Little Sac River Priority Watershed
2013 Sampling Summary Report

Missouri Department of Conservation
Fisheries Division-Southwest Region

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Executive Summary

The Little Sac River Priority Watershed is located in Greene and Polk counties, Missouri, within the Ozark/Osage Ecological Drainage Unit (EDU). Nine sites were sampled within the Little Sac watershed during the summer field season of 2013 in an effort to establish baseline aquatic community data, determine Index of Biotic Integrity (IBI) and Stream Condition Index (SCI) scores, compare the list of species collected to historic samples and targeted species predicted to occur within the watershed, and collect baseline habitat data. The fish communities and physical habitats were sampled according to Resource Assessment and Monitoring (RAM) protocol and fish Index of Biotic Integrity (IBI) scores were calculated. In addition to fish samples, macroinvertebrate surveys were conducted to calculate Stream Condition Index (SCI) scores for all stream reaches sampled. A total of forty-two fish species were collected from nine sites in the Little Sac River watershed. Of the 63 fish species previously observed from historic collections in the Little Sac watershed, 40 were observed in the 2013 samples. Additionally, two species observed in the 2013 samples were never documented in the watershed according to the WIA or RSD-IAD data. Two sites of the nine sites sampled in the Little Sac River watershed (LSR01 and LSR02) were designated as "highly impaired". The other seven sites sampled in the watershed were designated as "not impaired" based fish IBI scores. One hundred and seventy-three different macroinvertebrate taxa were collected from sites in the Little Sac watershed. Macroinvertebrate data showed similar results as the IBI data, as seven of the nine sites in the Little Sac watershed scored high in the Stream Condition Index, designating those reaches as "fully biologically supporting". The few high stress level factors that do exist in the watershed, calculated by the Human Stress Index, include the high percent of land used for agriculture and the number of stream crossings in the drainage. These potential threats should be addressed by engaging conservation partners and other stakeholders in the watershed to promote best management practices on agricultural land and by working with county road districts to install crossings that facilitate fish passage when stream crossings are scheduled for replacement.

Introduction

The Little Sac River Priority Watershed is located in Greene and Polk counties, Missouri, within the Ozark/Osage Ecological Drainage Unit (EDU) (Figure 1; Appendix A). The Little Sac main-stem flows for approximately 49 miles from its headwaters just west of the town of Strafford before reaching its terminus as a fifth order stream in the Little Sac Arm of Stockton Lake. The Little Sac main-stem is impounded in two locations just north of the city of Springfield creating the 820-acre Fellows Lake and the 300-acre McDaniel Lake, both owned by City Utilities of Springfield as drinking water supply lakes. The entire Little Sac watershed encompasses approximately 190,000 acres. The Little Sac River watershed was designated an MDC Priority Watershed by Southwest Region Fisheries staff for a variety of reasons, including its value as a sport fishery, direct influence on the high profile Stockton Lake recreational area, its role as a major drinking water source for the City of Springfield, the existing network of conservation partners, and the potential to expand best management practices and landscape conservation in the watershed (Boman, MDC internal document).

The Little Sac Priority Watershed lies within the Ozark/Osage EDU, and is classified within the Finley Creek and Middle Upper Little Sac Aquatic Ecological System Types (AES Type 23 and 24, Appendix B and C). The watershed spans two different Land Type Associations (LTA's) with three named LTA's; including the Springfield Karst Prairie Plain which is an Ozark Prairie/Savannah Dissected Plain LTA type (Appendix D), and the Little Sac River Oak Savanna/Woodland Low Hills and Middle Sac River Oak/Savanna Woodland Low Hills which are Ozark Oak Savanna/Woodland (Dissected) Plains LTA types (Appendix E). In addition to the Little Sac River, North Dry Sac River, South Dry Sac River, Asher Creek, Bear Creek, Browns Branch, Coates Branch, Flint Hill Branch, King Branch, Pea Ridge Creek, Sims Branch, Slagle Creek, Spring Branch, Tinkle Branch, Tommie Creek, Venable Spring Branch and Walnut Creek are other named streams in the Little Sac River watershed. The total watershed area at the downstream outlet of the Little Sac River is approximately 296 square miles (767 km^2) (Figure 2). Approximately 51% of the land cover within the watershed boundary is grassland, with some sparse (about 29%) deciduous forest cover (Figure 3). The watershed has approximately 447 miles (719.4 km) of stream segments that represent Strahler stream orders 1 through 5 (including 292.2 miles 1^{st} order, 87.5 miles 2^{nd} order, 23.3 miles 3^{rd} order, 34.1 miles 4^{th} order, and 10.0 miles 5^{th} order; Figure 4). Intermittent and perennial flowing stream segments make up 316.7 miles and 130.4 miles of stream in the watershed, respectively (Figure 5). While there are numerous karst features located within the watershed, there are no reaches within the watershed designated as cold water habitat (Figure 6). A local land relief map reveals how the Little Sac River watershed consists of mostly shallow rolling terrain (Figure 7).

Assessing the human threats of a watershed using geospatial analysis is very difficult; however the USGS Gap Analysis Program's (GAP) Human Stress Index can be used as a coarse-scale assessment of human disturbances that may be having deleterious effects on an aquatic system (Sowa et al. 2005). Using the presence of various known human stressors in the watershed as metrics, this method produces an index score for specific areas. The highest scores indicate high threats in the watershed. Using this process, the Little Sac River watershed was assigned a Human Stress Index score of 322, which is a relatively low HSI score. High stress level values (3) were attributed to three human stressors in the watershed, including high percent agriculture, degree of hydrological alteration and the density of stream crossings. However, stressors including number of dams, density of coal and lead mines, number of CAFO's, number of exotic species and percent urban use received lower stress level values (1 or 2). Mapping of available GIS layers for specific stress sources revealed six Superfund sites, eighteen underground storage tanks, twenty-three NPDES permitted facilities, one wastewater treatment plant, sixty-one hazardous waste sites, one landfill, six major dams and eleven CAFO sites located within the Little Sac River Priority Watershed (Figure 8). As verification of the high stress level value associated with the density of stream crossings, five hundred and forty-five road crossings are documented within

the Little Sac River watershed, many of which may have the potential to limit or eliminate aquatic organism passage and alter local stream habitat (Figure 9). Four major power lines also cut across portions of the watershed, which may be areas of degraded riparian vegetation and possible sources of stress (Figure 9).

GIS was also used to locate existing biotic records within the Little Sac Priority Watershed. The Resource Science Division's Integrated Aquatic Database (RSD-IAD) was used to identify previous fish and crayfish sampling locations and data within the watershed. In addition, the Sac River Watershed Inventory and Assessment (WIA) was used to compile historic fish and crayfish sampling data. Prior to 2013, the Resource Assessment and Monitoring (RAM) master database shows that three RAM protocol fish or macroinvertebrate samples have been conducted in Little Sac River watershed.

The objectives of sampling in the Little Sac River Priority Watershed were to:

1.) Establish baseline aquatic community data (fish, crayfish, and macroinvertebrate) at several sites within the watershed.
2.) Use Index of Biotic Integrity (IBI) and Stream Condition Index (SCI) analysis to assess the relative health of the aquatic communities throughout the watershed.
3.) Generate a recent species list for fish and crayfish species and compare the list of species collected in 2013 to historic samples and targeted species predicted to occur within the watershed.
4.) Collect baseline habitat data at sampling sites to describe in-channel, bank, fish cover and riparian habitat conditions.

Methods

Data Collection

Nine sites were sampled within the Little Sac watershed during the summer field season of 2013 (Table 1, Figure 4). Sampled stream segments were randomly selected by assigning every available valley segment type (VST) in the watershed a number and using a random number generator to select the segments. Sites were selected on the Little Sac River proper and associated tributaries including the North Dry Sac, Sims Branch, Asher Creek, Slagle Creek and two unnamed tributaries. The sampling site coordinates within each selected stream segment were determined in ArcMap by selecting a coordinate position that was located near the approximate center of the randomly selected stream segment. All randomly chosen sampling sites were scouted to locate access and obtain landowner permission. When site scouting revealed that a site may not be suitable for sampling (due to lack of landowner permission or the stream channel was dry) the site location was moved within the original random segment or another randomly selected segment/site was chosen altogether. The sampling reach length (forty times the stream's wetted width up to a maximum reach length of 300 meters) was measured and marked with flagging prior to the sampling date. It is important to note that the Resource Assessment and Monitoring (RAM) sampling protocol guidance from Resource Science Division (RSD) currently recommends dropping the 300 meter site length cap and sampling the entire length calculated from forty times the wetted width. Southwest Region Fisheries staff has chosen to keep the 300 meter maximum length due to other responsibilities that require staff time outside of priority watershed sampling. Thus, site lengths over 300 meters, which could require multiple days to complete the sample, were avoided due to limitations in time and manpower.

