

Freshwater Mussels (*Bivalvia: Unionidae*) of the La Moine and Spoon Rivers, Illinois

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ABSTRACT

Understanding the distribution of current mussel communities within a basin is the initial step towards conserving these imperiled animals. Two basins in which little was known of the current mussel communities are the La Moine and Spoon Rivers in western Illinois. The mussel communities were sampled at 87 locations within these two basins between 2009-2011 and historical mussel communities served as a comparison within these basins. The current samples produced 1,171 live mussels representing 21 species from the La Moine River basin and 1,291 live individuals representing 21 species from the Spoon River basin. Forty-three species have been collected from the Spoon River basin since 1892. The La Moine River basin has not been sampled as thoroughly as the Spoon and only 25 species have been documented from this basin since the first samples in the late 1980's.

INTRODUCTION

Freshwater mussels (*Bivalvia: Unionidae*) are a crucial component of freshwater ecosystems (Howard and Cuffey, 2006; Vaughn and Hakenkamp, 2001). They improve water quality by removing suspended sediments from the water column (Howard and Cuffey, 2006), and filtering microscopic organisms and detritus from the water (Strayer and Smith, 2003). Due to their sessile feeding habits and relative inability to escape disturbances (e.g., pollutants and sedimentation), mussel populations may be an indicator of the 'health' of water bodies (Williams et al., 1993). Thus, lack of mussels in a stream may indicate poor water quality. In addition, mussels also are a food source for various vertebrates (Diggins and Stewart, 2000; Shively and Vidrine, 1984; Williams et al., 2008).

Eastern North America still has some of the most diverse freshwater mussel populations in the world, even though populations throughout the North America have declined drastically over the past century (Bogan, 1993; Williams et al., 1993). Of the approximately 300 species historically found in the United States, only 70 species are considered stable (Williams et al., 1993). The rivers of Illinois once provided habitat for 80 species of mussels, but these rivers have seen a decline in mussel populations similar to the decline world-wide (Cummings and Mayer 1997). Of the 80 historical species, 17 are no longer found alive in Illinois (6 due to extinction) and 29 species are listed as endangered, threat-

ened or as a species of special concern (Tiemann et al., 2007; Cummings and Mayer, 1997; Illinois Endangered Species Protection Board, 2011).

The goal of our study was to provide documentation of the freshwater mussel species present in the Spoon and La Moine River basins. Through past surveys, a total of 41 species have been documented from the Spoon River basin and 23 species have been documented from the La Moine River basin (Tiemann et al., 2007). The number of live species in these basins appear to be declining, and since 1969, 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., 2007). The current status of the missing species is unknown, and neither basin has been surveyed in recent years. The last mussel survey of the Spoon River basin was in 1971 (Starrett, unpublished); the La Moine River basin was last surveyed between 1989-91, but only in McDonough and Hancock counties (Baumgardner, 1995).

METHODS

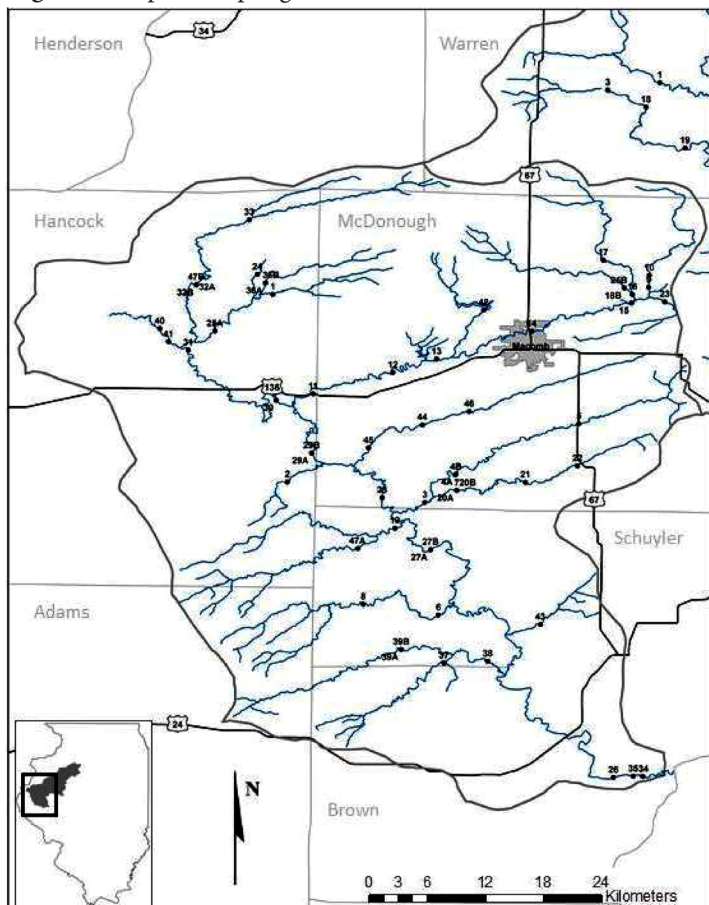
The La Moine and Spoon River basins drain approximately 8300 km² of land between the Mississippi and Illinois Rivers in western Illinois (Figures 1 and 2). These rivers are of similar length and drainage area (La Moine: 203 km, 3,497 km², Spoon River: 260 km, 4,805 km²), and empty into the La Grange Pool of the Illinois River (IDNR, 2001; IDNR, 1998). Both rivers flow primarily through the Galesburg Section of

the western forest-prairie natural division, although the headwaters of the Spoon River rise in the western section of the Grand Prairie Division (Schwegman, 1973).

Sites were selected throughout the La Moine and Spoon River basins based on the following criteria: 1) historical data was available for the site, 2) the site was part of the Illinois Department of Natural Resources and Illinois Environmental Protection Agency Intensive Basin Survey, 3) or because there was a lack of data from that portion of the stream.

