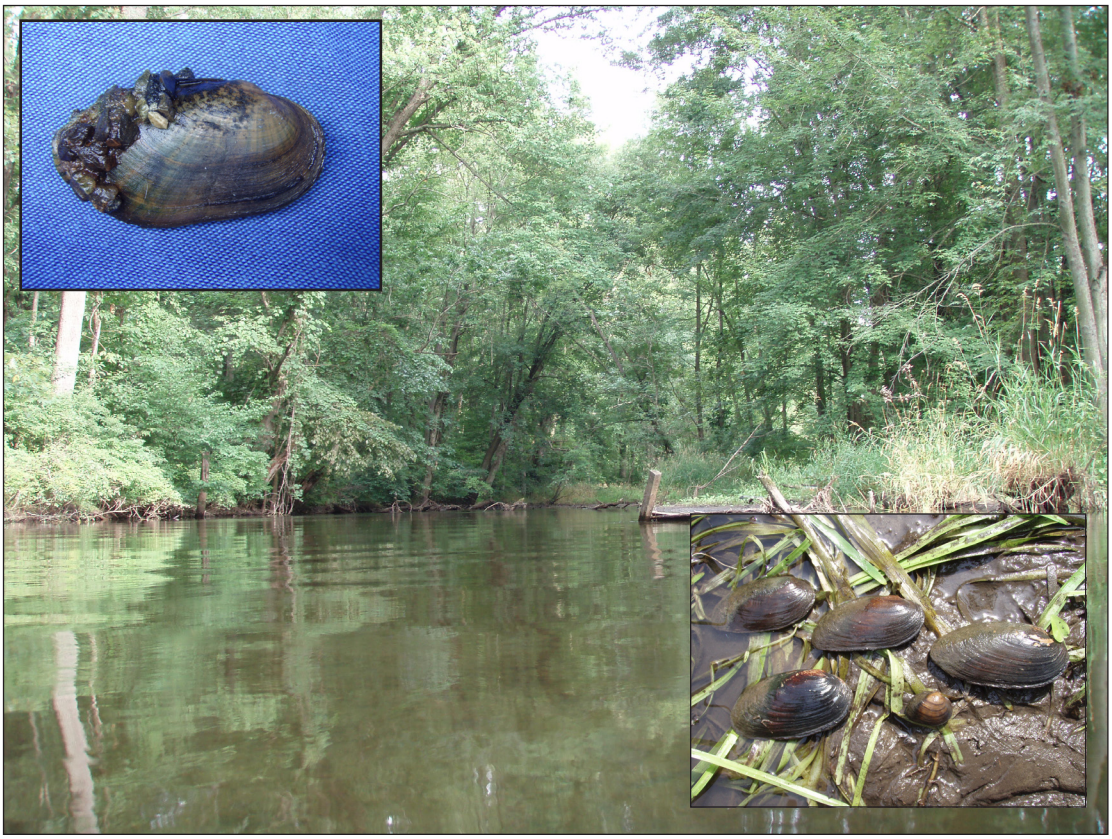
The Unionid Mussel Community of the Paw Paw River Watershed in Southwest Michigan, with Water Quality and Habitat Measures



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Background photo: Site 9 in the South Branch of the Paw Paw River. **Inset photos, left:** Ellipse (*Venustaconcha ellipsiformis*) from Site 9 with caddisfly cases attached, **right:** Spike (*Elliptio dilatata*) and wabash pigtoe (*Fusconaia flava*) from Site 22 in the main stem of the Paw Paw River. Photos by Peter Badra.

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The purpose of this project is to describe the unionid mussel community and habitat at sites throughout the Paw Paw River watershed, making this information available to inform management and conservation planning decisions. The data will also be used to investigate ecological hypotheses at a future time with The Nature Conservancy and partners from the University of Michigan. This report documents the methods used and results of the survey.

Methods

We surveyed 45 sites in the Paw Paw River watershed for unionid mussels, measured water chemistry variables, and scored a Qualitative Habitat Evaluation Index (QHEI) at each site. Prior to sampling, a larger pool of potential sites was created to ensure there would be 45 sites that would give coverage of the main stem, larger tributaries, and a wide range of surface geology types. Some potential sites were omitted when field visits revealed that the channel was too deep to survey by wading, or that land owner permission would be difficult to get.

Handheld GPS units (Garmin 12XL) were used to document the position of survey sites. Latitude and longitude of each site were recorded. Water chemistry and habitat data were taken to quantify and describe the range of environmental variables unionids are utilizing in the Paw Paw watershed.