During the sample day, water quality parameters were first measured at one location in the sampling reach upstream from any disturbance caused by entering the stream. Conductivity was measured with an electronic meter, dissolved oxygen (DO) and ammonia were determined with HACH reagent kits, temperature with a hand held

thermometer, pH with a hand held probe, and turbidity was measured with a turbidity tube. Stream discharge was measured at each sampling site with a Marsh-McBirney flow-meter (Kaufmann et al. 1999).

At each site, the fish community and physical habitat were sampled according to the Resource Assessment and Monitoring protocol (Fischer and Combes 2003; Kaufmann et al. 1999). Fish collection data was used to calculate Index of Biotic Integrity (IBI) scores to measure stream health. Crayfish were collected using ten, one square meter kick seines in various habitats throughout the site. In addition to fish and crayfish surveys by regional Fisheries staff, the RSD statewide RAM crew conducted fall (September) macroinvertebrate samples at all sites. Macroinvertebrate data was used to calculate Stream Condition Index (SCI) scores for all stream reaches sampled.

Table 1. Little Sac River watershed sampling site data for the nine sampled reaches. The unique id for each site is the identification number used for the site in the RAM master database.

Site and Unique ID	Date surveyed	Stream Name	Strahler order	Flow type	Midpoint Coordinates
LSR01, LSRO11-13	6/20/2013	Unnamed tributary	2	intermittent	488956, 4128201
LSR02, LSR021-13	6/18/2013	Unnamed tributary	2	intermittent	478550, 4130340
LSR03, LSR031-13	7/23/2013	Sims Branch	2	perennial	471913, 4139256
LSRO4, LSR041-13	8/1/2013	North Dry Sac	3	perennial	466879, 4142965
LSR05, LSR051-13	7/16/2013	Little Sac River	4	perennial	464093, 4138224
LSR06, LSR061-13	7/3/2013	Asher Creek	2	perennial	458377, 4136792
LSR07, LSR071-13	7/2/2013	Asher Creek	4	perennial	458471, 4142810
LSR08, LSR081-13	6/27/2013	Slagle Creek	4	perennial	460407, 4150902
LSR09, LSR091-13	6/25/2013	Slagle Creek	4	perennial	458867, 4150595

Data entry and analysis

All RAM fish, physical habitat, stream discharge, and water quality data were entered into a standard Microsoft Access database template provided by RSD staff. The completed database was sent to RSD staff for statistical analysis including generation of IBI scores, generation of fish community metric values, and summarization of multiple fish and habitat parameters. Macroinvertebrate data was collected and analyzed by the RSD statewide RAM crew to calculate SCI scores.

In addition, fish data were entered into an Excel database and used to calculate species catch per unit effort (CPUE) and relative abundance (% abundance of the species in relation to the total fish sample) for each site. Crayfish data were also entered into an Excel database and used to calculate crayfish densities. Maps were constructed using ArcGIS software to illustrate fish community IBI scores and macroinvertebrate SCI scores.

Results

Historic fish and crayfish species

Using the Sac River WIA and the RSD-IAD project, historical records showed that 63 fish species and three crayfish species have been documented in the Little Sac River watershed prior to 2013 (Table 2 and Table 3).

Table 2. Fish species observed in historical samples in the Little Sac River watershed according to the Sac River WIA and the RSD-IAD Project. Species shaded in grey were also observed in 2013 samples.

Family Name	Common Name	Genus species
Atherinidae	**Brook Silversides**	***Labidesthes sicculus***
	Inland Silversides	*Menidia beryllina*
Catostomidae	**White Sucker**	***Catostomus commersoni***
	Northern Hog Sucker	***Hypentelium nigricans***
	Silver Redhorse	*Moxostoma anisurum*
	Black Redhorse	***Moxostoma duquesnei***
	Golden Redhorse	***Moxostoma erythrurum***
Centrachidae	**Ozark Bass**	***Ambloplites constellatus***
	Green Sunfish	***Lepomis cyanellus***
	Orangespotted Sunfish	*Lepomis humilis*
	Bluegill	***Lepomis macrochirus***
	Longear Sunfish	***Lepomis megalotis***
	Smallmouth Bass	***Micropterus dolomieu***
	Spotted Bass	***Micropterus punctulatus***
	Largemouth Bass	***Micropterus salmoides***
	White Crappie	*Pomoxis annularis*
	Black Crappie	*Pomoxis nigromaculatus*
Clupeidae	Gizzard Shad	*Dorosoma cepedianum*
Cottidae	**Banded Sculpin**	***Cottus carolinae***
Cyprinidae	**Largescale Stoneroller**	***Campostoma oligolepis***
	Central Stoneroller	***Campostoma pullum***
	Red Shiner	*Cyprinella lutrensis*
	Blacktail Shiner	***Cyprinella venusta***
	Common Carp	***Cyprinus carpio***
	Gravel Chub	*Erimystax x-punctatus*
	Striped Shiner	***Luxilus crysocephalus***
	Bleeding Shiner	***Luxilus zonatus***
	Redfin Shiner	***Lythrurus umbratilis***
	Hornyhead Chub	*Nocomis biguttatus*
	Golden Shiner	*Notemigonous crysoleucas*
	Emerald Shiner	*Notropis athernoides*
	Ghost Shiner	*Notropis buchanani*
	Blacknose Shiner	*Notropis heterolepis*
	Sand Shiner	*Notropis ludibundis*

Table 2. continued

	Ozark Minnow	***Notropis nubilus***
	Carmine Shiner	*Notropis percobromus*
	Suckermouth Minnow	*Phenacobius mirabilis*
	Bluntnose Minnow	***Pimephales notatus***
	Fathead Minnow	*Pimpehales promelas*
	Southern Redbelly Dace	***Phoxinus erythrogaster***
	Creek Chub	***Semotilus atromaculatus***
Fundulidae	**Northern Studfish**	***Fundulus catenatus***
	Blackspotted Topminnow	***Fundulus olivaceus***
Ictaluridae	**Black Bullhead**	***Ameiurus melas***
	Yellow Bullhead	***Ameiurus natalis***
	Channel catfish	***Ictalurus punctatus***
	Slender Madtom	***Noturus exilis***
	Stonecat	*Noturus flavus*
Lepisosteidae	Longnose Gar	*Lepisosteus osseus*
Percidae	**Greenside Darter**	***Etheostoma blennioides***
	Rainbow Darter	***Etheostoma caeruleum***
	Fantail Darter	***Etheostoma flabellare***
	Least Darter	*Etheostoma microperca*
	Niangua Darter	*Etheostoma nianguae*
	Jonny Darter	*Etheostoma nigrum*
	Stippled Darter	***Etheostoma punctulatum***
	Orangethroat Darter	***Etheostoma spectabile***
	Missouri Saddled Darter	***Etheostoma tetrazonum***
	Banded Darter	***Etheostoma zonale***
	Logperch	***Percina caprodes***
	Slenderhead Darter	*Percina phoxocephala*
Poeciliidae	**Western Mosquitofish**	***Gambusia affinis***
Sciaenidae	**Freshwater Drum**	***Aplodinotus grunniens***

Table 3. Crayfish species observed in historical samples in the Little Sac River watershed according to the Sac River WIA and the RSD-IAD project. Species shaded in grey were also observed in 2013 samples.

Common Name	Genus species
Bristly Cave crayfish	*Cambarus setosus*
Golden Crayfish	*Orconectes luteus*
Northern crayfish	*Orconectes virilis*

Fish species, distribution, and catch rates

A total of forty-two fish species were collected from nine sites in the Little Sac River watershed (Table 4 and Table 5). The Largescale Stoneroller ***(****Campostoma oligolepis)*, Central Stoneroller (*Campostoma pullum*) and Orangethroat Darter (*Etheostoma spectabile*) were the only three species present at all nine sites. Creek Chub (*Semotilus atromaculatus*) were observed at all but one of the nine sites (LSR09). The Largescale Stoneroller, Central Stoneroller and Creek Chub dominated the cyprinid community in the watershed although Bleeding Shiners (*Luxilus zonatus*), Ozark Minnows (*Notropis nubilus*) and Bluntnose Minnows (*Pimephales notatus*) were also prevalent at most sites (Table 6). Orangethroat Darters were the most abundant and widely distributed percid species sampled, although Fantail Darters (*Etheostoma flabellare*), Rainbow Darters (*Etheostoma caeruleum*) and Stippled Darters (*Etheostoma punctulatum*) were observed regularly throughout the basin. The Centrarchid community was mostly dominated by Longear Sunfish (*Lepomis megalotis*), Green Sunfish (*Lepomis cyanellus*) and Bluegill (*Lepomis macrochirus*). Present at seven of the nine sites, Slender Madtoms (Noturus exilis) were the most abundant ictalurid species, although multiple species in that family were observed throughout the watershed. Western mosquitofish were collected at all but one site. Multiple catostomid species were observed, including the White Sucker (*Catostomus commersoni*), Northern Hog Sucker (*Hypentelium nigricans*), Black Redhorse (*Moxostoma duquesnei*) and Golden Redhorse (*Moxostoma erythrurum*). Various species, including the Redear Sunfish (*Lepomis microlophus*), Smallmouth Bass (*Micropterus dolomieu*), Blacktail Shiner (*Cyprinella venusta*), Black Bullhead (*Ameiurus melas*), Channel Catfish (*Ictalurus punctatus*), Missouri Saddled Darter (*Etheostoma tetrazonum*), Banded Darter (*Etheostoma zonale*) and Freshwater Drum (*Aplodinotus grunniens*) were only observed in one site in the watershed.

