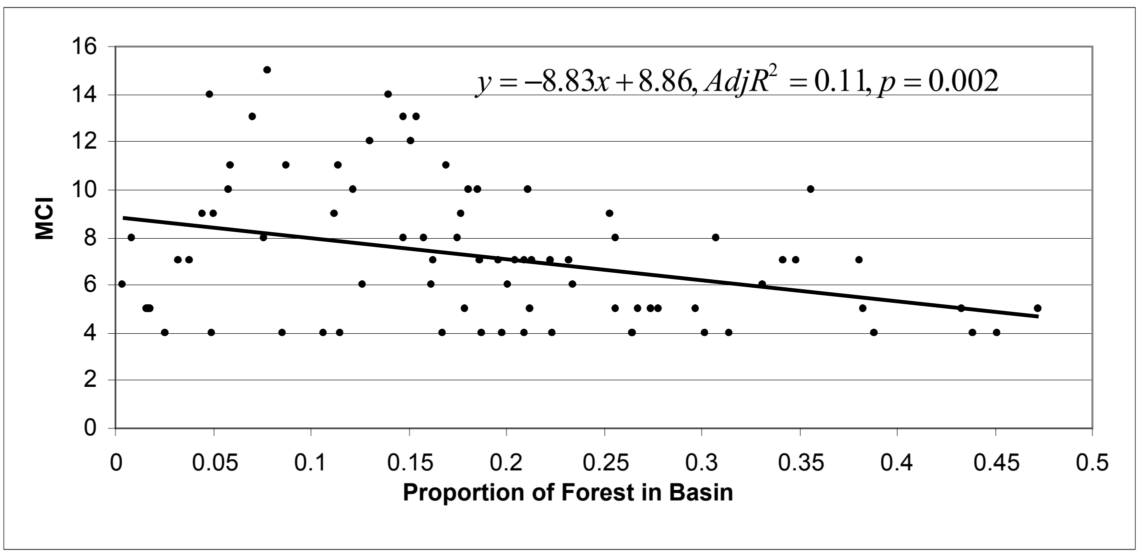

Figure 9. Comparison of site MCI versus the proportion of forest land in the site's watershed.

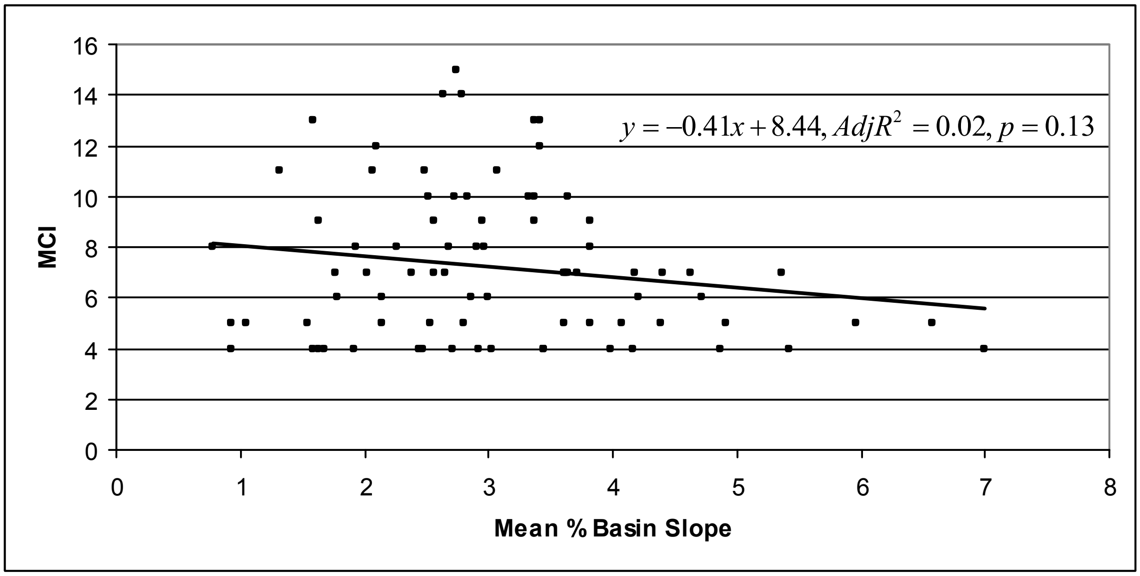

Figure 10. Comparison of site MCI versus the mean basin slope in the site's watershed.