At each site, a four-hour timed search method was implemented. While timed searches are not appropriate for assessing population density, abundance, or precise changes over time, they are appropriate for preliminary surveys and detecting species' presence at a site (Strayer and Smith, 2003). At most sites, based on site-specific conditions, live individuals and shell material were collected by hand-grabbing and visual sampling. Due to high water restrictions at three sites, mussels were collected using a brail (Sites 45, 46, and 47, Table 1). A haphazard sampling design was implemented during sampling, and an effort was made to sample all available habitat types. Following the four-hour search, live individuals were identified to species and total lengths (mm) were measured. The nomenclature employed in this report follows Turgeon et al. (1998), except for recent taxonomic changes to the gender ending of lilliput (*Toxolasma parvum*), which follows Williams et al. (2008). One representative of

Figure 1. Map of sampling locations in the La Moine River basin.



each species was kept from each location and sent to the Illinois Natural History Survey (INHS) Mollusk Collection for species confirmation. If only shell material was collected for a species, the shell was classified as recent dead (periostracum present, nacre pearly, and soft tissue may be present) or relict (periostracum eroded, nacre faded, shell chalky) based on condition of the best shell found. The remaining live individuals were returned to the stream.

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

RESULTS

Forty-seven sites were sampled from the La Moine River basin (Figure 1, Table 1) and 40 sites from the Spoon River basin (Figure 2, Table 3). From the La Moine River basin, 1,169 live individuals were collected representing 21 species (Table 2) during 177 person hours of sampling. Twenty-four of the 47 sites sampled in the La Moine River basin produced live individuals. Wabash pigtoe (*Fus-*

Table 1. Sample locations in the La Moine River basin.

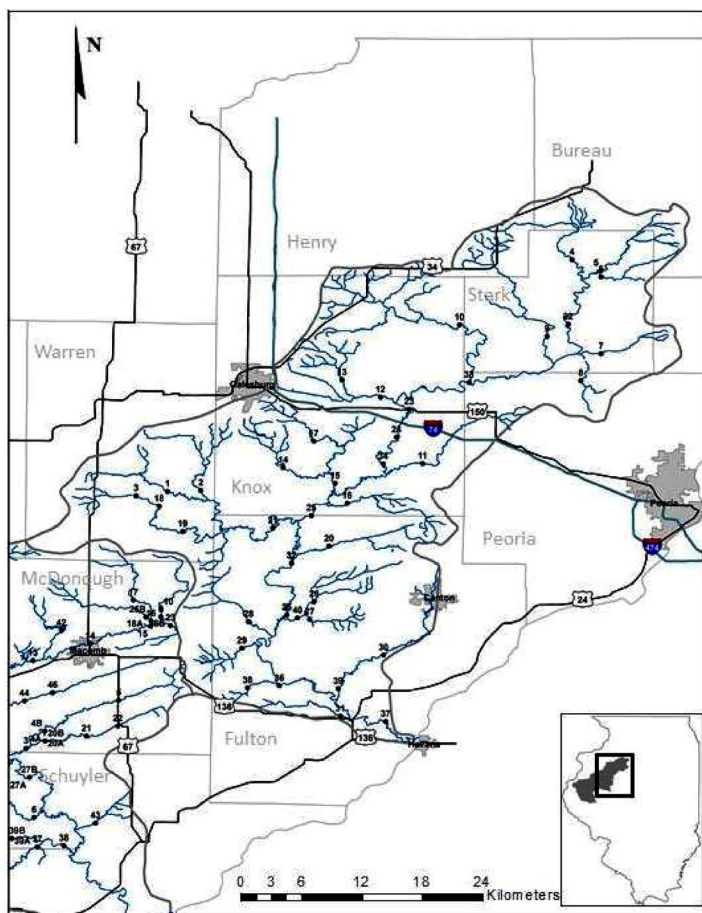
Site	Date	Stream	Location	Latitude	Longitude
1	10-Aug-10	Baptist Creek	4.3 mi S LaHarpe, 2850E bridge	40.521	-90.957
2	10-Jun-10	Bronson Creek	1.8 mi NW Plymouth, 2900E bridge	40.311	-90.941
3	6-Jul-10	Camp Creek	5.7 mi SSW Fandon, 50N Bridge	40.288	-90.789
4A	1-Sep-09	Camp Creek	3.4 mi S Fandon, 800E Bridge	40.320	-90.755
4B	10-Aug-10	Camp Creek	3.4 mi S Fandon, 800E bridge	40.320	-90.754
5	3-Sep-09	Camp Creek	3.4 mi N Industry, 1525E bridge	40.376	-90.619
6	5-Jul-10	Cedar Creek	0.6 mi NNW Camden, IL Route 99 bridge	40.162	-90.774
7	9-Aug-10	Cedar Creek	6.3 mi SE Augusta, Huntsville Rd bridge	40.302	-90.754
8	5-Jul-10	Cedar Creek*	4.8 mi WNW Camden, 250E bridge	40.174	-90.857
9	31-Aug-10	Drowning Fork	2.5 mi SW Bushnell, 1700N bridge	40.529	-90.542
10	3-Jul-10	Drowning Fork*	2.0 mi WSW Bushnell, 1900N bridge	40.542	-90.541
11	14-Aug-09	E. Fork LaMoine River	6.4 mi W Colchester, Rt 136 bridge	40.410	-90.912
12	31-Aug-10	E. Fork LaMoine River	1.7 mi WNW Colchester, 1100N bridge	40.434	-90.824
13	17-Sep-09	E. Fork LaMoine River	1.8 mi NNE Colchester, 700E bridge	40.449	-90.776
14	13-Aug-09	E. Fork LaMoine River	1.4 mi N Macomb, Glenwood Park	40.480	-90.671