Of the 63 fish species previously observed from historic collections in the Little Sac watershed, 40 were observed in the 2013 samples. Additionally, two species observed in the 2013 samples were never documented in the watershed according to the WIA or RSD-IAD data (Table 7).

Table 4. Total species abundance and total catch per unit effort (total # of individuals/ hour) of fish collected during the 2013 sampling of the Little Sac River watershed (electrofishing; seining).

Site	**LSR01**	**LSR02**	**LSR03**	**LSR04**	**LSR05**	**LSR06**	**LSR07**	**LSR08**	**LSR09**
Stream order	2	2	2	3	4	2	4	4	4
Total species	7;2	7;6	21;15	27;19	29;11	20;13	27;17	27;19	21;14
Effort	0.59;0.05	0.41;0.05	0.86;0.08	1.39;0.20	0.77;0.11	0.98;0.12	0.87;0.12	1.40;0.14	2.0;0.10
Total CPUE	**659;567**	**93;471**	**574;1692**	**515;1095**	**1337;1102**	**130;3139**	**855;1594**	**386;698**	**237;1295**

Table 5. Percent relative abundance of fish species collected during the 2013 sampling of the Little Sac River watershed. A value of 0 indicates the species' was present, but in a relative abundance of < 1. (% relative abundance from electrofishing sample; seine sample)

Species	LSR01	LSR02	LSR03	LSR04	LSR05	LSR06	LSR07	LSR08	LSR09
Brook Silversides	--	--	--;3	0;1	--;12	--	0;12	0;4	0;1
White Sucker	--	--	--	1;22	0;--	--	--	1;1	1;1
Northern Hog Sucker	--	--	1;--	1;1	1;--	--	1;--	0;--	--
Black Redhorse	--	--	--	0;3	4;--	--	2;--	0;5	--
Golden Redhorse	--	--	--	--	0;--	--	0;--	--	--
Ozark Bass	--	--	--	1;--	0;--	--	--	0;--	--
Green Sunfish	9;--	--	3;--	2;--	0;--	5;--	6;-	3;--	4;--
Bluegill	--	--	3;1	0;0	0;--	2;0	10;5	6;4	1;--
Longear Sunfish	--	--	20;8	13;25	3;7	4;--	7;4	8;--	4;--
Redear Sunfish	--	--	--	--	--	--	0;--	--	--
Smallmouth Bass	--	--	--	0;0	--	--	--	--	--
Spotted Bass	--	--	--	0;1	0;--	--	--	--	--
Largemouth Bass	--	--	0;1	--	1;--	2;1	3;1	1;5	0;5
Banded Sculpin	--	--	5;1	0;--	--	14;0	2;--	--	--
Largescale Stoneroller	35;50	13;23	8;11	26;6	19;2	6;9	21;9	28;7	21;2
Central Stoneroller	35;50	13;23	8;12	26;6	19;2	7;9	21;9	28;7	21;2
Blacktail Shiner	--	--	--	--	--	--	--	0;--	--
Common Carp	--	--	--	--	0;--	--	--	1;--	--
Striped Shiner	--	--	--	0;1	--	--	--	1;1	--;2
Bleeding Shiner	--	--	2;45	5;14	2;44	2;2	3;7	1;8	3;2
Redfin Shiner	--	--	--	--	0;12	--;63	0;1	--;5	1;--
Ozark Minnow	--	--	0;11	5;10	--	1;--	3;30	2;6	4;3
Bluntnose Minnow	--	--	1;0	2;2	6;4	2;4	4;5	7;8	1;5
Southern Redbelly Dace	15;--	--	25;1	--	--	5;1	0;6	--	--
Creek Chub	2;--	13;14	2;1	0;--	0;1	9;1	--;1	10;--	--
Northern Studfish	--	--	1;1	--	--	--	0;1	--	--
Blackspotted Topminnow	--	--	1;1	0;--	0;--	5;5	1;1	0;--	--
Black Bullhead	--	--	--	--	--	2;--	--	--	--
Yellow Bullhead	--	--	1;--	1;--	--	3;--	1;--	1;--	1;--
Channel catfish	--	--	--	--	0;--	--	--	--	--
Slender Madtom	--	5;5	4;--	3;0	0;--	--	1;--	4;--	6;--
Flathead Catfish	--	--	--	--	0;--	--	--	0;--	--
Greenside Darter	--	--	--	1;0	6;--	--	0;--	--;11	1;1
Rainbow Darter	--	--	1;--	2;2	2;--	9;--	2;1	1;1	3;--
Fantail Darter	--	26;32	1;--	1;0	1;--	--;0	--	0;2	10;2
Stippled Darter	1;--	--	4;--	4;--	--;1	2;--	1;--	0;--	0;--
Orangethroat Darter	3;--	26;5	3;1	3;3	2;1	18;--	4;3	2;4	13;7
Missouri Saddled Darter	--	--	--	0;--	--	--	--	--	--
Banded Darter	--	--	--	--	0;--	--	--	--	--
Logperch	--	--	--	--	3;--	1;--	2;--	1;1	1;5

Table 5. Continued

Western Mosquitofish	--	3;--	1;2	1;0	--;14	3;3	3;6	1;10	6;63
Freshwater Drum	--	--	--	--	1;--	--	--	--	--

Table 6. Catch per unit effort of fish species (# of individuals in a species/ hour) collected during the 2013 sampling in the Little Sac River watershed (CPUE electrofishing; CPUE seining).

Species	LSR01	LSR02	LSR03	LSR04	LSR05	LSR06	LSR07	LSR08	LSR09
Brook Silversides	--	--	-;48	--;15	--;33	--	1;197	1;28	0;10
White Sucker	--	--	--	7;240	1;--	--	--	3;7	1;10
Northern Hog Sucker	--	--	8;--	6;15	9;--	--	8;--	1;--	--
Black Redhorse	--	--	--	1;30	55;--	--	14;--	1;35	--
Golden Redhorse	--	--	--		4;--	--	2;--	1;--	--
Ozark Bass	--	--	--	3;--	5;--	--	--	--	--
Green Sunfish	59;--	--	--	12;--	4;--	6;--	48;--	11;--	9;--
Bluegill	--	--	17;24	1;5	1;--	3;9	88;77	21;28	3;--
Longear Sunfish	--	--	113;132	69;275	396;80	5;--	57;69	30;--	10;--
Redear Sunfish	--	--	--	--	--	--	--	--	--
Smallmouth Bass	--	--	--	1;5	--	--	--	--	--
Spotted Bass	--	--	--	1;15	3;--	--	--	--	--
Largemouth Bass	--	--	1;12	--	9;--	2;35	24;17	6;35	0;61
Banded Sculpin	--	--	28;12	1;--	--	18;9	18;--	--	--
Largescale Stoneroller	229;284	12;107	47;192	136;65	255;18	8;296	183;137	110;49	49;31
Central Stoneroller	229;284	12;107	47;204	136;65	255;27	9;296	183;129	110;49	49;31
Blacktail Shiner	--	--	--	--	--	--	--	1;--	--
Common Carp	--	--	--	--	1;--	--	--	3;--	--
Striped Shiner	--	--	--	2;10	--	--	--	2;7	--;31
Bleeding Shiner	--	--	12;768	24;155	33;489	2;78	29;111	3;56	6;20
Redfin Shiner	--	--	--	--	1;133	--;1991	2;17	--;35	2;--
Ozark Minnow	--	--	-;180	28;105	--	1;--	29;471	9;42	9;41
Bluntnose Minnow	--	--	6;--	8;25	76;44	2;122	35;77	29;56	1;16
Southern Redbelly Dace	102;--	--	143;24	--	--	7;17	1;94	--	--
Creek Chub	15;--	12;64	13;24	1;--	3;9	12;35	-;17	--;70	--
Northern Studfish	--	--	6;12	--	--	--	2;9	--	--
Blackspotted Topminnow	--	--	3;12	1;--	3;--	7;165	9;17	1;--	--
Black Bullhead	--	--	--	--	--	2;--	--	--	--
Yellow Bullhead	--	--	6;--	4;--	--	1;--	10;--	2;--	1;--
Channel catfish	--	--	--	--	1;--	--	--	--	--
Slender Madtom	--	5;21	22;--	18;5	5;--	--	5;--	16;--	14;--
Flathead Catfish	--	--	--	--	--	--	--	--	--
Greenside Darter	--	--	--	3;5	78;--	--	2;--	--;77	1;10
Rainbow Darter	--	--	7;--	9;20	31;--	12;--	17;9	5;7	6;--
Fantail Darter	--	24;150	34;--	5;5	13;--	--;9	--	1;14	25;20
Stippled Darter	3;--	--	22;--	19;--	1;9	3;--	6;--	1;--	0;--

Table 6. Continued

Orangethroat Darter	20;--	24;21	19;12	14;35	30;9	23;--	38;51	8;28	30;92
Missouri Saddled Darter	--	--	--	1;--	--	--	--	--	--
Banded Darter	--	--	--	--	5;--	--	--	--	--
Logperch	--	--	--	--	44;--	1;--	15;--	6;7	3;61
Western Mosquitofish	--	2;--	3;36	3;--	--;151	4;87	26;94	4;70	13;816
Freshwater Drum	--	--	--	--	10;--	--	--	--	--

Table 7. Fish species collected in 2013 that were not previously documented in the Little Sac River watershed in WIA or RSD-IAD databases.