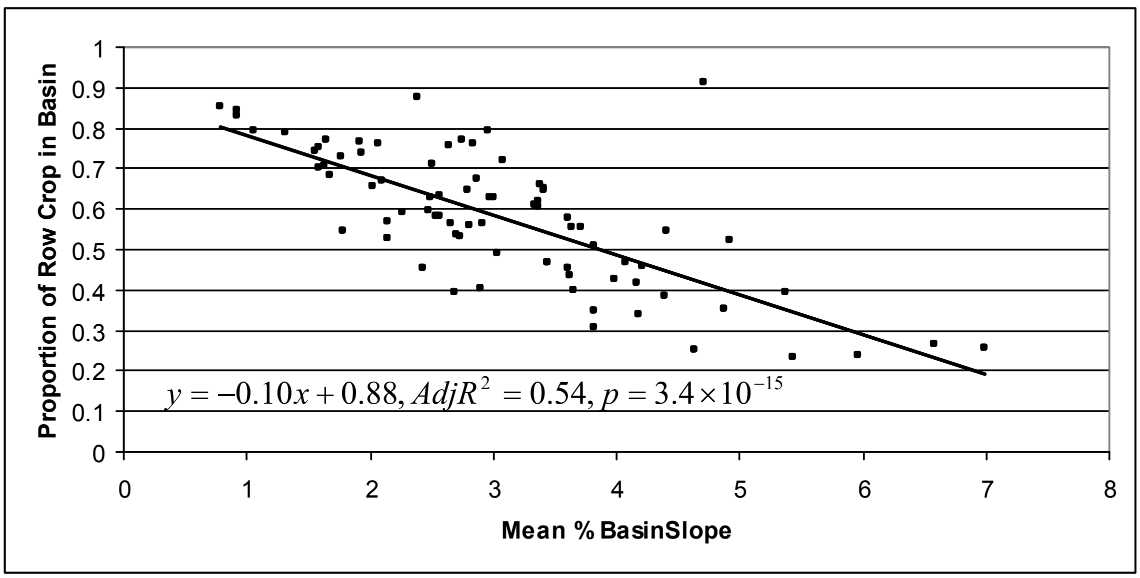

Figure 11. Comparison of proportion of row crop in site basin versus mean basin slope for each site.

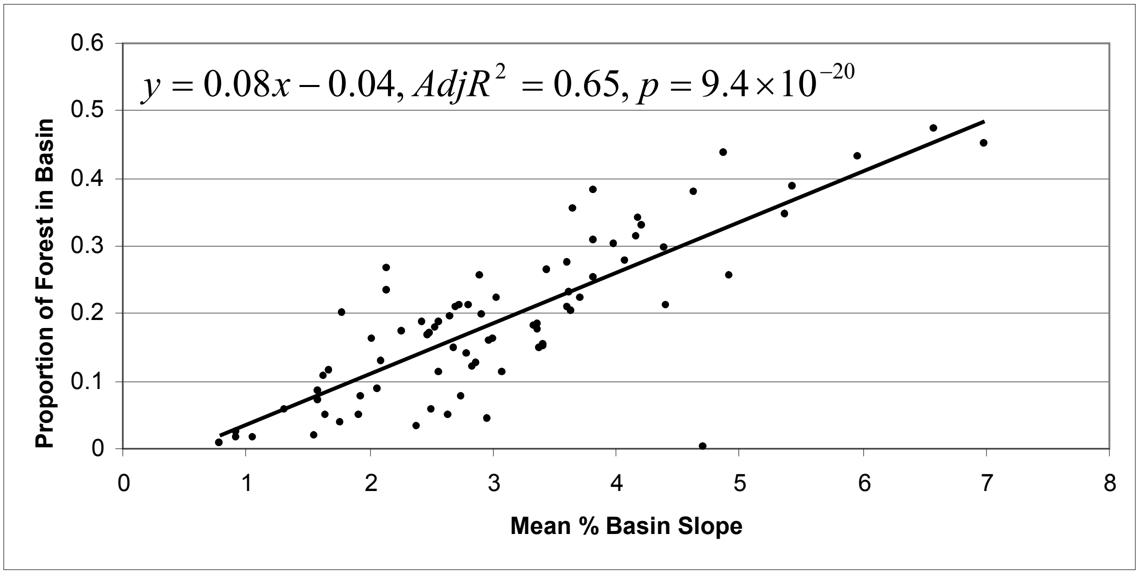

Figure 12. Comparison of proportion of forest in site basin versus mean basin slope for each site.