15	31-Aug-10	E. Fork LaMoine River	4 mi SW Bushnell, 1800E bridge	40.512	-90.561
16	23-Sep-09	E. Fork LaMoine River	3.6 mi SW Bushnell, 1650N bridge	40.521	-90.560
17	3-Jul-10	E. Fork LaMoine River	4.3 mi E Good Hope, Waco Rd bridge	40.559	-90.592
18A	3-Jul-10	Farmers Fork	3.7 mi WSW Bushnell, 1700N bridge	40.528	-90.569
18B	31-Aug-10	Farmers Fork	3.7 mi WSW Bushnell, 1700N bridge	40.528	-90.569
19	10-Jun-10	Flour Creek	5.6 mi ESE Plymouth, Flour Creek Rd bridge	40.260	-90.822
20A	15-Sep-09	Grindstone Creek	4.6 mi S Fandon, 800E bridge	40.302	-90.754
20B	9-Aug-10	Grindstone Creek	4.6 mi S Fandon, 800E bridge	40.302	-90.754
21	12-Aug-09	Grindstone Creek	3.9 mi WSW Industry, E 1200th St bridge	40.311	-90.678
22	3-Sep-09	Grindstone Creek	0.7 mi W Industry, 350N bridge	40.329	-90.620
23	12-Jul-10	Kepple Creek	2.9 mi SSW Bushnell, 2000E bridge	40.513	-90.524
24	2-Jul-10	La Harpe Creek	2.8 mi S La Harpe, 2750Ebridge	40.544	-90.974
25A	2-Jul-10	La Harpe Creek	7.5 mi NE Carthage, 1950N bridge	40.480	-91.020
25B	10-Aug-10	La Harpe Creek	7.5 mi NE Carthage, 1950N bridge	40.528	-90.569
26	15-Oct-10	La Moine River	4.2 mi SE Ripley, La Grange Lock Rd	39.981	-90.581
27A	11-Oct-10	La Moine River	5.7 mi N Camden, Guinea Rd bridge	40.235	-90.782
27B	29-Aug-11	La Moine River	5.7 mi N Camden, Guinea Rd bridge	40.236	-90.782
28	9-Sep-10	La Moine River	4.4 mi E Plymouth, 75N Bridge	40.294	-90.836
29A	7-Oct-10	La Moine River	3.6 mi N Plymouth, St. Mary's Rd bridge	40.344	-90.914
29B	29-Aug-11	La Moine River	3.6 mi N Plymouth, St. Mary's Rd bridge	40.344	-90.914
30	9-Sep-10	La Moine River	7.9 mi NNW Plymouth, 1420E bridge	40.403	-90.953
31	24-Aug-10	La Moine River	5.4 mi ENE Carthage, 1800E bridge	40.459	-91.050
32A	10-Oct-10	La Moine River	5.2 mi SW La Harpe, 2300N bridge	40.532	-91.041
32B	30-Aug-11	La Moine River	5.2 mi SW LaHarpe, 2300N bridge	40.532	-91.041
33	4-Jul-10	La Moine River	1.6 mi NNW La Harpe, Route 94 bridge	40.605	-90.983
34	15-Oct-10	La Moine River	7.0 mi WSW Beardstown	39.982	-90.548
35	15-Oct-10	La Moine River	7.5 mi WSW Beardstown	39.982	-90.559
36A	2-Jul-10	Little Creek*	3.4 mi S La Harpe 2300N bridge	40.534	-90.965
36B	10-Aug-11	Little Creek	3.4 mi S LaHarpe, 2300N bridge	40.534	-90.965
37	29-Jun-10	Little Missouri Creek	3.1 mi S Camden, IL Route 99 bridge	40.109	-90.768
38	6-Jul-10	Missouri Creek	4.0 mi SE Camden, Avery Rd bridge	40.111	-90.719
39A	6-Jul-10	Missouri Creek	3.1 mi SW Camden, Missouri Creek Rd bridge	40.124	-90.815
39B	9-Aug-10	Missouri Creek	3.1 mi SW Camden, Missouri Creek Rd bridge	40.124	-90.815
40	10-Jun-10	Rock Creek	4.8 mi ENE Ferris, 2200E bridge	40.483	-91.081
41	2-Jul-10	Rock Creek*	4.9 mi NE Carthage, 2250E bridge	40.468	-91.072
42	25-Aug-09	Spring Creek	4.1 mi NW Macomb, Spring Lake Park	40.503	-90.724
43	6-Jul-10	Stony Branch	5.6 mi WNW Rushville, Rattlesnake Ranch bridge	40.152	-90.661
44	31-Aug-10	Troublesome Creek	3.5 mi S Colchester, 600E bridge	40.375	-90.792
45	30-Sep-09	Troublesome Creek	4.9 mi WSW Fandon, 450N bridge	40.349	-90.851
46	1-Sep-09	Troublesome Creek	1.9 mi. NE Fandon, 875E bridge	40.390	-90.740
47A	10-Jun-10	Williams Creek	4.6 mi E Augusta, Williams Creek Rd ford	40.237	-90.863
47B	9-Aug-10	Williams Creek	4.6 mi E Augusta, Williams Creek Rd ford	40.532	-91.041