Family Name	Common Name	Genus species
Centrachidae	Redear sunfish	*Lepomis microlophus*
Ictaluridae	Flathead catfish	*Pylodictis olivaris*

Fish Index of Biotic Integrity evaluation of fish community health

The overall health of the stream using fish community data was evaluated using two biotic indexes, the RAM IBI (Fischer and Combes 2003) and the Missouri Criteria IBI (MO IBI) (Doisy et al. 2008). The RAM IBI consists of 11 metrics (Table 8) and provides a total site score ranging from 0 (low biological integrity) to 100 (high biological integrity). RAM IBI site scores for the Little Sac River Priority Watershed sites ranged from 38 to 87 with a mean score of 70.0 +/- 11.6 (Figure 10, Table 8). The lowest RAM IBI score (38) was observed at site LSR02, which was located on an intermittent unnamed tributary just downstream of Fellows Lake. The second lowest score (51) occurred at site LSR01, which was also located on an intermittent unnamed tributary in the uppermost headwaters of the basin. The highest site score (87) was located at site LSR07, on a 4th order stretch of Asher Creek approximately 1.5 miles upstream of the confluence with the Little Sac River. The remaining six sites (LSR03, 04, 05, 06, 08 and 09) produced relatively high RAM IBI scores ranging from 69 to 82. Table eight demonstrates the effects of various IBI metrics on the total RAM IBI score of Little Sac River sites. As a generalization across all sites, values for percent tolerant individuals, percent individuals being carnivores, percent individuals being insectivores and invertivores, and percent individuals being omnivores and herbivores were the lowest scores. Conversely, sites generally exhibited high values for the number of native individuals, number of native species, number of native minnow species, number of native benthic species, number of native water column species and number of long-lived species. The lowest scoring site (LSR02) exhibited very low scores for number of native individuals, number of native water column species, number of native sunfish species, number of long-lived species and percent individuals that were carnivores. The highest scoring site (LSR07) only scored low in percent tolerant individuals, scored fair in percent individuals being insectivores and invertivores, and scored high in all other metrics.

The MO IBI consists of nine metrics (Table 8) and provides a total site score ranging from 9 to 45. The MO IBI site score classifies the health of the fish community into three possible categories: highly impaired (9-28), impaired (29-36), and no impairment (37-45). MO IBI site scores for the Little Sac River Priority Watershed ranged from 13 to 43 with a mean score of 35.7 +/- 8.7 (Figure 11, Table 8). Using the MO IBI, two sites out of the nine sites sampled in the Little

Sac River watershed (LSR01 and LSR02) were designated as "highly impaired". All other seven sites sampled in the watershed were designated as "not impaired" based on the MO IBI criteria and scoring.

Table 8. Index of Biotic Integrity (IBI) scores and metric values. For each metric, the first number represents the metric value. The number following the semicolon represents the metric score. Shaded columns represent sites designated as impaired or highly impaired.

Site	LSR01	LSR02	LSR03	LSR04	LSR05	LSR06	LSR07	LSR08	LSR09	Mean Score
Stream Order	**2**	**2**	**2**	**3**	**4**	**2**	**4**	**4**	**4**	
RAM IBI Score	**51**	**38**	**76**	**78**	**76**	**73**	**87**	**82**	**69**	**70.0**
MO IBI	**19**	**13**	**43**	**43**	**43**	**41**	**41**	**39**	**39**	**35.7**
RAM IBI	Metric value; metric score (on a 0-10 scale)									
# of native individuals	415; 10	60; 2.5	635; 10	636; 8.8	1146; 10	476; 8.9	906; 10	635; 10	605; 6.1	**8.5**
# of native minnow species	4; 5.5	3; 4.1	7; 9.5	7; 9.4	6; 8	8; 10	8; 10	9; 10	7; 9.4	**8.4**
# of native benthic species	2; 4.5	2; 4.6	5; 10	7; 10	6; 10	4; 6.7	6; 10	5; 10	5; 7.2	**8.1**
# of native water column species	2; 2.2	2; 2.2	9; 9.9	11; 10	10; 10	8; 8.8	11; 10	11; 10	8; 8.8	**8.0**
# of native sunfish species	1; 3.5	0; 0	3; 9.4	3; 8.2	3; 7.7	3; 9.2	4; 10	3; 8.6	3; 8.5	**7.2**
# of long-lived species	4; 3.8	3; 2.8	12; 10	17; 10	16; 10	10; 8.8	15; 10	15; 10	10; 8.4	**8.2**
# of native species	8; 4.4	7; 3.9	23; 10	21; 10	30; 10	22; 10	28; 10	29; 10	22; 10	**8.7**
% tolerant individuals	8; 1	2; 7.9	6; 2.4	4; 5.3	2; 7.8	6; 3.1	16; 1	10; 1	22; 1	**3.4**
% individuals carnivores	8; 10	0; 0	3; 4	4; 6	1; 1.4	3; 3.6	8; 10	5; 6.7	4; 5.9	**5.3**
% individuals insectivores and invertivores	3; 1.4	23; 9.3	15; 5.8	19; 7.7	15; 5.9	12; 4.8	11; 4.6	11; 4.2	19; 7.7	**5.7**
% individuals omnivores and herbivores	86; 10	33; 4.2	44; 2.3	55; 0.4	41; 2.8	22; 6.2	62; 10	68; 10	41; 2.8	**5.4**
MO IBI	Metric value; metric score (1, 3, or 5)									
# of native individuals	415; 3	60; 1	635; 5	636; 5	1146; 5	476; 5	906; 5	635; 5	605; 5	**4.3**

Table 8. continued

# of native minnow species	4; 3	3; 3	7; 5	7; 5	6; 5	8; 5	8; 5	9; 5	7; 5	**4.6**
# of native benthic species	2; 1	2; 1	5; 5	7; 5	6; 5	4; 3	6; 5	5; 5	5; 3	**3.7**
# of native water column species	2; 1	2; 1	9; 5	11; 5	10; 5	8; 5	11; 5	11; 5	8; 5	**4.1**
# of native darter species	2; 3	1; 1	3; 5	5; 5	5; 5	3; 5	4; 5	4; 5	4; 5	**4.3**
# of native lithophilic species	6; 1	5; 1	17; 5	21; 5	20; 5	14; 5	20; 5	20; 5	14; 5	**4.1**
% of the 3 dominant species	94; 1	80; 3	48; 5	52; 5	62; 5	66; 3	48; 5	64; 3	63; 5	**3.6**
% native insectivore cyprinid species	0; 1	0; 1	12; 3	11; 3	8; 3	50; 5	3; 1	4; 1	4; 1	**2.1**
% native sunfishes	8; 5	0; 1	20; 5	11; 5	28; 5	4; 5	15; 5	11; 5	7; 5	**4.6**

Crayfish species and abundance

Of the three crayfish species observed in historical samples in the Little Sac River watershed, only two were observed in 2013 (Table 3 and Table 9). No Bristly Cave Crayfish were observed in the Little Sac watershed during sampling in 2013. Golden Crayfish were the most abundant species observed throughout the Little Sac watershed and were found at all sites. The Northern Crayfish was also observed at all sites in somewhat lower numbers. The highest total crayfish density (38.1/m^2) was observed at LSR07, while the lowest (3.5/m^2) was observed at LSR01.

Table 9. Total crayfish density and species percent relative abundance obtained from individuals collected in the Little Sac River watershed.

Site	**LS01**	**LS02**	**LS03**	**LS04**	**LS05**	**LS06**	**LS07**	**LS08**	**LS09**
Stream Order	2	2	2	3	4	2	4	4	4
Effort (hrs.)	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Total Number Collected	35	341	67	139	151	203	381	140	149
				Species % relative abundance					
Northern crayfish	71	62	31	10	1	39	25	39	34
Golden crayfish	29	38	69	90	99	61	75	61	66

Macroinvertebrate Taxa and Stream Condition Index Scores

Stream Condition Index (SCI) scoring consists of four metrics including taxa richness, Ephemeroptera, Plecoptera and Trichoptera (EPT) richness, Biotic Index and the Shannon Diversity Index (Appendix F). Each metric gets a score of 1, 3, or 5, generating a total score of 4-20. Scores ranging from 16-20 indicate a stream reach that is fully biologically supporting. Scores ranging from 10-14 designate reaches as being partially biologically supporting and scores ranging from 4-8 indicate reaches that are non-biologically supporting. Table 10 and Figure 12 contain the SCI scores and metrics for the Little Sac River watershed samples. One hundred and seventy-three different taxa were collected from sites in the Little Sac watershed. Sites LSR03, 04, 05, 06 and 09 exhibited the greatest taxa richness with over 80 different taxa collected at each site. The lowest taxa richness was observed at LSR02 with only 42 different taxa observed. Sites LSR03, 05 and 09 produced the highest SCI scores possible with values of 20, and seven of the nine sites in the Little Sac watershed scored high in the Stream Condition Index, designating those reaches as "fully biologically supporting". Site LSR01 scored a SCI of 12 and was designated "partially biologically functioning. Based on its SCI score of eight, LSR02 was designated as "non-biologically supporting". A full list of species collected by site can be found in Appendix G.