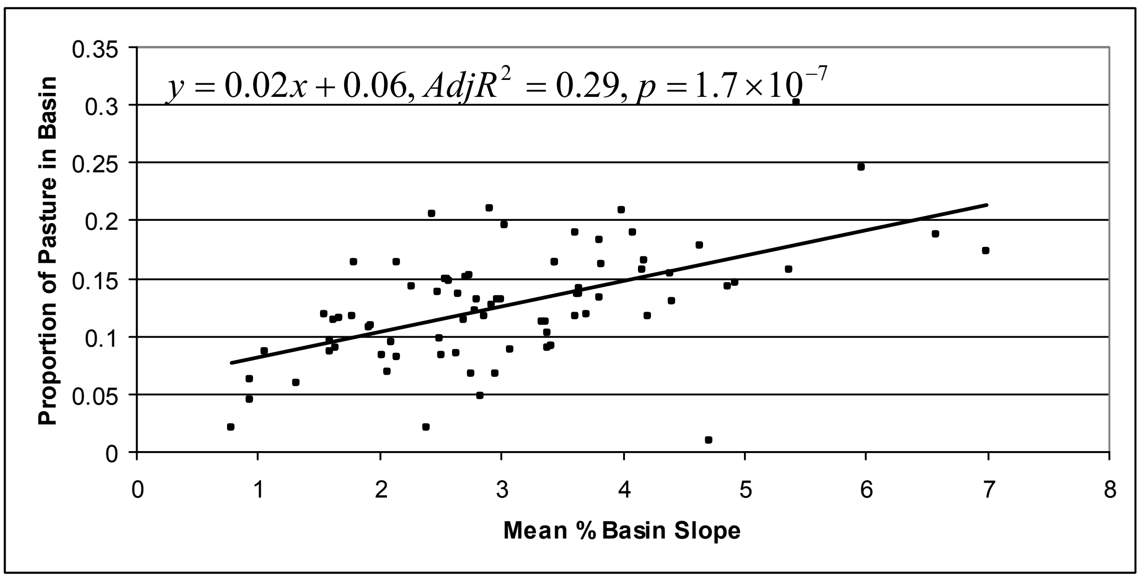

Figure 13. Comparison of proportion of pasture in site basin versus mean basin slope for each site.

Historical Data

Historical mussel data for the La Moine River basin were divided into four time periods. The survey completed by Baumgardner (1995) was supplemented by additional INHS data and are the earliest samples known on the La Moine, herein designated as “pre-1991”. Surveys during this time period collected 13 live species from the La Moine basin, as well as deceased shell of 4 additional species (Table 7). Surveys completed between 1991-2000 entirely consisted of INHS collection data and also produced 13 live species, 3 of which were not found live in the previous time period. The number of live species collected from the La Moine basin increased to 18 from INHS surveys between the years 2001-2009. In my survey, 20 species were found live. Overall, 26 species have been found as live individuals or deceased shell from the La Moine River basin.

The mussels of the Spoon River basin have been studied more thouroughly than those in the La Moine basin. The Spoon River historical data were divided into seven time periods. The first were samples performed by W.S. Strode in between 1892-1912. In this time period 38 species were collected from the Spoon River (Table 8). Surveys done in 1949 by J.M. Reed (INHS data) found only 14 species. Since 1957, the number of live species found in the Spoon River basin has ranged from 17 (1990s INHS surveys) to 21 (2000-2009 INHS surveys and W.C. Starrett 1971), but has remained relatively constant.

I found 22 species alive in the Spoon River basin. A relic shell of Snuffbox (*E. triquetra*), which had never been recorded from the Spoon River, was found during my survey. From over 100 years of sampling, a total of 43 species have been collected as either live individuals or deceased shell from the Spoon River basin.