conaia flava) was the most common species in the La Moine River basin, comprising 15.3% of all live individuals. Plain pocketbook (*Lampsilis cardium*) and pistolgrip (*Tritogonia verrucosa*) made up 12.7% and 11.9% of live individuals, respectively. No species found in the La Moine River basin were represented by shell material only, at least one live individual was found for each species.

Table 2. Species and number of live freshwater mussels found at each site in the La Moine River basin. Only sites where live individuals or shell material were found are listed. Numbers indicate the number of live individuals found, D represents only freshly deceased shells collected and R indicates only relic shell material found.

		Site																						
Species	Common Name	1	3	4B	6	7	8	9	10	11	12	13	14	15	16	18A	18B	19	20A	20B	22	23		
Subfamily Ambleminae																								
<i>Amblema plicata</i>	threeridge										D	R												
<i>Fusconaia flava</i>	Wabash pigtoe							D		4	17	10	40	21	6	17	60							
<i>Quadrula pustulosa</i>	pimpleback							D	1	12	41	9	18	14		1	1							
<i>Quadrula quadrula</i>	mapleleaf			1					R	2	4	3	30	5	2	1	1							
<i>Tritogonia verrucosa</i>	pistolgrip			D						2	5	5	9	4					6	10				
<i>Unio merus tetralasmus</i>	pondhorn					4	4	1	D									D						
Subfamily Anodontinae																								
<i>Lasmigona complanata</i>	white heelsplitter	R		2				D	D	1		1	1	1	1	2	R	D	3	23		D		
<i>Pyganodon grandis</i>	giant floater		D					6	1				2	D		11	19			D				
<i>Strophitus undulatus</i>	creeper			1				D	D	5	1	7	30	13	4	7	14		2	21				
<i>Utterbackia imbecillis</i>	paper pondshell									D			1											
Subfamily Lampsilinae																								
<i>Lampsilis cardium</i>	plain pocketbook	22	1							9	43	71	11						3	7				
<i>Lampsilis siliquoidea</i>	fatmucket										6	11	5											
<i>Lampsilis teres</i>	yellow sandshell									1	2													
<i>Leptodea fragilis</i>	fragile papershell				R			D	D	2	D	1	2	R					1	3				
<i>Ligumia subrostrata</i>	pondmussel		1	2				9	D						1	2	10		2	6				
<i>Obliquaria reflexa</i>	threehorn wartyback																							
<i>Potamilus alatus</i>	pink heelsplitter																					R		
<i>Potamilus ohiensis</i>	pink papershell																			R				
<i>Toxolasma parvum</i>	lilliput			D	D	D		23	D	1				5		D	64		2	D				
<i>Truncilla donaciformis</i>	fawnsfoot																							
<i>Truncilla truncata</i>	deertoe									2		2	2											
Total Live Individuals Collected		0	2	6	0	4	4	39	2	41	119	120	151	63	14	41	169	0	17	72	0	0		
Live Species		0	2	4	0	1	1	4	2	11	8	10	12	7	5	7	7	0	6	7	0	0		
Live + Fresh Dead Species		0	3	6	1	2	1	9	8	12	10	10	12	8	5	8	7	2	6	8	1	1		
Total Species		1	3	7	0	2	1	9	9	12	10	11	12	9	5	8	8	0	6	9	0	2		
		Site																						
Species	Common Name	24	25A	25B	27B	28	29A	29B	30	31	32A	32B	36B	37	38	39B	40	42	44	45	47B	Total		
Subfamily Ambleminae																								
<i>Amblema plicata</i>	threeridge							1													R	1		
<i>Fusconaia flava</i>	Wabash pigtoe		1		1			2													R	179		
<i>Quadrula pustulosa</i>	pimpleback				1	1	D	6	D											1		106		
<i>Quadrula quadrula</i>	mapleleaf				1	1		6	1	D		1						12		2		73		
<i>Tritogonia verrucosa</i>	pistolgrip				2	3	2	75	8			8						R				139		
<i>Unio merus tetralasmus</i>	pondhorn	D									R		R				R		R			9		
Subfamily Anodontinae																								
<i>Lasmigona complanata</i>	white heelsplitter	D	1	1				4			3	22			D		D	7	4	4	D	81		
<i>Pyganodon grandis</i>	giant floater					1			1									6		3		50		
<i>Strophitus undulatus</i>	creeper						D	D				1							9	12		127		
<i>Utterbackia imbecillis</i>	paper pondshell				1			1										10				13		
Subfamily Lampsilinae																								
<i>Lampsilis cardium</i>	plain pocketbook		1	D	1		R	1	1									R	R			149		
<i>Lampsilis siliquoidea</i>	fatmucket																	1			R	23		
<i>Lampsilis teres</i>	yellow sandshell		1	1	3	3	D	23	D	1												35		
<i>Leptodea fragilis</i>	fragile papershell		1		1	9	D	5	2		D	R	1						R	D		27		
<i>Ligumia subrostrata</i>	pondmussel									D							R	R				33		
<i>Obliquaria reflexa</i>	threehorn wartyback					1		3														4		
<i>Potamilus alatus</i>	pink heelsplitter							1							R							1		
<i>Potamilus ohiensis</i>	pink papershell			R		1																1		
<i>Toxolasma parvum</i>	lilliput		1	3							3	R	D			R	D	D	3		D	105		
<i>Truncilla donaciformis</i>	fawnsfoot					3		2														5		
<i>Truncilla truncata</i>	deertoe							2														8		
Total Live Individuals Collected		0	6	5	11	23	2	132	13	1	3	35	0	0	0	0	0	36	16	22	0	1169		
Live Species		0	6	3	8	9	1	14	5	1	1	5	0	0	0	0	0	5	3	5	0	21		
Live + Fresh Dead Species		2	6	4	8	9	5	15	7	3	2	5	0	1	1	0	2	6	3	6	2	21		
Total Species		2	6	5	8	9	6	15	7	3	3	6	2	1	2	1	4	9	6	6	5	21		

Figure 2. Map of sample locations in the Spoon River basin.



In the Spoon River basin, 1,291 live individuals of 21 species (Table 4) and shell material of an additional 8 species were collected in 160 person-hours of sampling. Live individuals were found at 34 of the 40 Spoon River basin sites. *L. cardium* was 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 the white heelsplitter (*Lasmigona complanata*) accounted for 13%.

No threatened or endangered mussel species were collected alive during this survey although relict shells were collected. A relict shell of the state endangered snuffbox (*Epioblasma triquetra*) was found at Spoon River site 24. Relict shells of three state threatened species, slippershell mussel (*Alasmidonta viridis*), spike (*Elliptio dilatata*) and black sandshell (*Ligumia recta*), were also found in the Spoon River basin.

Historical mussel data for the La Moine River basin was divided into four time periods. The survey completed by Baumgardner (1995) was supplemented by additional INHS data and are the earliest samples known from the La Moine River basin, herein designated as “pre-1991.” Surveys during this time period recorded 13 live species from the La Moine River basin, as well as shell material of 4 additional species (Table 5). 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

Table 3. Sample locations in the Spoon River basin.