Water chemistry data were taken prior to searching for unionids to avoid stirring up silt that could affect measurements. Dissolved oxygen and temperature were recorded with a YSI Model 55 handheld meter. Conductivity and pH were recorded with an Oakton handheld meter. Alkalinity was measured with a LaMotte kit (model DR-A) and hardness was measured with a Hach kit.

Surveys were performed to determine the presence/absence and abundance of unionid mussel species at each site. A measured search area was used to standardize sampling effort among sites and allow unionid density estimates to be made. Typically 128m^2 provided a good compromise between amount of search effort per site and the number of sites to be completed within the timeline of the project. Less area was searched at some sites due to a lack of habitat shallow enough to survey by wading. The search area was measured by taking an average of three stream width measurements, and dividing it into 128 to get a reach length that would give 128m^2. When possible, sites were searched from bank to bank so that the area equaled the stream width times the reach length.

Live unionids and shells were located with a combination of visual and tactile means. Glass bottom buckets were used to facilitate visual searches. At sites where visual detection was difficult (e.g. pebble sized substrate with silt), hands were passed through the substrate to a depth of approximately 5cm. Occasional tactile searches through the substrate were made at sites where primarily visual detection was used to help ensure that buried unionids were not being overlooked. Live individuals were identified to species, measured for length, and planted back into the substrate anterior end down. Shells were identified to species. The presence/absence of dreissenid mussels (*Dreissena polymorpha* and *Dreissena bugensis*), and Asian clams (*Corbicula fluminea*) was recorded. Other aquatic taxa such as fish, crayfish, and herps were noted when observed.

QHEI data forms and scoring of other habitat measures were completed after sampling for unionids. Substrate within each transect was characterized by estimating the percent composition by volume of each of the following six particle size classes (diameter); boulder (>256mm), cobble (256-64mm), pebble (64-16mm), gravel (16-2mm), sand (2-0.0625mm), silt/clay (<0.0625). Woody debris, aquatic vegetation, exposed solid clay substrate, and eroded banks were noted when observed.

Results

Sampling took place from July through October 1, 2009. The main stem of the Paw Paw has a relatively deep channel with steep sides. Most of the pre-selected sites in the main stem were too deep, even at lower than average discharge in September, to sample for unionid mussels using wading techniques. In order to locate and access habitat shallow enough to survey in the main stem, we used a canoe to float five reaches in the main stem of the Paw Paw. Sites 1-27 and 30-32 were accessed at road crossings, and sites 28, 29, and 33-45 were accessed by canoe. While canoeing on the Paw Paw, exposed unionid shells were observed on the river bank at three locations (spot checks 1-3). Though the river was too deep to survey, the shells were identified to species and a gps point was taken. Locations of survey sites are given in Table 1.

Higher unionid abundance and species richness was found in the main stem of the Paw Paw compared to the tributaries (Tables 2 and 3). A total of 17 unionid species were observed, including one shell of the state endangered lilliput (*Toxolasma parvus*), the state threatened slippershell (*Alasmidonta viridis*), and four species of special concern. Live unionids were observed at 17 of 45 sites, with maximum species richness of 11 species at site 40 and maximum density of 5.09 indvs./m^2 at site 22. Spike (*Elliptio dilatata*) was the most abundant species overall, followed by wabash pigtoe (*Fusconaia flava*). The species of special concern, ellipse (*Venustaconcha ellipsiformis*)

was found frequently, 11 of 45 sites plus two spot checks. No dreissenids (zebra or quagga mussels) were observed in the Paw Paw watershed. Live Asian clams were observed at one site in the South Branch of the Paw Paw River, one site in the North Branch of the Paw Paw River, and one in the main stem of the Paw Paw. Asian clam shells were observed at six sites in the main stem of the Paw Paw (Table 3).

Water chemistry measures are given in Table 4. QHEI, substrate composition, and stream habitat type are given in Table 5. Substrate in the Paw Paw watershed often had a high proportion of sand. At some sites, the sand substrate appeared unstable, i.e. it could be seen flowing downstream with the current. These sites typically did not support any unionids.

Incidental taxa are given in Table 6. The introduced round goby (*Neogobius melanostomus*) was observed at the two most downstream sites in the watershed. Belted kingfisher (*Megaceryle alcyon*) and great blue heron (*Ardea herodias*) were common in the main stem of the Paw Paw. One muskrat (*Ondatra zibethicus*) and several muskrat burrows were spotted.