Table 10. Index scores using macroinvertebrate collection data for the Little Sac River Priority Watershed.

Site	LSR01	LSR02	LSR03	LSR04	LSR05	LSR06	LSR07	LSR08	LSR09
Stream order	2	2	2	3	4	2	4	4	4
Taxa Richness	69	42	87	83	86	80	79	77	85
EPT Richness	13	7	27	26	29	25	27	23	26
Biotic Index	6.78	7.62	5.43	6.25	5.63	5.12	5.55	6.37	6.2
Shannon Diversity	2.72	1.56	3.51	3.36	3.72	3.55	3.37	3.42	3.28
Stream Condition Index	**12**	**8**	**20**	**18**	**20**	**18**	**18**	**18**	**20**

Habitat and Water Quality

Stream discharge for sampled sites ranged from 0.01 to 0.92 cubic meters per second (Table 11). Stream water temperature ranged from 16°C to 27°C and dissolved oxygen ranged from 5 to 8 mg/L. Turbidity was less than 10 NTU's for all sites based on the degree of precision obtained from our turbidity tube method. The pH values measured between 7.8 and 8.7 and ammonia levels at most sites was measured at 0.5 ppm or less, with the exception of LSR05, where ammonia was measured at 1.0 ppm.

Table 11. Stream discharge and water quality parameters measured at eight sites during fish and physical habitat sampling in the Little Sac River Priority Watershed.

Site	LSR01	LSR02	LSR03	LSR04	LSR05	LSR06	LSR07	LSR08	LSR09
Temperature (°C)	17	19	24	23	24	16	20	26	27
Dissolved oxygen (mg/L)	8	7	7	5	6	9	8	7	7
pH	8.1	7.8	8.7	8.5	8.6	8.8	8.7	8.4	8.5
Turbidity (NTU's)	<10	<10	<10	<10	<10	<10	<10	<10	<10
Ammonia (ppm)	<0.5	<0.5	0.5	<0.5	1.0	0.5	0.5	0.5	<0.5
Discharge (m^3/sec)	0.014	0.010	0.013	0.376	0.088	0.138	0.317	0.499	0.92

The mean wetted width for sampled sites ranged from 3.72 to 18.27 meters and average depths ranged from 0.21 to 0.60m (Table 12). The difference between mean bankfull height and incised height was moderate to substantial at all sites, indicating that stream channel incision or head-cutting has occurred throughout the watershed. Mean bank canopy density ranged from 75% to 99%. Mean mid-channel canopy density ranged from 24%-89%. Undercut banks, overhanging vegetation and brush/small woody debris were the dominant fish cover types among all sites; however two sites also had high densities of aquatic macrophytes. In general, coarse gravel was the dominant substrate type throughout the watershed, although LSR03 and LSR04 had a primarily bedrock stream bed while LSR05 had mostly cobble substrate. Mean substrate embeddedness ranged from 28% to 45%. The amount of large woody debris was moderate through the watershed, with the exception of LSR03, where in-channel and above-channel volumes of large woody debris reached 43.6 and 43.3 cubic meters, respectively. Correlation analysis of habitat values with RAM IBI scores and MO IBI scores revealed very few correlations ($r \geq 0.75$; Appendix H). Both RAM IBI scores and MO IBI scores were positively correlated with wetted width, bankfull width and depth. SCI scores calculated from macroinvertebrate collections were also positively correlated with bankfull width. There was also a strong positive correlation between crayfish densities and percent fine gravel. MO IBI scores and SCI scores were negatively correlated with percent coarse gravel.

Table 12. Summarized habitat data for nine sampling sites within the Little Sac River Priority Watershed. Values represent the mean value for that parameter at that site. Percent values for substrates represent the percent for that parameter of the entire sampling reach. Percent values for fish cover represent the percent of transects within the site where that cover type was observed. The volume of large woody debris is reported in cubic meters.

Site	LSR01	LSR02	LSR03	LSR04	LSR05	LSR06	LSR07	LSR08	LSR09
Stream order	2	2	2	3	4	2	4	4	4
RAM IBI Score	51	38	76	78	76	73	87	82	69
MO Biocriteria IBI Score	19	13	43	43	43	41	41	39	39
Macroinvert SCI score	12	8	20	18	20	18	18	18	20
Crayfish densities (#/m^2)	3.5	34.1	4.6	12.5	14.9	12.3	28.5	8.6	9.9
Bank Measurements									
Wetted width (m)	3.72	3.31	7.82	18.27	14.66	7.41	14.76	14.36	11.88
Bankfull width (m)	6.25	4.03	12.46	23.15	22.89	11.23	22.48	19.00	16.36
Bankfull height (m)	0.64	0.33	0.50	0.57	1.00	0.65	1.14	0.56	0.55
Incised height (m)	1.63	1.59	1.17	2.00	1.91	1.35	2.29	2.10	1.94
Bank angle (°)	43.0	26.0	42.0	41.0	22.0	46.0	44.0	27.0	35.0
Undercut distance (m)	0.00	0.00	0.70	0.75	0.00	1.00	0.50	0.00	0.00
Thalweg									
Depth (m)	0.27	0.21	0.32	0.48	0.59	0.45	0.60	0.48	0.50
Slope (%)	0.6	0.5	2.5	0.0	1.7	1.0	0.7	0.2	0.2
Large Woody Debris									
Large woody debris in channel (m3)	3.81	3.13	43.60	0.23	4.74	10.81	16.17	2.91	7.18
Large woody debris above channel (m3)	1.98	1.76	43.36	0.00	0.42	0.06	0.00	0.00	1.42
Canopy Cover									
% bank canopy cover	95	96	93	85	97	99	75	99	87
% mid-channel canopy cover	88	89	68	39	62	84	24	86	55

Table 12. continued

Fish Cover									
% Filamentous algae	0	0	18	1	0	0	27	0	0
% Aquatic macrophytes	0	0	100	7	55	0	100	1	73
% Large woody debris	0	1	36	1	36	1	27	27	18
% Brush/Small debris	73	73	91	18	36	73	73	36	45
% Overhanging vegetation	73	82	100	82	100	100	73	82	73
% Undercut banks	82	1	55	82	64	100	82	82	45
% Boulder	0	0	64	0	45	1	0	18	0
% Artificial structure	0	0	0	0	0	0	0	0	0
Channel Unit									
% Pool	43	43	62	74	36	61	79	58	52
% Glide	29	35	19	15	56	17	13	22	32
% Riffle	28	22	19	11	8	22	8	20	16
% Dry	0	0	0	0	0	0	0	0	0
Substrate									
% Fines	9	19	7	18	9	18	21	12	14
% Sand	0	0	0	1	0	0	0	0	0
% Fine gravel	11	21	11	10	10	17	20	10	16
% Coarse gravel	56	54	23	16	18	29	44	28	36
% Cobble	16	3	2	8	50	29	9	16	29
% Boulder	0	0	2	3	10	0	0	6	0
% Bedrock	3	0	55	43	3	5	0	26	1
% Hardpan	2	3	0	0	0	0	5	0	3
% Wood	4	0	0	1	1	3	0	2	0
% Embeddedness	45	28	37	33	30	29	44	40	34

Discussion

Surveys conducted during 2013 were successful in establishing baseline fish, crayfish, aquatic macroinvertebrate and habitat data for the Little Sac River Priority Watershed. In addition, a comprehensive characterization of current land use and human stressors was also achieved.

While RSD-IAD records from historical fish collections showed 63 fish species documented in the Little Sac River watershed in the past, only 42 fish species were observed during sampling in 2013. Many of the fish species historically observed in the watershed that were not observed in 2013, including the Inland Silversides (*Menidia beryllina*), crappie species (*Pomoxis spp*.), Gizzard Shad (*Dorosoma cepedianum*), and Longnose Gar *(Lepisosteus osseus*), could be considered more lentic or larger river species and were probably observed within the Little Sac Arm of Stockton Lake or in the lowest stretches of the Little Sac River that feed into these arms. A number of others species observed in historical samples were not collected by MDC staff in 2013. The most dominant species present throughout all sites were Central and Largescale Stonerollers and Orangethroat Darters, which are typically abundant species in Ozark streams. According to historical databases, Flathead Catfish and Redear Sunfish were observed for the first time in the watershed in 2013. In general, the observation of many of the historically documented species indicates fish sampling in 2013 was successful in describing the fish community in that drainage.