Site	Date	Stream	Location	Latitude	Longitude
1	16-Jul-10	Cedar Creek	3.5 Mi SSE Berwick, 147th St bridge	40.758	-90.529
2	16-Jul-10	Cedar Fork	4 mi SE Berwick, 90th Ave bridge	40.760	-90.468
3	16-Jul-10	Negro Creek	4.2 mi NE Roseville, 105th St bridge	40.750	-90.587
4	19-Jul-10	W Fork Spoon River	2 mi E Elmira, Rt 93 bridge	41.181	-89.788
5	19-Jul-10	E Fork Spoon River	4 mi SW Bradford, 1300E bridge	41.161	-89.735
6	20-Jul-10	Coopers Defeat Creek	1.8 mi NE Modena, 1300E bridge	41.150	-89.735
7	20-Jul-10	Camp Creek	4 mi SSE Wyoming, 1300E bridge	41.009	-89.735
8	20-Jul-10	Prince Run	2 mi N Princeville, 22300N bridge	40.960	-89.772
9	21-Jul-10	Indian Creek	3.5 mi SW Wyoming, 450N bridge	41.041	-89.834
10	21-Jul-10	Walnut Creek	4.6 mi NW West Jersey, 2350E bridge	41.062	-89.995
11	21-Jul-10	French Creek	4 mi NW Yates City, 2000E bridge	40.809	-90.062
12	21-Jul-10	Court Creek	1.5 mi W Dahinda, 1600E bridge	40.930	-90.139
13	21-Jul-10	North Creek	5 mi ENE East Galesburg, 1700N bridge	40.962	-90.210
14	22-Jul-10	Brush Creek	4 mi E Abingdon, 600N bridge	40.801	-90.318
15	22-Jul-10	Haw Creek	3.5 mi SW Maquon, 400N bridge	40.772	-90.222
16	22-Jul-10	Littlers Creek	2 mi NW Rapatee, 1300E bridge	40.736	-90.200
17	22-Jul-10	Haw Creek	3 mi S Knoxville, 950E bridge	40.850	-90.261
18	23-Jul-10	Negro Creek	6.3 mi E Roseville, IL 116 bridge	40.731	-90.545
19	23-Jul-10	Swan Creek	2.5 mi SE Greenbush, 1500E bridge	40.685	-90.502
20	2-Aug-10	Coal Creek	4 mi SE London Mills, 1100E bridge	40.658	-90.233
21	2-Aug-10	Cedar Creek	3.5 mi SW London Mills, 3400N bridge	40.691	-90.336
22	3-Aug-10	Spoon River	2 mi W Wyoming, Rt 17 bridge	41.063	-89.795
23	3-Aug-10	Spoon River	2.5 mi SE Dahinda, Rt 150 bridge	40.908	-90.087
24	3-Aug-10	Spoon River	5 mi NE Maquon, Hwy 17 bridge	40.857	-90.110
25	3-Aug-10	Spoon River	London Mills, 2nd St bridge	40.714	-90.266
26	4-Aug-10	Turkey Creek	1 mi SE Blyton, 900N bridge	40.557	-90.261
27	4-Aug-10	Put Creek	3 mi S Blyton, 2300N bridge	40.524	-90.269
28	4-Aug-10	Shaw Creek	1.5 mi NW Marietta, 325E bridge	40.520	-90.381
29	5-Aug-10	Barker Creek	1.8 mi S Marietta, 250E bridge	40.471	-90.393
30	5-Aug-10	Big Creek	2 mi SW Bryant, 1650E bridge	40.459	-90.133
31	5-Aug-10	Tater Creek	1.5 mi NW Duncan Mills	40.347	-90.213
32	26-Aug-10	Spoon River	0.5 mi E Ellisville, Rt 17 bridge	40.627	-90.302
33	30-Aug-10	Spoon River	Elmore, Mill Rd bridge	40.957	-89.977
34	30-Aug-10	Spoon River	0.8 mi ENE Maquon, 650N bridge 1	40.808	-90.134
35	30-Aug-10	Spoon River	3.5 mi NW Smithfield, 2350N bridge	40.532	-90.311
36	1-Sep-10	Spoon River	Bernadotte	40.403	-90.325
37	1-Sep-10	Spoon River	3 mi S Lewistown, Waterford Rd bridge	40.337	-90.130
38	22-Sep-10	Francis Creek	4.5 mi NW Ipava, E Holler Rd bridge	40.399	-90.383
39	24-Sep-10	Big Creek	3.3 mi W Lewistown, Co Rd 14 bridge	40.398	-90.216
40	25-Sep-10	Put Creek	5.8 mi WNW Cuba, Co Rd 2 bridge	40.527	-90.291

period. Shell material of *Utterbackia imbecillis*, which had not been previously recorded, was also found in this time period. The number of live species collected from the La Moine River basin increased to 18 from INHS surveys between the years 2001-2009. In this survey, 21 species were found live. Overall, 25 species have been documented from the La Moine River basin.

The mussels of the Spoon River basin have been studied more thoroughly than those in the La Moine River basin. The Spoon River basin historical data was divided into seven time periods. The first were samples performed by W.S. Strode between 1892-1912. In this time period, 36 species were collected from the Spoon River basin, all of which were represented by live individuals (Table 6). Surveys done in 1949 by J.M. Reed (INHS data) found only 14 species, also all represented by live individuals. 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. In this survey, 21 species were found live. From over 100 years of sampling, a total of 43 species have been collected as either live individuals or shell material from the Spoon River basin.

Table 4. Species and number of live freshwater mussels found at each site in the Spoon River basin. Only sites where live individuals or shell material were found are listed. Numbers indicate the number of live individuals found, D represents only freshly deceased shells collected and R indicates only relic shell material found. Threatened or endangered species indicated next to species name (SE = State Endangered, ST = State Threatened).