All species found in the Paw Paw watershed during this survey have historic (1934) occurrence records at the UMMZ collection, with the exception of lilliput (*Toxolasma parvus*) (Table 7). All species documented at the UMMZ collection were found in this survey except white heelsplitter (*Lasmigona complanata*). White heelsplitter was collected from Watervliet, MI in 1934. Twelve lots/historic records exist at UMMZ for lilliput. It was reported from the Huron, Macatawa/Black River east of Holland, Lake Erie, River Rouge, Stony Creek and Otter Creek (Monroe Co.), River Raisin, and Grand River watersheds.

Acknowledgments

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Table 1. Latitude and longitude of sites surveyed in the Paw Paw River watershed in the summer of 2009

Site Number	Stream	Nearest Road	Latitude (N)	Longitude (W)
1	Brush Creek	Red Arrow Hwy	42.21946	-86.04286
2	Brush Creek	52nd St.	42.17397	-86.05181
3	Brush Creek	72nd Ave.	42.15685	-86.05610
4	White Creek	County Rd. 215	42.14955	-86.07001
5	Brush Creek	County Rd. 215	42.14781	-86.06608
6	S. Br. Paw Paw River	60th Ave.	42.20093	-85.90234
7	S. Br. Paw Paw River	72nd Ave.	42.15734	-85.90849
8	Eagle Lake Drain	39th St.	42.16254	-85.92657
9	S. Br. Paw Paw River	35624 Riverview Dr. (address)	42.24984	-85.89293
10	Brandywine Creek	38th Ave.	42.28105	-85.89819
11	Brandywine Creek	36th Ave.	42.28818	-85.91639
12	Brandywine Creek	M43	42.30270	-85.91812
13	N. Br. Brandywine Creek	28th Ave.	42.31753	-85.91924
14	E. Br. Paw Paw River	30th St.	42.19682	-85.84260
15	E. Br. Paw Paw River	26th St.	42.18133	-85.80322
16	Hayden Creek	32nd St.	42.26613	-85.86339
17	Mill Creek	Red Arrow Hwy	42.18641	-86.25763
18	Mill Creek	Carmody Rd.	42.15751	-86.25826
19	Pine Creek	Red Arrow Hwy	42.20600	-86.18226
20	Paw Paw River	3550th St.	42.26656	-85.89326
21	Paw Paw River	3750th St. (County Rd. 665)	42.26708	-85.91254
22	Paw Paw River	48th St.	42.23694	-86.01333
23	N. Br. Paw Paw River	between Whiskey Run Rd. & 32nd Ave.	42.98761	-85.83057
24	E. Br. Paw Paw River	County Rd. 657 (28th St.)	42.19487	-85.82346
25	E. Br. Paw Paw River	County Rd. 653	42.21318	-85.86214
26	Blue Creek	Territorial Rd. (near Millburg)	42.12175	-86.33824
27	Ox Creek	Empire Ave.	42.10155	-86.43879
28	Paw Paw River	accessed by canoe	42.22300	-86.05707
29	Paw Paw River	accessed by canoe	42.22726	-86.06554
30	Paw Paw River	5950th St.	42.22694	-86.12361
31	Paw Paw River	County Rd. 673 (52nd St., Lawrence)	42.22361	-86.05167
32	N. Br. Paw Paw River	M40	42.27096	-85.87764
33	Paw Paw River	accessed by canoe	42.23250	-86.01714
34	Paw Paw River	accessed by canoe	42.22468	-86.04736
35	Paw Paw River	accessed by canoe	42.23268	-86.11320
36	Paw Paw River	accessed by canoe	42.23283	-86.11643
37	Paw Paw River	accessed by canoe	42.22572	-86.12221
38	Paw Paw River	accessed by canoe	42.22268	-86.16626
39	Paw Paw River	accessed by canoe	42.22269	-86.19316
40	Paw Paw River	accessed by canoe	42.19329	-86.25777
41	Paw Paw River	accessed by canoe	42.19047	-86.27576
42	Paw Paw River	accessed by canoe	42.19111	-86.30333
43	Paw Paw River	accessed by canoe	42.19670	-86.30472
44	Paw Paw River	accessed by canoe	42.20129	-86.32800
45	Paw Paw River	accessed by canoe	42.20284	-86.33482
spot check 1	Paw Paw River	accessed by canoe	42.22380	-86.03545
spot check 2	Paw Paw River	accessed by canoe	42.23160	-86.11138
spot check 3	Paw Paw River	accessed by canoe	42.23144	-86.11825