Fish IBI scores, both RAM IBI and MO Criteria IBI, indicated the majority of sites sampled in the Little Sac River watershed are not ecologically impaired. The two sites that were considered highly impaired (LSR01 and LSR02) were located on intermittent, 2nd order stream reaches. Because of the intermittent flow at on these reaches, the designation of these sites as highly impaired cannot imply that impairment is due to anthropogenic sources. Intermittent stream reaches will score low using IBI's due to their ephemeral nature and the resulting extirpation of fish communities from those areas during dry seasons. Using the Human Stressor Index (HSI) available from the MORAP GIS data, the Little Sac watershed received a relatively low stress index score (322), with high percent agriculture, number of stream crossings, and degree of hydrological alteration being the only high stress level factors. Fish IBI scores in the Little Sac basin may be used as ecological support for the HIS scores, as most sites within the watershed were designated as "not impaired". Based on MORAP location information of environmental stressors within the watershed, the highest concentration of potential stressors exists in headwater region along the southernmost boundary of the watershed, within the northern urban areas of Springfield.

Stream Condition Index scores calculated using aquatic macroinvertebrate data reinforce stream health designations produced by fish IBI data. Seven of the nine sites were designated as "fully biologically functioning" based on macroinvertebrate samples. The two sites receiving lower SCI scores, designating those reaches as "partially biologically functioning" or "non-biologically functioning", were located at LSR01 and LSR02. Again, these sites are located on intermittent stream reaches, which are naturally expected to score low on aquatic macroinvertebrate indices given that the stream reaches are devoid of most, if not all, aquatic habitats during periods of low precipitation runoff.

Data collected during 2013 can be used to provide direction in the Little Sac River Priority Watershed as efforts progress. The Little Sac River watershed was designated as a priority geography for Southwest Regional Fisheries staff because of its value as a sport fishery, direct influence on the Stockton Lake recreational area, its role as a major drinking water source for the City of Springfield and the existing network of conservation partners. By all biotic measures in this sample, data suggests the main goal in the Little Sac watershed should be protection of a high quality resource. The few high stress level factors that do exist in the watershed as calculated by the Human Stress Index, including agricultural practices and the number of stream crossings in the drainage, should be addressed by engaging conservation partners and other stakeholders in the watershed to promote best management practices on agricultural land and working with county road districts to install crossings that facilitate fish passage when bridges come up for replacement.

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Appendix A.

DESCRIPTION OF THE OSAGE EDU

The Osage EDU (Figure 1) lies in south-central Missouri and encompasses the lower portion of the Osage River watershed, which falls within the Ozark Highlands as defined by Bailey (1995). Overall there are 16,553 km of primary stream channel within this EDU, of which 4,794 km are classified as perennial in the 1:100,000 National Hydrography Dataset. The Osage River, for which this EDU is named, is the third largest river in Missouri and is a tributary to the Missouri River. Other major streams within this EDU include the Sac, Pomme de Terre, and Niangua Rivers.

The landscape of this EDU is nearly equally divided among three ecological subsections; the Central Plateau, Osage River Hills, and Springfield Plain. The average gradient across all stream size classes is 11.9 m/km. Average gradients (m/km) by size class are: headwater 15.7, creek, 3.6, small river 1.0, and large river 0.3. For sake of brevity and ease of comparative understanding it is best to describe the geographic variation in landscape and stream conditions in terms of these broader ecoregions.

The southern and eastern portions of the Osage EDU fall within the Central Plateau Ecological Subsection. The Central Plateau Subsection consists of some of the least dissected portions of the Ozark Highlands. It is dominated by a thick carobnate geology consisting mainly of cherty dolomites and some prominent sandstones, all of Ordovician age. Soil surface textures are mainly cherty loams or silt loams with moderate to slow infiltration rates. Fragipans are widespread in the subsoil. Relief in this portion of the EDU is generally 50-150 feet. Floodplains tend to be narrow and not extensive, with very gravelly soils. This area is minimally dissected and many of the streams are either ephemeral or intermittent. Stream gradients are lower, substrates smaller, and waters are warmer and more turbid than those found in the Osage River Hill subsection. Only a few small springs are found in this low relief landscape. This area was historically covered in a diverse mosaic of prairie, savanna, and open oak woodlands. Today it is largely covered in pasture and second growth timber. Some of the principle management concerns include fragmentation and inundation by Lake of the Ozarks and Pomme de Terre reservoir, overgrazing, fragmentation of riparian forest cover, gravel mines, and runoff from CAFOs and abandoned lead mines.

The northern portion of the EDU falls within the Osage River Hills Ecological Subsection. This subsection is composed of hilly to rugged lands bordering the Osage River and the lower mainstems of the principle tributaries. Cherty dolomites and sandstones of the Gasconade and Roubidoux formations underlie the area. Karst features are very prevalent in those areas underlain by dolomite. Springs, some quite large, are abundant here resulting in coldwater fisheries in some streams like the Niangua River. Relief is quite high (200-350 feet), with some areas over 350 feet. Soils are moderately thick and mainly coarse to very coarse loams and silty loams with moderate infiltration rates. Smaller streams have relatively high gradients and carry large bedloads of cobble, gravel, and sand, which result in extensive gravel and sand bars. Riffles are well developed and waters are generally very clear and often cool. Historically this region was covered in a mosaic of tallgrass prairie, glades, oak savanna, oak woodlands, and oak forests. Most of the prairie and open woodlands have been converted to pasture, however, a high percentage of the glade, woodland, and forest remains within the steepest lands. Some of the principle management concerns include fragmentation and inundation by Lake of the Ozarks and Truman Reservoir, intense recreational use, gravel mining, and runoff from abandoned lead mines.

The southwestern portion of the EDU falls within the Springfield Plain. This ecological subsection is mainly underlain by very cherty Mississippian limestones, with some smaller inclusions of more resistant Pennsylvanian sandstone and shale deposits, which tend to form ridges that rise above a generally flat plain. The high percentage of limestone results in high groundwater contributions to streams within this AES-Type, and springs and other karst features (sinkhole ponds/caves) are quite abundant. Local relief is generally 100 to 200 feet. The moderately deep soils formed from the

weathering of the underlying cherty limestones, are loams/silt-loams of medium to fine textured, have slow to moderate infiltration rates and often are covered with thin layer of loess. Streams have an Ozark-Border character, with moderate gradients and spring influence. Waters are fairly clear and substrates mainly chert gravel and cobble, with well-defined riffles, although some streams still have relatively high percentages of fine materials, mainly sand. Gravel and sand bars are quite prevalent. Historically this are represented a transition zone between the prairies to the west and the forests to the east. Prairies graded into extensive oak savannas and into oak woodlands and oak forests in the most dissected areas. Glades, sinkhole ponds, and depressional wetlands were scattered throughout this area. Today this subsection is dominated by fescue pasture and small isolated woodlots of invasive trees and shrubs. Some of the principle management concerns include fragmentation and inundation by Stockton Lake and Truman Reservoir, overgrazing, fragmentation of riparian forest cover, urbanization, and runoff from CAFOs and abandoned lead mines.

A total of eight different Aquatic Ecological System Types (Figure 1) were delineated within the Osage EDU in order to account for the more detailed, but equally important, differences in watershed, stream conditions and aquatic fauna that exist within this EDU. The AES Types are described in Appendix 1.

There are 116 fish, 46 mussel and 6 crayfish species that either inhabit, or at one time inhabited, the Osage EDU. According to the Missouri Natural Heritage database there are 17 globally listed (rare, threatened, or endangered) species and 32 state listed species. The Osage EDU contains a unique combination of species that are characteristic of of neighboring EDUs in the Ozarks and Central Plains. Distinctive fish species include the bluestripe darter, Niangua darter, and Ozark cavefish. Common or distinctive mussel species include the giant floater, fatmucket, northern brokenray, Ouachita kidneyshell, Ozark pigtoe, pondmussel, and western fanshell. Common or distinctive crayfish include the bristly cave, devil, golden, and virile crayfish. Of the 168 fish, mussel and crayfish species present in the EDU, 89 are considered target species (61 fish, 25 mussels and 3 crayfish) (Table 1).

Appendix B.

AES-Type 24 (Finley Creek)

Geographic location:

Restricted to the Ozark Aquatic Subregion.