		Site																			
Species	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Subfamily Ambleminae																					
<i>Amblema plicata</i>	three ridge					R		R		R											
<i>Elliptio dilatata</i> (SE)	spike						R	R			R										
<i>Fusconia flava</i>	Wabash pigtoe		14			19		R		11	33	8				12			5	7	
<i>Pleurobema sintoxia</i>	round pigtoe									1	10					3					
<i>Quadrula metanevra</i>	monkeyface										1										
<i>Quadrula pustulosa</i>	pimpleback					2				4	23	4				14	D			4	
<i>Quadrula quadrula</i>	mapleleaf															7					
<i>Tritogonia verrucosa</i>	pistolgrip		1			7														1	
<i>Unio merus tetralasmus</i>	pondhorn																	1	1		
Subfamily Anodontinae																					
<i>Alasmodonta viridis</i> (ST)	slippershell mussel				D	R	10	6	25		R	R			1						D
<i>Anodontoides ferussacianus</i>	cylindrical papershell				7	2			133		4	16			D	D		7	2	4	3
<i>Lasmigona complanata</i>	white heelsplitter	1	D	D					6			2			D	D			4		R
<i>Lasmigona compressa</i>	creek heelsplitter	3				2					D	9			D	D			4	2	
<i>Lasmigona costata</i>	flutedshell																				
<i>Pyganodon grandis</i>	giant floater					D					R						6				
<i>Strophitus undulatus</i>	creeper		3		2	1			1	1	7	12	1	D		1	3	2	5	1	D
Subfamily Lampsilinae																					
<i>Actinonaias ligmentina</i>	mucket																				
<i>Epioblasma triquetra</i> (SE)	snuffbox																				
<i>Lampsilis cardium</i>	plain pocketbook	3	1			45	D	R		42	8	12	15	3	D		3			22	
<i>Lampsilis siliquoidea</i>	fatmucket	D	5	1		9		R		2	6		2		1		1	1	1	14	
<i>Lampsilis teres</i>	yellow sandshell																				
<i>Leptodea fragilis</i>	fragile papershell	D	D		D	D					D										
<i>Ligumia recta</i> (SE)	black sandshell																				
<i>Obliquaria reflexa</i>	threehorn wartyback																				
<i>Potamilus alatus</i>	pink heelsplitter																				
<i>Potamilus ohioensis</i>	pink papershell																				
<i>Toxolasma parvum</i>	lilliput	1	D						D	D	R	1				1	1				D
<i>Truncilla donaciformis</i>	fawnsfoot																				
<i>Truncilla truncata</i>	deertoe																				
<i>Venustaconcha ellipsiformis</i>	ellipse																				
Total Live Individuals Collected		8	24	1	9	87	10	6	165	61	92	64	18	4	1	38	21	6	20	54	0
Live Species		4	5	1	2	8	1	1	4	6	8	8	3	2	1	6	6	4	6	8	0
Live + Fresh Dead Species		6	8	2	4	10	2	1	5	7	10	8	3	5	4	6	8	4	6	8	3
Total Species		6	8	2	4	12	3	6	5	9	14	8	3	5	4	6	8	4	6	8	4

		Site																				
Species	Common Name	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	39	40	Total	
Subfamily Ambleminae																						
<i>Amblema plicata</i>	three ridge	R	1	D	R				R					R	R	R		R			1	
<i>Elliptio dilatata</i> (SE)	spike	R	R	R	R									R			R				R	
<i>Fusconia flava</i>	Wabash pigtoe	23	D	6	28		R							19	14	D					188	
<i>Pleurobema sintoxia</i>	round pigtoe		1	7	13	2							D	27	3	R					67	
<i>Quadrula metanevra</i>	monkeyface	3	2	14	91	3							D	34	D	D					148	
<i>Quadrula pustulosa</i>	pimpleback	17	1	2	19				R				1	31	16	2		R	1		140	
<i>Quadrula quadrula</i>	mapleleaf	2		3	19	1		5	1		D		D	3	8	2	1	D	2		52	
<i>Tritogonia verrucosa</i>	pistolgrip	12	D					1			1			4							27	
<i>Unio merus tetralasmus</i>	pondhorn						D			D		D									2	
Subfamily Anodontinae																						
<i>Alasmodonta viridis</i> (ST)	slippershell mussel										R	R										
<i>Anodontoides ferussacianus</i>	cylindrical papershell																				R	
<i>Lasmigona complanata</i>	white heelsplitter	1							R					R	1						63	
<i>Lasmigona compressa</i>	creek heelsplitter	1	3		2				1		1	R		1	D	2	D		D		172	
<i>Lasmigona costata</i>	flutedshell			D										D							27	
<i>Pyganodon grandis</i>	giant floater				R									R							R	
<i>Strophitus undulatus</i>	creeper	11									D								R	R	6	
Subfamily Lampsilinae																						
<i>Actinonaias ligmentina</i>	mucket				R										R	R	R				R	
<i>Epioblasma triquetra</i> (SE)	snuffbox				R																R	
<i>Lampsilis cardium</i>	plain pocketbook	13	6	34	D	3		D	2	D	D		3	59	1	3	R		3		278	
<i>Lampsilis siliquoidea</i>	fatmucket	R	R	R	1		R	D						1		R					45	
<i>Lampsilis teres</i>	yellow sandshell																R				R	
<i>Leptodea fragilis</i>	fragile papershell	2	D	D	1	D		D			D		D	D	D	D	D	1	D		4	
<i>Ligumia recta</i> (SE)	black sandshell													R							R	
<i>Obliquaria reflexa</i>	threehorn wartyback																		1		1	
<i>Potamilus alatus</i>	pink heelsplitter																	D			D	
<i>Potamilus ohioensis</i>	pink papershell										1						1	4			6	
<i>Toxolasma parvum</i>	lilliput						D		D	D		D									4	
<i>Truncilla donaciformis</i>	fawnsfoot				1								1			D					2	
<i>Truncilla truncata</i>	deertoe																				1	
<i>Venustaconcha ellipsiformis</i>	ellipse		R	R			R								1		R				R	
Total Live Individuals Collected		85	14	66	179	9	0	6	4	0	3	0	5	182	43	9	2	6	6	0	1291	
Live Species		10	6	6	10	4	0	2	3	0	2	0	3	11	6	4	2	3	3	0	21	
Live + Fresh Dead Species		10	11	9	11	6	3	5	5	3	7	2	8	13	10	8	4	5	5	0	23	
Total Species		13	14	12	16	6	6	5	8	3	7	3	9	18	12	13	10	7	6	1	30	

Table 5. Comparison of current and historical mussel species collected from the La Moine River basin. “L” indicates species found alive and “X” represents only shell (dead or relict) of species found at time of collection.