Table 2. Scientific and common names of unionid mussels found during 2009 surveys. (L=live individuals; S=species represented by shell only; E=state listed as endangered; T=state listed as threatened; SpC=species of special concern)

Species	Common Name	Main Stem	North Branch	Hayden Creek	East Branch	South Branch (Eagle Lake Drain)	Brush (White) Creek	Pine Creek	Mill Creek	Blue Creek	Ox Creek	Brandy-wine Creek
Actinonaias ligamentina	Mucket	S										
Alasmidonta marginata (SpC)	Elktoe	S										
Alasmidonta viridis (T)	Slippershell	S			S							
Amblema plicata	Threeridge	L										
Anodontoides ferussacianus	Cylindrical papershell	S				S						S
Elliptio dilatata	Spike	L	L			L						
Fusconaia flava	Wabash pigtoe	L	L			L	S					
Lampsilis siliquoidea	Fatmucket	L				S						
Lampsilis ventricosa	Pocketbook	S										
Lasmigona compressa	Creek heelsplitter					L			S			
Lasmigona costata	Fluted-shell	L										
Pleurobema sintoxia (SpC)	Round pigtoe	S										
Pyganodon grandis	Giant floater	S										
Strophitus undulatus	Strange floater	S		S	S	L			S			
Toxolasma parvus (E)	Lilliput	S										
Venustaconcha ellipsiformis (SpC)	Ellipse	L				L						
Villosa iris (SpC)	Rainbow	L			S							
# species live		7	2	0	0	5	0	0	0	0	0	0
# species live or shell		16	2	1	3	7	1	0	2	0	0	1
# sites surveyed		20	2	1	4	4	5	1	2	1	1	4
Corbicula fluminea	Asian clam	L	L									
Dreissena polymorpha	Zebra mussel											

Table 3. Numbers of unionids (#), relative abundance (RA), and density (D, indvs./m2) recorded at each site. Number of shells found are given in parentheses.

	1			2			3			4			5			6		
Species	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D
Actinonaias ligamentina																		
Alasmidonta marginata (SpC)																		
Alasmidonta viridis (T)																		
Amblema plicata																		
Anodontoides ferussacianus																		
Elliptio dilatata																		
Fusconaia flava													SA					
Lampsilis siliquoidea																		
Lampsilis ventricosa																		
Lasmigona compressa																		
Lasmigona costata																		
Pleurobema sintoxia (SpC)																		
Pyganodon grandis																		
Strophitus undulatus																		
Toxolasma parvus (E)																		
Venustaconcha ellipsiformis (SpC)																		
Villosa iris (SpC)																		
Total # individuals and density	0		0.00	0		0.00	0		0.00	0		0.00	0		0.00	0		0.00
# species live	0			0			0			0			0			0		
# species live or shell	0			0			0			0			1			0		
Area searched (m^2)	128			128			128			128			128			128		
Corbicula fluminea																		
Dreissena polymorpha																		

A - *Fusconia flava* shell found during pebble counts

Table 3. (cont.)

	7			8			9			10			11			12		
Species	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D
Actinonaias ligamentina																		
Alasmidonta marginata (SpC)																		
Alasmidonta viridis (T)																		
Amblema plicata																		
Anodontoides ferussacianus							S									S		
Elliptio dilatata							1	0.03	0.01									
Fusconaia flava							27	0.82	0.21									
Lampsilis siliquoidea							S											
Lampsilis ventricosa																		
Lasmigona compressa							1B											
Lasmigona costata																		
Pleurobema sintoxia (SpC)																		
Pyganodon grandis																		
Strophitus undulatus							4	0.12	0.03									
Toxolasma parvus (E)																		
Venustaconcha ellipsiformis (SpC)							1	0.03	0.01									
Villosa iris (SpC)																		
Total # individuals and density	0		0.00	0		0.00	33		0.26	0		0.00	0		0.00	0		0.00
# species live	0			0			5			0			0			0		
# species live or shell	0			0			7			0			0			1		
Area searched (m^2)	128			128			128			128			128			128		
Corbicula fluminea							L											
Dreissena polymorpha																		

B - found outside transect

Table 3. (cont.)