Table 6. Historical mussel species collected from the La Moine River basin. L represents the species was found alive in the time frame. D represents only shell of species were collected.

			pre-1991	1991-2000	2001-2009	2009-2010
Species		**Common Name**	(Baumgardner & INHS)	(INHS Data)	(INHS Data)	Current Survey
Subfamily Ambleminae						
Amblema plicata		Threeridge	L	L	L	
Fusconia flava		Wabash pigtoe		L	L	L
Megalonaias nervosa		Washboard	D			
Pleurobema sintoxia		Round pigtoe				L
Quadrula nodulata		Wartyback	D			
Quadrula pustulosa		Pimpleback		L	L	L
Quadrula quadrula		Mapleleaf	L	L	L	L
Tritogonia verrucosa		Pistolgrip	L	L	L	L
Uniomerus tetralasmus		Pondhorn	L	L	L	L
Subfamily Anodontinae						
Anodonta suborbiculata		Flat floater			L	
Lasmigona complanata		White heelsplitter	L	L	L	L
Pyganodon grandis		Giant floater	L	L	L	L
Strophitus undulatus		Creeper	L	L	L	L
Utterbackia imbecillis		Paper pondshell		D	L	L
Subfamily Lampsilinae						
Actinonaias ligamentina		Mucket	D		L	
Lampsilis cardium		Plain pocketbook	D	L	L	L
Lampsilis siliquoidea		Fatmucket	L	L		L
Lampsilis teres		Yellow sandshell	L		L	L
Leptodea fragilis		Fragile papershell	L	L	L	L
Ligumia subrostrata		Pondmussel			L	L
Obliquaria reflexa		Threehorn wartyback				L
Potamilus alatus		Pink heelsplitter	L			D
Potamilus ohiensis		Pink papershell	L			L
Toxolasma parvus		Lilliput	L	L	L	L
Truncilla donaciformes		Fawnsfoot				L
Truncilla truncata		Deertoe			L	L
Total Species	26	**Total Live Species**	13	13	18	20

Table 7. Historical mussel species collected from the Spoon River basin (1892-1971). L represents the species was found alive in the time frame. D represents only shell of species were collected.

Species	Common Name	1892-1912 (Strode)	1949 (Reed)	1957 (Matteson)	1971 (Starrett)
Subfamily Ambleminae					
Amblema plicata	Threeridge	L	L	L	L
Cyclonaias tuberculata	Purple wartyback	L			
Elliptio crassidens	Elephant-ear				D
Elliptio dilatata	Spike	L			D
Fusconia flava	Wabash pigtoe	L	L	L	L
Megalonaias nervosa	Washboard	L			
Plethobasus cyphyus	Sheepnose	L			
Pleurobema sintoxia	Round pigtoe	L	L	L	L
Quadrula fragosa	Winged mapleleaf	L			
Quadrula metanevra	Monkeyface	L	L	L	L
Quadrula nodulata	Wartyback	L			
Quadrula pustulosa	Pimpleback	L	L	L	L
Quadrula quadrula	Mapleleaf	L		L	L
Tritogonia verrucosa	Pistolgrip	L	L	L	L
Uniomerus tetralasmus	Pondhorn				
Subfamily Anodontinae					
Alasmidonta marginata	Elktoe	L			
Alasmidonta viridis	Slippershell mussel				D
Anodonta suborbiculata	Flat floater	L			
Anodontoides ferussacianus	Cylindrical papershell			L	L
Arcidens confragosus	Rock-pocketbook	L			
Lasmigona complanata	White heelsplitter	L	L	L	L
Lasmigona compressa	Creek heelsplitter			L	L
Lasmigona costata	Fluted-shell	L	L	D	
Pyganodon grandis	Giant floater	L	L	L	L
Strophitus undulatus	Creeper	L	L	L	L
Utterbackia imbecillis	Paper pondshell	L			
Subfamily Lampsilinae					
Actinonaias ligamentina	Mucket	L			L
Epioblasma triquetra	Snuffbox				
Lampsilis cardium	Plain pocketbook	L	L	L	L
Lampsilis higginsi	Higgins eye	L			L
Lampsilis siliquoidea	Fatmucket	L		L	L
Lampsilis teres	Yellow sandshell	L	L	L	L
Leptodea fragilis	Fragile papershell	L	L	L	L
Ligumia recta	Black sandshell	L		L	
Obliquaria reflexa	Threehorn wartyback	L			
Obovaria olivaria	Hickorynut	L			D
Potamilus alatus	Pink heelsplitter	L			D
Potamilus capax	Fat pocketbook	L			
Potamilus ohiensis	Pink papershell	L	L	L	L
Toxolasma parvus	Lilliput	L		L	L