Ozark/ Osage EDU

Ozark/ White EDU

Ozark/ Neosho EDU

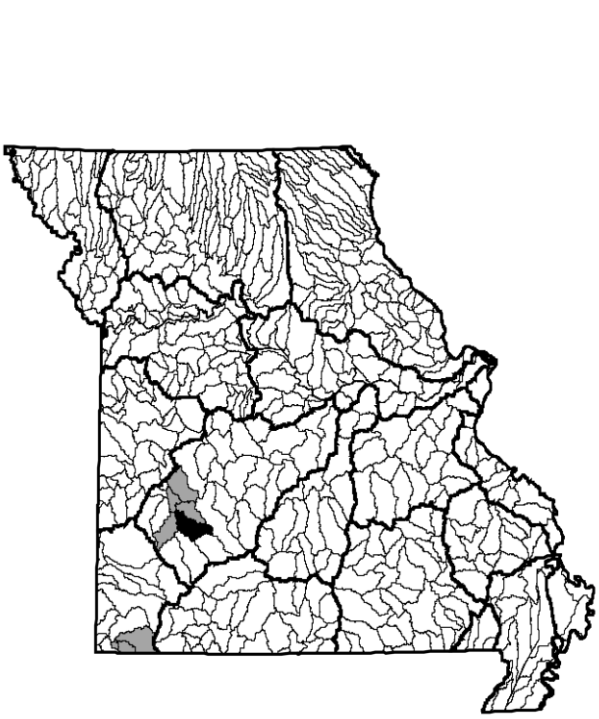
Description:

This AES-Type is located in the Ozarks of southwest Missouri. Local relief ranges from nearly zero to slightly over 200 feet. The geology here consists of Mississippian period cherty limestones with significant karst features including sinkholes, caves and springs. Some of the highest densities of sinkholes in the state of Missouri can be found within this AES-Type. Minor amounts of dolomite and sandstone are also present. The deep soils were formed in weathered cherty limestone and often have loess as the surface material. Surface soil textures consist of cherty and silt loam soils with moderate to slow infiltration rates. Stream discharge is highest at the end of winter and early spring and subsequently diminishes throughout summer and into fall. Heavy rain events can produce flash flooding. Streams carry bed loads consisting of sand and chert gravel, but carry very little suspended sediment. Some of the highest densities of losing streams in the state are found in this Type, especially in the James River and Indian Creek drainages. Springs are common and can be quite large contributing significantly to stream base flows. Groundwater is abundant and of good quality. Coldwater is an important ecological feature of this Type. There are 489 headwater/creek springs and one main stem spring scattered throughout the 14 individual units comprising this Type. This AES-Type contains one spring over 10 cfs. The median spring count is 29.5. The combined headwater and creek mean stream gradient is 13.3 meters per kilometer. The historic vegetation consisted primarily of prairie, but timber was located along the stream valleys.

Typical unit: 464 – Finley Creek

Appendix C

AES-Type 23 (Middle Upper Little Sac)



Geographic location:

Restricted to the Ozark Aquatic Subregion.

Ozark/ Osage EDU

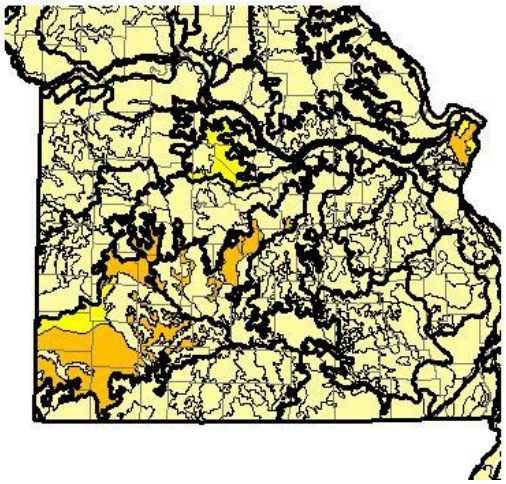
Ozark/ Neosho EDU

Description:

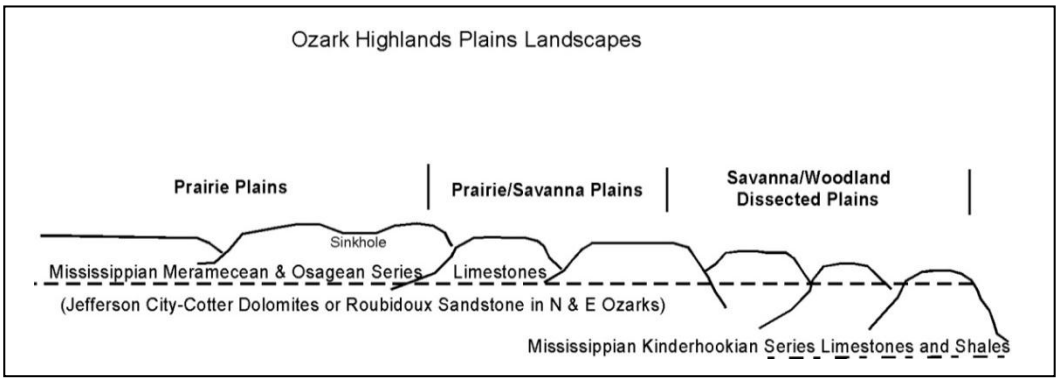
This AES-Type is located within the Ozarks in southwest Missouri. Local relief is variable, but typically ranges from 50 to over 200 feet. This area consists of Mississippian cherty limestone geologic formations with some karst features. Some of the deeper stream valleys cut down into the Ordovician Jefferson City – Cotter Formation. Soils in this AES-Type were formed in weathered cherty limestone and are deep. Surface soil texture consists of cherty soils and silt loams with moderate to slow infiltration rates. Streams have narrow floodplains and carry bedloads of gravel and sand that form bars. Stream flows are highest at the end of winter and into spring and diminish the rest of the year. Flash floods can occur after large rain events. Springs are common and can be quite large contributing greatly to stream base flows. Groundwater is relatively abundant and of good quality. There are 43 headwater/creek springs with no main stem springs scattered throughout the eight individual units comprising this AES-Type. The median spring count is 3.5. The combined headwater and creek mean stream gradient is relatively high at 12.9 meters per kilometer. Historically the vegetation within this AES-Type consisted of prairie on the flatter portions with oak savanna and woodlands on the more rugged sections.

Typical unit: 412 – Middle Upper Little Sac River

Z9 OZARK PRAIRIE PLAINS (yellow) & Z10 PRAIRIE/SAVANNA DISSECTED PLAINS (orange) LTAS



CHARACTERISTICS: High, flat to gently rolling landscapes with less than 100 feet of local relief. These landscapes occur mainly in the western Ozarks where prairie was more prevalent, but also in the vicinity of St. Louis. They are often associated with karst areas. Historically, prairie dominated the highest, flattest areas and graded into post oak barrens and savanna. Intermittent headwater streams, as well as sinkhole basins were prevalent. Today, these landscapes are largely fescue pasture with small, isolated woodlots, except where urban development dominates. Substantial opportunity for grassland and savanna management exists.

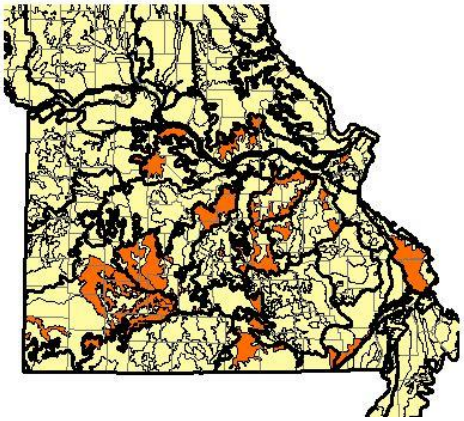


MANAGEMENT ISSUES AND OPPORTUNITIES:

- These landscapes encompass over 3 million acres. Conservation lands make up 18,000 acres (less than 1% of the area). Consequently, private land programs may dominate land conservation efforts. Prominent conservation lands include Bois d' Arc, Talbot, Diamond Grove, Sloan, and Rinquelin Conservation Areas (MDC), Mount Vernon Prairie Natural Area (TNC), and Woods Prairie (Ozark Regional Land Trust).
- While some of the largest patches of grassland in the Ozarks occur on these LTAs, they are mainly fescue pasture with limited diversity.
- Very few prairie or savanna communities remain, making these ecosystems among the most endangered in the Ozarks. Management using prescribed fire in these landscapes has illustrated the resiliency of prairie and savanna systems.
- 582 Heritage records, most records are for upland prairie species. There are also many records for headwater stream and small river species, including federally listed Neosho Madtom, Topeka Shiner and Arkansas Darter. Other important habitats include glades (with geocarpon), and caves (with Ozark cavefish, Indiana and gray bats).
- Land use in sinkhole plains and headwater streams, especially intensive livestock grazing and riparian clearing, may impact water quality here and downstream.
- Grassland management can potentially supply native forage.
- Access to roads and towns offers opportunities for interpretation, picnic grounds and short trails.