	13			14			15			16			17			18		
Species	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D
Actinonaias ligamentina																		
Alasmidonta marginata (SpC)																		
Alasmidonta viridis (T)																		
Amblema plicata																		
Anodontoides ferussacianus																		
Elliptio dilatata																		
Fusconaia flava																		
Lampsilis siliquoidea																		
Lampsilis ventricosa																		
Lasmigona compressa													S					
Lasmigona costata																		
Pleurobema sintoxia (SpC)																		
Pyganodon grandis																		
Strophitus undulatus										S			S					
Toxolasma parvus (E)																		
Venustaconcha ellipsiformis (SpC)																		
Villosa iris (SpC)							S(1)											
Total # individuals and density	0		0.00	0		0.00	0		0.00	0		0.00	0		0.00	0		0.00
# species live	0			0			0			0			0			0		
# species live or shell	0			0			1			1			2			0		
Area searched (m^2)	95			128			128			128			128			128		
Corbicula fluminea																		
Dreissena polymorpha																		

Table 3. (cont.)

	19			20			21			22			23			24		
Species	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D
Actinonaias ligamentina																		
Alasmidonta marginata (SpC)																		
Alasmidonta viridis (T)																		
Amblema plicata																		
Anodontoides ferussacianus							S											
Elliptio dilatata				1	1.00	0.01	125	0.93	0.98	230	0.82	4.18	1	0.50	0.01			
Fusconaia flava							8	0.06	0.06	31	0.11	0.56	1	0.50	0.01			
Lampsilis siliquoidea										1	0.00	0.02						
Lampsilis ventricosa																		
Lasmigona compressa																		
Lasmigona costata										1	0.00	0.02						
Pleurobema sintoxia (SpC)																		
Pyganodon grandis							S			S								
Strophitus undulatus										S								
Toxolasma parvus (E)																		
Venustaconcha ellipsiformis (SpC)				1B			1	0.01	0.01	15	0.05	0.27						
Villosa iris (SpC)										2	0.01	0.04						
Total # individuals and density	0		0.00	1		0.01	134		1.05	280		5.09	2		0.02	0		0.00
# species live	0			2			3			6			2			0		
# species live or shell	0			2			5			8			2			0		
Area searched (m^2)	128			128			128			55			128			128		
Corbicula fluminea										L			L					
Dreissena polymorpha																		

B - found outside transect

Table 3. (cont.)

Species	25			26			27			28			29			30		
	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D
Actinonaias ligamentina																		
Alasmidonta marginata (SpC)																		
Alasmidonta viridis (T)	SB												S(1)					
Amblema plicata																		
Anodontoides ferussacianus																		
Elliptio dilatata										1	0.33	0.01	4	0.57	0.03			
Fusconaia flava										S			1	0.14	0.01	1	1.00	0.01
Lampsilis siliquoidea													S					
Lampsilis ventricosa																		
Lasmigona compressa																		
Lasmigona costata																		
Pleurobema sintoxia (SpC)																		
Pyganodon grandis																		
Strophitus undulatus	S												S					
Toxolasma parvus (E)																		
Venustaconcha ellipsiformis (SpC)										2	0.67	0.03	2	0.29	0.01			
Villosa iris (SpC)																		
Total # individuals and density	0		0.00	0		0.00	0		0.00	3		0.04	7		0.05	1		0.01
# species live	0			0			0			2			3			1		
# species live or shell	2			0			0			3			6			1		
Area searched (m^2)	128			128			128			74			137			114		
Corbicula fluminea																		
Dreissena polymorpha																		

B - found outside transect

Table 3. (cont.)

	31			32			33			34			35			36		
Species	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D
Actinonaias ligamentina																		
Alasmidonta marginata (SpC)																		
Alasmidonta viridis (T)				S														
Amblema plicata																		
Anodontoides ferussacianus																		
Elliptio dilatata	3	1.00	0.04	2	1.00	0.02	9	1.00	0.07	108	0.67	0.84	2	1.00	0.01			
Fusconaia flava										46	0.29	0.36						
Lampsilis siliquoidea																		
Lampsilis ventricosa																		
Lasmigona compressa																		
Lasmigona costata										1	0.01	0.01						
Pleurobema sintoxia (SpC)																		
Pyganodon grandis										S								
Strophitus undulatus																		
Toxolasma parvus (E)																		
Venustaconcha ellipsiformis (SpC)										6	0.04	0.05						
Villosa iris (SpC)																		
Total # individuals and density	3		0.04	2		0.02	9		0.07	161		1.26	2		0.01	0		0.00
# species live	1			1			1			4			1			0		
# species live or shell	1			2			1			5			1			0		
Area searched (m^2)	67			109			128			128			182			136		
Corbicula fluminea	S						S			S								
Dreissena polymorpha																		

Table 3. (cont.)