Table 7. (continued)

Truncilla donaciformes		Fawnsfoot	L		L	L
Truncilla truncata		Deertoe	L			
Venustancha ellipsiformes		Ellipse				
Total Species	43	**Total Live Species**	38	14	20	21

Table 7. (continued) Historical mussel species collected from the Spoon River basin (1990-2010). L represents the species was found alive in the time frame. D represents only shell of species were collected.

		1990s	**2000 - 2009**	**2010**
Species	**Common Name**	(INHS)	(INHS)	Current Survey
Subfamily Ambleminae				
Amblema plicata	Threeridge	L	L	L
Cyclonaias tuberculata	Purple wartyback			
Elliptio crassidens	Elephant-ear			
Elliptio dilatata	Spike	D	D	D
Fusconia flava	Wabash pigtoe	L	L	L
Megalonaias nervosa	Washboard			
Plethobasus cyphyus	Sheepnose			
Pleurobema sintoxia	Round pigtoe	L	L	L
Quadrula fragosa	Winged mapleleaf			
Quadrula metanevra	Monkeyface	L	L	L
Quadrula nodulata	Wartyback			
Quadrula pustulosa	Pimpleback	L	L	L
Quadrula quadrula	Mapleleaf	L	L	L
Tritogonia verrucosa	Pistolgrip	L	L	L
Uniomerus tetralasmus	Pondhorn		L	L
Subfamily Anodontinae				
Alasmidonta marginata	Elktoe			
Alasmidonta viridis	Slippershell mussel			D
Anodonta suborbiculata	Flat floater			
Anodontoides ferussacianus	Cylindrical papershell	L	L	L
Arcidens confragosus	Rock-pocketbook			
Lasmigona complanata	White heelsplitter	L	L	L
Lasmigona compressa	Creek heelsplitter	L	L	L
Lasmigona costata	Fluted-shell		D	D
Pyganodon grandis	Giant floater	L	L	L
Strophitus undulatus	Creeper	L	L	L
Utterbackia imbecillis	Paper pondshell			
Subfamily Lampsilinae				
Actinonaias ligamentina	Mucket		D	D
Epioblasma triquetra	Snuffbox			D
Lampsilis cardium	Plain pocketbook	L	L	L
Lampsilis higginsi	Higgins eye			
Lampsilis siliquoidea	Fatmucket	L	L	L
Lampsilis teres	Yellow sandshell		L	L
Leptodea fragilis	Fragile papershell	L	L	L
Ligumia recta	Black sandshell		D	D
Obliquaria reflexa	Threehorn wartyback			L
Obovaria olivaria	Hickorynut			
Potamilus alatus	Pink heelsplitter		L	D
Potamilus capax	Fat pocketbook			
Potamilus ohiensis	Pink papershell	L	L	L
Toxolasma parvus	Lilliput	L		L

Table 7. (continued)

Truncilla donaciformes		Fawnsfoot		L	L
Truncilla truncata		Deertoe		L	L
Venustancha ellipsiformes		Ellipse	D		D
Total Species	43	**Total Live Species**	17	21	22

DISCUSSION

This survey found Highly Valued mussel assemblages in both the La Moine and Spoon River basins. These communities tend to be located in the middle reaches of both river basins (Figure 5). According to Watters (1993) and Figure 6, you would expect to find more mussel species, and possibly a higher MCI, in the lower reaches of a river system, where basin size is greater. It is possible that these intermediate regions provide suitable habitat for both headwater species (*Ligumia subrostrata, Uniomerus tetralasmus* and *Utterbackia imbecillis*) and species that prefer more flow (*Obliquaria reflexa, Lampsilis teres* and *Quadrula metanevra*). Another explanation could be a decrease in hand searching efficiency in deeper regions of a river. Western Illinois experienced higher than average precipitation and river flow during the summer of 2010. High waters created an environment that was not optimal for hand searching, and it is possible that my sampling missed some individuals in downstream locations.