Species	Common Name	pre-1991 (Baumgardner & INHS)	1991-2000 (INHS Data)	2001-2009 (INHS Data)	2009-2011 Current Survey
Subfamily Ambleminae					
<i>Amblema plicata</i>	threeridge	L	L	L	L
<i>Fusconia flava</i>	Wabash pigtoe		L	L	L
<i>Megalonaias nervosa</i>	washboard	X			
<i>Quadrula nodulata</i>	wartyback	X			
<i>Quadrula pustulosa</i>	pimpleback		L	L	L
<i>Quadrula quadrula</i>	mapleleaf	L	L	L	L
<i>Tritogonia verrucosa</i>	pistolgrip	L	L	L	L
<i>Unio merus tetrasmus</i>	pondhorn	L	L	L	L
Subfamily Anodontinae					
<i>Anodonta suborbiculata</i>	flat floater			L	
<i>Lasmigona complanata</i>	white heelsplitter	L	L	L	L
<i>Pyganodon grandis</i>	giant floater	L	L	L	L
<i>Strophitus undulatus</i>	creeper	L	L	L	L
<i>Utterbackia imbecillis</i>	paper pondshell		X	L	L
Subfamily Lampsilinae					
<i>Actinonaias ligamentina</i>	mucket	X			
<i>Lampsilis cardium</i>	plain pocketbook	X	L	L	L
<i>Lampsilis siliquoidea</i>	fatmucket	L	L		L
<i>Lampsilis teres</i>	yellow sandshell	L		L	L
<i>Leptodea fragilis</i>	fragile papershell	L	L	L	L
<i>Ligumia subrostrata</i>	pondmussel			L	L
<i>Obliquaria reflexa</i>	threehorn wartyback				L
<i>Potamilus alatus</i>	pink heelsplitter	L			L
<i>Potamilus ohioensis</i>	pink papershell	L			L
<i>Toxolasma parvum</i>	lilliput	L	L	L	L
<i>Truncilla donaciformis</i>	fawnsfoot				L
<i>Truncilla truncata</i>	deertoe			L	L
Total Species	25	13	13	17	21
	Total Live Species	17	14	17	21

DISCUSSION

Based on the historical data available for the Spoon River basin, many species have been extirpated from this drainage within the last century (Strode, 1892). Forty-three are known historically, yet only 21 have been collected alive within the last decade (Table 6). The loss of species in this basin should be no surprise, since the majority of mussel species in United States and Canada are extinct, endangered, threatened, or of special concern (Williams et al., 1993). The historical collection data we have available suggests that many species were lost between 1912 and 1949 (Table 6), although this is simply speculation.

The historical data available for the La

Moine River basin indicates that 25 species were present at one time, although we do not have data for this basin before the late 1980's. The Spoon and La Moine River basins are similar in size, location, and present mussel communities, thus we believe that there were likely more than 25 species present in the La Moine River basin in the early 1900's, despite the lack of any shell material. Records from the Spoon River basin show that 12 species have not been collected, in any form, after 1990 (Table 6). It is possible that shell material from these species has been completely eroded, buried or washed downstream.

We found that the current mussel communities of the La Moine and Spoon River

basins are similar to each other and consist primarily of common, widespread mussels found throughout Illinois. Seventeen mussel species are common to both the Spoon and La Moine River basins, all of which are considered stable in Illinois (Cummings and Mayer, 1992). Species with either federal or state conservation status were only represented in our surveys by relict shell material, and it is unlikely that viable populations exist in the Spoon or La Moine River basins at this time. Although species' loss has occurred in these basins over time, both basins still maintain over 20 live species of mussels.

Within each watershed, particular streams appear to support exceptional diversity in this geographical context. In the La Moine River basin, we collected more than ten live species at several sampling locations in the East Fork La Moine and La Moine River, just downstream of its confluence with the East Fork La Moine River. In the Spoon River basin, we found the greatest species diversity within the mainstem and its larger tributaries (e.g., Cedar, Indian, and Walnut Creek). Conversely, we found several headwater streams in the La Moine River basin containing only shell material. While mussel diversity often increases with stream size (Strayer, 1983), the absence of live mussels with shell material present may indicate that these headwater species can no longer persist here. It is unclear at this time whether this is due to current water quality issues, lack of habitat or if their decline was caused by past water quality issues and these tributaries are too far from stable populations for these species to recolonize. A similar pattern has been observed in other Midwestern systems (Myers-Kinzie et al., 2001), and the documentation of headwater species' loss may be an important issue to consider in the future.

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Table 5. Comparison of current and historical mussel species collected from the Spoon River basin. “L” indicates species found alive and “X” represents only shell (dead or relict) of species found at time of collection. Threatened or endangered species indicated next to species name (FE = Federal Endangered, SE = State Endangered, ST = State Threatened).