Species	37			38			39			40			41			42		
	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D
Actinonaias ligamentina										S								
Alasmidonta marginata (SpC)										S								
Alasmidonta viridis (T)				S(1)(1)B						S(2)								
Amblema plicata							6	0.32	0.05	2	0.40	0.016						
Anodontoides ferussacianus																		
Elliptio dilatata	109	0.96	0.85	65	0.94	0.90	9	0.47	0.08	1	0.20	0.008						
Fusconaia flava	1	0.01	0.01				3	0.16	0.03	S								
Lampsilis siliquoidea	2	0.02	0.02	S						S								
Lampsilis ventricosa				S						S								
Lasmigona compressa																		
Lasmigona costata				S														
Pleurobema sintoxia (SpC)																		
Pyganodon grandis				S									S					
Strophitus undulatus										S								
Toxolasma parvus (E)										S(1)								
Venustaconcha ellipsiformis (SpC)	1	0.01	0.01	4	0.06	0.06	1	0.05	0.01	2	0.40	0.016						
Villosa iris (SpC)																		
Total # individuals and density	113		0.88	69		0.96	19		0.16	5		0.04	0		0.00	0		0.00
# species live	4			2			4			3			0			0		
# species live or shell	4			7			4			11			1			0		
Area searched (m^2)	128			72			118			128			131			103		
Corbicula fluminea																S		
Dreissena polymorpha																		

B - one shell found outside transect

Table 3. (cont.)

	43			44			45			spot check 1			spot check 2			spot check 3		
Species	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D
Actinonaias ligamentina																		
Alasmidonta marginata (SpC)																		
Alasmidonta viridis (T)																		
Amblema plicata																		
Anodontoides ferussacianus																		
Elliptio dilatata																S		
Fusconaia flava																		
Lampsilis siliquoidea																		
Lampsilis ventricosa																		
Lasmigona compressa																		
Lasmigona costata																		
Pleurobema sintoxia (SpC)													S					
Pyganodon grandis																		
Strophitus undulatus																		
Toxolasma parvus (E)																		
Venustaconcha ellipsiformis (SpC)										S(1)						S(1)		
Villosa iris (SpC)																		
Total # individuals and density	0		0.00	0		0.00	0		0.00	0		0.00	0		0.00	0		0.00
# species live	0			0			0			0			0			0		
# species live or shell	0			0			0			1			1			2		
Area searched (m^2)	128			122			142											
Corbicula fluminea				S			S											
Dreissena polymorpha																		

Table 4. Water chemistry measures taken at each site.