A site's MCI was also shown to be related to the land use practices in the site basin. Based on the results from Arbuckle and Downing (2002), it was unexpected to find that the more row crop in a site's basin, the higher the MCI; also, it was unexpected that basin slope had no significant relationship to MCI. Because there was not a significant relationship between slope and MCI, the relationships between basin slope and land use categories were found. The close relationship between slope and land use could indicate an indirect relationship to MCI. Areas with lower slopes tend to have a higher proportion of row crop and areas with greater slope have more forest and pasture. Meador and Goldstein (2003) and Wang et al. (2000) found similar results to this when comparing Fish Index of Biotic Integrity (IBI) and number of fish species to land use practices. They explained that this relationship was due to areas with a high proportion of agriculture having a lower proportion of urbanized, impervious ground cover. I do not feel that their explanation is suitable for my study since my study area was not at all urbanized. Meador and Goldstein (2003) found that some basins with high amounts of agriculture had high IBIs and offered the explanation that high amounts of agriculture may not be as detrimental to some fish communities as previously thought. From the results of this study, I am willing to make a similar explanation for freshwater mussel communities.

In this study the only intolerant species found was the Monkeyface (*Quadrula metanevra*) and it was found only in the Spoon River basin. All other species found are considered tolerant, in regards to MCI. Analysis of the historical mussel species of the Spoon River basin shows that 18 species are no longer found alive in the basin and that the majority of these species have not been found since 1949. Of the species no longer found, 2 are federally endangered (*L. higginsi, P. capax*), 2 are state endangered (*P. cyphus, E. triquetra*) and 5 are state threatened (*C. tuberculata, E. crassidens, E. dilatata, A. viridis* and *L. recta*). At the time of the decline of these species from the Spoon River, there was an increase in the proportion of agriculture land in Illinois (Ramankutty and Foley 1999). The amount of land used for agriculture in this region has remained constant since the 1970s and so have the number of species found in the Spoon. The increase in agriculture during the beginning of 20th century could be a reason for the decline in the number of mussel species during that time period. The surviving mussel communities are capable of living in a landscape high in agriculture and could explain the positive relationship seen between row crop land use and MCI.

A similar negative relationship when comparing proportion of pasture in a basin to fish IBI was found by Meador and Goldstein (2003). The grazing of buffer vegetation can allow for an increase in sediment in run off along with nutrients from excrement (Platts 1991). As found in this study area, pasture land is often located in basins with a high slope and the steeper slope can increase runoff. While sampling I often noticed pasture land either adjacent to or encompassing a stream. Wading livestock can have obvious negative effects on freshwater mussels due to trampling and increased suspended sediment. Increased runoff, nutrients, and suspended sediment, as well as trampling and fewer fish species can all help explain the negative relationship between pasture land and MCI.

The surveys of both river basins found fewer live species than were historically known. In the Spoon River, just over half the number of historical species has been found still occupying the basin. Studies similar to this one are needed from basins with healthier, more extensive mussel communities for comparisons to be made. If it is found that a basin like the La Moine or Spoon have similar characteristics as a system with a more extensive mussel community, then it may be possible for the reintroduction of extirpated species. It is not outrageous to think some basins may be near the point of attempting to reintroduce the extirpated mussels of that system. Sietman et al. (2001) sampled six species from the Upper Illinois River that were thought to have been extirpated and *O. reflexa* was found live in the Spoon River during my survey, for the first time since 1892.

Although the number of live species in the Spoon River basin has seemed relatively constant since 1957, the number of live species found in the La Moine appears to be increasing since 1990. This is most likely a product of under-sampling of the mussels of the La Moine River. Unlike the Spoon River, very is little is known of La Moine River mussels before 1990. Because of their similar sizes, locations and current mussel communities, I feel that a mussel survey that occurred on the La Moine alongside Strode's Spoon River survey (1892) would have yielded similar species numbers.

My survey has helped to understand the mussel communities of both basins. A recent, basin-wide mussel survey of either basin was necessary and showed that the two basins were similar in the live species collected from them. The land use in both basins in predominately row crop agriculture and land use analyses suggest that this land use may not be completely detrimental to current mussel communities. But, as seen in the Spoon River basin, mussel communities are not as species rich as they once were and further analysis of other basins may need to be accomplished to further our understanding of the effects of land use on mussel communities.

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