Species	Common Name	1892-1912 (Strode)	1949 (Reed)	1957 (Matteson)	1971 (Starrett)	1990s (INHS)	2000-2009 (INHS)	2010 Current Survey
Subfamily Ambleminae								
<i>Amblema plicata</i>	three ridge	L	L	L	L	L	L	L
<i>Cyclonaias tuberculata</i> (ST)	purple wartyback	L						
<i>Elliptio crassidens</i> (ST)	elephant ear				X			
<i>Elliptio dilatata</i> (ST)	spike	L			X	X	X	L
<i>Fusconia flava</i>	Wabash pigtoe	L	L	L	L	L	L	L
<i>Megalonaias nervosa</i>	washboard	L						
<i>Plethobasus cyphus</i> (SE)	sheepnose	L						
<i>Pleurobema sintoxia</i>	round pigtoe	L	L	L	L	L	L	L
<i>Quadrula fragosa</i>	winged maple leaf	L						
<i>Quadrula metanevra</i>	monkey face	L	L	L	L	L	L	L
<i>Quadrula nodulata</i>	wartyback	L						
<i>Quadrula pustulosa</i>	pimpleback	L	L	L	L	L	L	L
<i>Quadrula quadrula</i>	maple leaf	L		L	L	L	L	L
<i>Tritogonia verrucosa</i>	pistol grip	L	L	L	L	L	L	L
<i>Unio merus tetrasmus</i>	pond horn						L	L
Subfamily Anodontinae								
<i>Alasmodonta marginata</i>	elk toe	L						
<i>Alasmodonta viridis</i> (ST)	slippershell mussel				X			X
<i>Anodonta suborbiculata</i>	flat floater	L						
<i>Anodontoides ferussacianus</i>	cylindrical papershell			L	L	L	L	L
<i>Arcidens confragosus</i>	rock pocketbook	L						
<i>Lasmigona complanata</i>	white heelsplitter	L	L	L	L	L	L	L
<i>Lasmigona compressa</i>	creek heelsplitter			L	L	L	L	L
<i>Lasmigona costata</i>	fluted shell	L	L	X			X	X
<i>Pyganodon grandis</i>	giant floater	L	L	L	L	L	L	L
<i>Strophitus undulatus</i>	creeper	L	L	L	L	L	L	L
<i>Utterbackia imbecillis</i>	paper pondshell	L						
Subfamily Lampsilinae								
<i>Actinonaias ligamentina</i>	mucket	L			L		X	X
<i>Epioblasma triquetra</i> (SE)	snuffbox							X
<i>Lampsilis cardium</i>	plain pocketbook	L	L	L	L	L	L	L
<i>Lampsilis higginsii</i> (FE)	Higgins eye	L			L			
<i>Lampsilis siliquoidea</i>	fat mucket	L		L	L	L	L	L
<i>Lampsilis teres</i>	yellow sandshell	L	L	L	L		X	X
<i>Leptodea fragilis</i>	fragile papershell	L	L	L	L	L	L	L
<i>Ligumia recta</i> (ST)	black sandshell	L		L			X	X
<i>Obliquaria reflexa</i>	threehorn wartyback	L						L
<i>Obovaria olivaria</i>	hickory nut	L			X			
<i>Potamilus alatus</i>	pink heelsplitter	L			X		L	X
<i>Potamilus capax</i> (FE)	fat pocketbook	L						
<i>Potamilus ohioensis</i>	pink papershell	L	L	L	L	L	L	L
<i>Toxolasma parvum</i>	lilliput	L		L	L	L		L
<i>Truncilla donaciformis</i>	fawn's foot	L		L	L		L	L
<i>Truncilla truncata</i>	deertoe	L					L	L
<i>Venustaconcha ellipsiformis</i>	ellipse					X		X
Total Species	43	Total Live Species	36	14	20	21	17	20
		Total Species	36	14	21	26	19	25
								30

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LITERATURE CITED

- Baumgardner, J.A. 1995. A survey of the freshwater mussels (Bivalvia: Unionidae) of the Upper La Moine River Basin. Master Degree Thesis, Western Illinois University, Macomb, IL. 130 pgs.
- Bogan, A.E. 1993. Freshwater bivalve extinctions (Mollusca: Unionidae): a search for causes. *American Zoologist*. 33(6): 599-609.
- Cummings, K.S. and C.A. Mayer. 1992. Field guide to freshwater mussels of the Midwest. *Illinois Natural History Survey Manual* 5. 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 the UMRCC Symposium, 16-18 October, 1995, St. Louis. Upper Mississippi River Conservation Committee, Rock Island, Illinois. 293 pp.
- Diggins, T.P., and K.M. Stewart. 2000. Evidence of large change in unionid mussel abundance from selective muskrat predation, as inferred by shell remains left on shore. *International Review of Hydrobiology* 85(4): 505-520.
- Howard, J.K. and K.M. Cuffey. 2006. The functional role of native freshwater mussels in the fluvial benthic environment. *Freshwater Biology*. 51: 460-474.
- Illinois Department of Natural Resources. 1998. Spoon River Area Assessment, Volume 2: Water Resources. 68 pp.
- Illinois Department of Natural Resources. 2001. La Moine River Area Assessment, Volume 2: Water Resources. 69 pp.
- Illinois Endangered Species Protection Board. 2011. Checklist of Endangered and Threatened Animals and Plants of Illinois. Illinois Endangered Species Protection Board, Springfield, Illinois. 18 pp.
- Myers-Kinzie, M.L., S.P. Wente and A. Spacie. 2001. Occurrence and distribution of freshwater mussels in small streams of Tippecanoe County, Indiana. *Proceedings of the Indiana Academy of Science* 110: 141-150.
- Schwegman, J.E. 1973. Comprehensive plan for the Illinois nature preserve system. Part 2. The natural divisions of Illinois. Illinois Nature Preserves Commission, Springfield. 32 pp.
- Shively, S.H., and M.F. Vidrine. 1984. Freshwater mollusks in the alimentary tract of a Mississippi Map Turtle. *Proceedings of the Louisiana*

- ana Academy of Sciences 47:27-29.
- Strayer, D. 1983. The effects of surface geology and stream size on freshwater mussel (Bivalvia, Unionidae) distribution in southeastern Michigan, USA. *Freshwater Biology* 13:252-264.
- Strayer, D.L. and D.R. Smith. 2003. A guide to sampling freshwater mussel populations. American Fisheries Society Monograph 8. American Fisheries Society, Bethesda, MD. 110 pages.
- Strode, W.S. 1892. The Unionidae of the Spoon River, Fulton County, Illinois. *The American Naturalist*. 26(306): 495-501.
- Tiemann, J.S., K.S. Cummings, and C.A. Mayer. 2007. Updates to the distributional checklist and status of Illinois freshwater mussels (Mollusca: Unionidae). *Transactions of the Illinois State Academy of Science*. 100(1):107-123.
- Turgeon, D.D., J.F. Quinn, A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelsen, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, 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. Special publication 26. American Fisheries Society, Bethesda Maryland. 526 pp.
- Vaughn, C.C. and C.C. Hakenkamp. 2001. The functional role of burrowing bivalves in freshwater ecosystems. *Freshwater Biology*. 46: 1431-1446.
- Williams, J.D., M.L. Warren Jr., 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.
- Williams, J.D., A.E. Bogan, and J.T. Garner. 2008. The freshwater mussels of Alabama and the Mobile Basin of Georgia, Mississippi, and Tennessee. University of Alabama Press, Tuscaloosa, Alabama. 908 p.