Site Number	Stream	DO (mg/L)	pH	Temperature (°C)	Conductivity (µS)	Alkalinity (ppm)	Hardness (mg/L)
1	Brush Creek	8.90	8.03	17.2	461	280	260
2	Brush Creek	8.69	8.03	18.1	437	216	280
3	Brush Creek	8.92	8.09	19.5	412	190	240
4	White Creek	8.66	8.00	16.2	446	170	280
5	Brush Creek	8.56	8.02	19.9	375	170	240
6	S. Br. Paw Paw River	8.76	8.07	18.1	551	245	360
7	S. Br. Paw Paw River	9.26	8.17	15.6	583	258	340
8	Eagle Lake Drain	9.74	8.01	16.2	552	250	360
9	S. Br. Paw Paw River	7.92	8.34	23.0	451	202	260
10	Brandywine Creek	8.36	8.05	16.8	481	200	300
11	Brandywine Creek	8.62	8.05	17.0	469	210	300
12	Brandywine Creek	8.49	8.11	17.9	451	220	280
13	N. Br. Brandywine Creek	8.61	8.29	21.5	474	230	300
14	E. Br. Paw Paw River	8.67	8.21	15.6	447	245	280
15	E. Br. Paw Paw River	8.61	8.27	19.8	466	268	280
16	Hayden Creek	9.05	8.30	19.8	437	195	260
17	Mill Creek	9.06	8.30	17.5	500	215	320
18	Mill Creek	8.93	8.27	18.0	470	215	340
19	Pine Creek	8.90	8.17	19.1	537	256	320
20	Paw Paw River	8.33	8.19	18.0	434	150	220
21	Paw Paw River	8.28	8.16	18.3	441	194	260
22	Paw Paw River	8.52	8.25	20.4	452	210	200
23	N. Br. Paw Paw River	6.83	7.88	22.4	426	190	240
24	E. Br. Paw Paw River	7.92	8.17	22.2	442	210	280
25	E. Br. Paw Paw River	10.07	8.28	20.5	423	240	260
26	Blue Creek	8.61	8.14	15.2	405	162	240
27	Ox Creek	7.14	7.98	20.4	630	230	320
28	Paw Paw River	8.22	8.22	18.6	472	210	240
29	Paw Paw River	8.20	8.24	18.8	474	220	260
30	Paw Paw River	8.55	8.27	16.2	475	210	300
31	Paw Paw River	8.44	8.26	16.1	473	200	260
32	N. Br. Paw Paw River	8.72	8.26	17.0	454	220	240
33	Paw Paw River	7.87	8.14	19.0	475	376	280
34	Paw Paw River	7.38	8.17	19.7	474	380	260
35	Paw Paw River	8.11	8.20	18.5	475	220	280
36	Paw Paw River	8.50	8.25	18.8	475	210	280
37	Paw Paw River	8.53	8.23	19.0	471	200	260
38	Paw Paw River	8.73	8.32	17.2	481	205	260
39	Paw Paw River	8.62	8.29	17.7	482	205	260
40	Paw Paw River	8.98	8.42	17.0	482	205	260
41	Paw Paw River	9.19	8.24	17.1	482	210	240
42	Paw Paw River	9.23	8.24	17.4	487	200	260
43	Paw Paw River	9.16	8.24	13.0	488	392	300
44	Paw Paw River	9.25	8.21	13.2	498	364	300
45	Paw Paw River	8.79	8.25	13.4	493	388	300

Table 5. Qualitative Habitat Index Scores, substrate composition, and stream habitat type for each sites surveyed.

Site	Stream	QHEI	Boulder	Cobble	Pebble	Gravel	Sand	Silt	Pool	Riffle	Run
1	Brush Creek	62.0	0	0	0	0	60	40	30	0	70
2	Brush Creek	57.0	0	0	0	0	70	30	25	0	75
3	Brush Creek	67.0	0	0	0	0	80	20	25	0	75
4	White Creek	66.0	0	0	0	0	90	10	20	0	80
5	Brush Creek	70.0	2	8	25	25	30	10	10	33	57
6	S. Br. Paw Paw River	56.5	0	0	0	5	75	20	20	0	80
7	S. Br. Paw Paw River	46.5	0	0	0	0	80	20	10	0	90
8	Eagle Lake Drain	50.5	0	5	10	20	50	15	10	0	90
9	S. Br. Paw Paw River	54.5	0	0	5	35	40	20	10	0	90
10	Brandywine Creek	50.0	0	0	0	0	95	5	5	0	95
11	Brandywine Creek	45.0	0	0	0	0	75	25	20	0	80
12	Brandywine Creek	51.0	0	0	0	5	65	30	20	0	80
13	N. Br. Brandywine Crk.	45.0	0	0	0	10	40	50	15	0	85
14	E. Br. Paw Paw River	57.5	0	0	5	10	70	15	10	0	90
15	E. Br. Paw Paw River	57.5	0	5	15	35	35	10	0	80	20
16	Hayden Creek	59.0	0	0	0	0	75	25	0	0	100
17	Mill Creek	58.5	5	15	20	20	20	20	0	0	100
18	Mill Creek	54.0	0	0	5	20	60	15	0	0	100
19	Pine Creek	42.0	0	0	0	30	40	30	0	0	100
20	Paw Paw River	47.5	0	0	0	0	60	40	0	0	100
21	Paw Paw River	46.5	0	0	0	0	75	25	0	0	100
22	Paw Paw River	58.5	0	5	35	15	25	20	0	0	100
23	N. Br. Paw Paw River	48.0	0	0	0	0	50	50	0	0	100
24	E. Br. Paw Paw River	69.5	0	0	0	10	90	0	20	0	80
25	E. Br. Paw Paw River	60.0	0	0	5	20	55	20	10	0	90
26	Blue Creek	62.5	0	0	0	0	80	20	10	0	90
27	Ox Creek	42.0	0	0	0	0	20	80	0	0	100
28	Paw Paw River	50.5	0	0	0	0	70	30	10	0	90
29	Paw Paw River	46.5	0	0	0	0	60	40	0	0	100
30	Paw Paw River	54.0	0	5	5	20	45	25	5	0	95
31	Paw Paw River	42.5	0	0	0	20	50	30	0	0	100
32	N. Br. Paw Paw River	49.5	0	0	0	0	50	50	10	0	90
33	Paw Paw River	61.0	0	0	0	0	80	20	0	0	100
34	Paw Paw River	58.0	0	0	0	0	80	20	0	0	100
35	Paw Paw River	64.0	0	0	0	0	95	5	15	0	85
36	Paw Paw River	54.0	0	0	0	2	93	5	0	0	100
37	Paw Paw River	54.0	2	0	28	30	30	10	0	0	100
38	Paw Paw River	65.0	0	0	30	35	20	15	10	0	90
39	Paw Paw River	52.5	0	0	0	0	60	40	10	0	90
40	Paw Paw River	42.0	0	0	25	30	40	5	0	0	100
41	Paw Paw River	53.0	0	0	0	0	95	5	0	0	100
42	Paw Paw River	62.0	0	0	0	0	95	5	20	0	80
43	Paw Paw River	58.0	0	0	0	0	90	10	10	0	90
44	Paw Paw River	64.0	0	0	0	0	90	10	5	0	95
45	Paw Paw River	52.5	0	0	0	0	10	90	0	0	100

Table 6. Taxa observed incidentally while performing unionid surveys.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mottled sculpin, *Cottus bairdii*	x	x	x	x	x			x		x	x	x		x	
Grass pickerel, *Esox a. vermiculatus*							x								
Iowa darter, *Etheostoma exile*						x									
Johnny darter, *Etheostoma nigrum*												x	x		
N. hog sucker, *Hypentelium nigricans*															
Round goby, *Neogobius melanostomus*															
N. watersnake, *Nerodia sipedon sipedon*											x				
Green frog, *Rana clamitans*		x		x				x			x				
Crayfish	x	x	x		x	x	x			x	x	x	x		x
Sponge															

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Mottled sculpin, *Cottus bairdii*	x	x	x	x	x				x		x			x	x
Grass pickerel, *Esox a. vermiculatus*				x			x								
Iowa darter, *Etheostoma exile*															
Johnny darter, *Etheostoma nigrum*	x			x			x					x	x	x	
N. hog sucker, *Hypentelium nigricans*							x								
Round goby, *Neogobius melanostomus*															
N. watersnake, *Nerodia sipedon sipedon*															
Green frog, *Rana clamitans*															
Crayfish		x	x	x	x		x	x				x			x
Sponge															

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Mottled sculpin, *Cottus bairdii*	x													x	
Grass pickerel, *Esox a. vermiculatus*															
Iowa darter, *Etheostoma exile*															
Johnny darter, *Etheostoma nigrum*						x						x		x	x
N. hog sucker, *Hypentelium nigricans*															
Round goby, *Neogobius melanostomus*														x	x
N. watersnake, *Nerodia sipedon sipedon*															
Green frog, *Rana clamitans*															
Crayfish	x	x			x	x								x*	x
Sponge								x							

* Rusty crayfish, *Orconectes rusticus*

Table 7. Unionid mussel species documented in this 2009 survey and in 1934 (from the University of Michigan Museum of Zoology mollusk collection).

Species	Common Name	Paw Paw 2009 survey	UMMZ historic records Paw Paw watershed (1934)
Actinonaias ligamentina	Mucket	x	x
Alasmidonta marginata (SpC)	Elktoe	x	x
Alasmidonta viridis (T)	Slippershell	x	x
Amblema plicata	Threeridge	x	x
Anodontoides ferussacianus	Cylindrical papershell	x	x
Elliptio dilatata	Spike	x	x
Fusconaia flava	Wabash pigtoe	x	x
Lampsilis siliquoidea	Fatmucket	x	x
Lampsilis ventricosa	Pocketbook	x	x
Lasmigona complanata	White heelsplitter		x
Lasmigona compressa	Creek heelsplitter	x	x
Lasmigona costata	Fluted-shell	x	x
Pleurobema sintoxia (SpC)	Round pigtoe	x	x
Pyganodon grandis	Giant floater	x	x
Strophitus undulatus	Strange floater	x	x
Toxolasma parvus (E)	Lilliput	x	
Venustaconcha ellipsiformis (SpC)	Ellipse	x	x
Villosa iris (SpC)	Rainbow	x	x