Z5 OZARK

OAK SAVANNA/WOODLAND DISSECTED PLAINS LTAs



CHARACTERISTICS: High, flat to moderately rolling landscapes most often on drainage divides throughout the Ozarks. Also includes the relatively shallow valleys and Low Hills LTAs in the more droughty western Ozarks. These landscapes occur mainly on somewhat shallow, droughty soils, with frequent fragipans. Historically, post oak and post oak-black oak savannas and woodlands with scattered prairie openings dominated. Frequently, these landscapes include karst areas with numerous sinkholes. Streams are often intermittent in shallow valleys with gravel bed channels. Today, a mosaic of fescue pasture, scattered trees and dense second growth oak woodlots exists with abrupt transitions. Many roads

MANAGEMENT ISSUES AND OPPORTUNITIES:

- These landscapes encompass over 4 million acres. Conservation lands make up 120,000 acres (3% of the area). Consequently, substantial conservation efforts may rely on private lands. Prominent conservation lands include Whetstone, White River Trace, Reform and Fort Crowder Conservation Areas (MDC), Bennett Springs and Stockton State Parks (DNR), Stockton Reservoir (COE), Mark Twain National Forest (USFS), and Bennett Springs Savanna (TNC).
- Though mosaics of grass, scattered trees and dense woodlands are common, they are often degraded by heavy grazing and the absence of fire. Wildfire is a problem in some areas.
- Very few prairie, savanna or woodland communities remain. “Ozark Barrens” are among the most endangered ecosystems in the Ozarks.
- Prescribed fire has illustrated the resiliency of the oak savanna and woodland systems.
- 575 Heritage records (including 160 species and 39 community types), many for headwater stream and small river species, plus the federally listed Missouri bladderpod, geocarpon, Niangua darter and Ozark cavefish.
- Other important habitats include prairie, woodland, sinkhole ponds, glades, caves, and globally unique chert glades.
- LTAs form critical corridors between major drainages.
- Land use in sinkhole plains and headwater streams may impact water quality and habitat downstream.
- Grassland, savanna and woodland management can potentially supply native forage and short log timber products.
- Roads and towns offer opportunities for interpretation, picnic grounds and short trails.

Appendix F

The calculation of Stream Condition Index.

Determining Stream Condition Index for Missouri macroinvertebrates

- 4 metrics
  - Total taxa
  - EPT taxa
  - Biotic index
  - Shannon diversity

  Each metric receives a score of 1, 3, or 5 to produce a score between 4 and 20

- 16-20 = Fully Biologically Supporting
- 10-14 = Partially Biologically Supporting
- 4-8 = Non Biologically Supporting

Appendix G

Macroinvertebrate taxa collected from sites in the Little Sac River Priority Watershed in 2013.

Taxa	LSR01	LSR02	LSR03	LSR04	LSR05	LSR06	LSR07	LSR08	LSR09
Ablabesmyia	X	-	X	X	X	-	X	X	X
Acerpenna	-	-	X	X	X	X	X	X	X
Acroneuria	-	-	X	X	X	X	X	X	X
Anopheles	X	X	X	-	-	X	X	X	X
Anthopotamus	-	-	-	X	X	-	X	-	-
Aquarius	X	-	X	-	-	-	-	-	-
Argia	X	X	X	X	X	X	X	X	X
Axarus	-	-	-	-	-	-	-	-	X
Baetidae	X	-	X	X	X	X	X	X	X
Baetis	X	-	X	X	X	X	X	X	X
Basiaeschna janata	X	-	-	-	-	-	-	-	-
Berosus	-	-	-	X	X	-	-	-	X
Boyeria	-	X	X	-	-	X	-	-	-
Branchiobdellida	-	-	-	-	-	X	-	X	-
Branchiura sowerbyi	-	-	-	X	-	-	-	X	X
Caecidotea (hypogean)	-	-	X	-	-	-	-	-	-
Caenis	X	-	X	X	-	-	-	X	-
Caenis anceps	-	-	-	X	-	X	X	X	X
Caenis latipennis	-	-	X	X	X	X	X	X	X
Calopterygidae	-	-	-	-	-	X	-	-	X
Calopteryx	X	X	X	-	-	X	-	-	-
Cardiocladius	-	-	X	-	X	-	-	-	-
Centroptilum	X	-	-	X	X	-	X	-	-
Ceratopogoninae	X	-	-	X	X	X	X	X	X
Ceratopsyche	-	-	X	-	-	-	-	-	-
Chaoborus	X	-	-	-	-	-	-	X	-
Cheumatopsyche	-	-	X	X	X	X	X	X	X
Chimarra	X	-	X	X	X	X	X	X	X
Chironomidae	-	-	-	-	-	-	X	-	-
Chironominae	-	-	-	-	-	X	-	-	-
Chironomus	X	X	X	X	-	-	X	X	X
Choroterpes	X	X	X	X	X	X	X	X	X
Chrysops	-	-	-	-	-	-	X	-	-
Cladotanytarsus	-	-	-	X	-	-	-	-	-
Corbicula	-	-	-	X	X	-	X	-	X
Corixidae	-	-	X	-	-	-	-	-	-
Corydalus	X	-	-	X	-	-	X	X	X
Corynoneura	-	-	-	-	X	X	-	-	-

Crangonyx	-	X	X	-	-	-	-	-	-
Cricotopus/Orthocladius	-	-	X	X	X	-	-	-	X
Cryptochironomus	X	-	X	X	X	-	X	X	X
Cryptotendipes	-	-	-	-	X	-	X	-	X
Dicrotendipes	X	X	X	X	X	X	X	X	X
Dubiraphia	-	X	X	X	X	X	X	X	X
Ectopria	-	-	X	X	X	X	X	-	-
Empididae	-	X	-	-	-	-	-	-	-
Enallagma	X	X	X	X	X	X	X	X	X
Ephemera	-	-	-	X	X	-	-	-	X
Erpobdellidae	X	-	X	X	X	X	X	-	X
Fallceon	X	-	X	-	-	X	X	-	X
Ferrissia	-	-	X	X	X	X	-	-	X
Forcipomyiinae	X	-	X	X	X	-	-	X	X
Gammarus	-	-	-	X	X	X	-	-	-
Gerris	X	-	-	-	-	-	-	X	-
Glyptotendipes	X	X	-	-	-	-	X	X	X
Gomphidae	-	-	-	-	-	-	X	-	X
Gomphus	-	-	-	X	-	-	-	-	-
Hagenius brevistylus	-	-	-	X	X	-	X	-	-
Helichus fastigiatus	-	-	-	-	-	X	-	-	-
Helichus lithophilus	-	-	-	X	-	-	-	-	-
Helicopsyche	-	-	X	-	-	-	-	X	-
Helisoma	-	-	-	X	-	-	X	-	-
Hemerodromia	-	-	X	X	X	X	-	X	X
Heptagenia	-	-	X	-	-	-	-	X	X
Heptageniidae	X	-	X	X	X	X	X	X	X
Hetaerina	-	-	-	-	X	-	-	-	-
Heterosternuta	-	-	X	-	-	-	-	-	-
Hexagenia	-	-	-	-	X	X	X	-	X
Hexagenia limbata	-	-	-	X	-	-	X	-	-
Hexatoma	-	-	-	X	-	X	X	X	X
Hyalella azteca	-	X	X	X	X	X	X	X	X
Hydracarina	X	X	X	X	X	X	X	X	X
Hydrobiidae	-	-	-	-	X	-	-	-	-
Hydrophilidae	X	-	-	-	-	-	-	-	-
Hydroporus	X	-	-	-	-	-	-	-	-
Hydropsyche	-	-	X	-	X	-	-	-	-
Hydropsychidae	-	-	X	X	X	X	X	X	X
Hydroptila	-	-	X	-	-	-	-	-	X
Hydroptilidae	-	-	X	-	X	-	-	-	-

Ishnura	X	-	-	-	-	-	-	-	-
Isonychia	-	-	X	X	X	X	X	X	X
Isonychia bicolor	-	-	-	-	X	X	-	-	X
Kiefferulus	X	-	-	-	-	-	-	-	-
Labrundinia	X	-	-	X	-	-	X	X	-
Laccophilus	-	-	X	-	-	-	-	-	-
Leptoceridae	-	-	X	-	-	-	-	X	-
Leucrocuta	-	-	-	X	X	X	X	X	X
Leuctra	-	-	-	-	-	X	X	-	-
Limnephilidae	-	-	X	-	-	-	-	-	-
Limnodrilus hoffmeisteri	X	X	X	X	X	X	X	X	X
Limonia	X	-	-	-	-	-	-	-	-
Lirceus	-	-	-	-	-	-	X	-	-
Lumbricina	X	-	-	-	X	-	X	X	X
Lumbriculidae	-	X	-	X	-	X	-	X	-
Lutrochus	-	-	-	X	X	-	-	-	-
Lymnaea (Fossaria)	-	-	-	-	X	-	-	-	-
Lype diversa	-	-	X	-	X	-	-	-	-
Macronychus glabratus	-	-	-	-	X	-	-	-	-
Menetus	X	X	X	X	X	-	X	X	-
Mesovelia	-	-	-	-	X	-	-	-	-
Microcylloepus	-	-	X	-	X	-	-	-	X
Micropsectra	X	X	-	-	-	X	-	-	-
Microtendipes	X	X	X	X	X	X	-	X	-
Microvelia	X	-	X	-	-	X	-	-	-
Muscidae	-	-	-	-	-	-	-	X	X
Nanocladius	X	-	-	-	-	-	-	-	-
Natarsia	-	-	-	-	-	X	-	X	-
Neoplea	-	-	-	-	-	-	-	-	X
Neoporus	-	X	X	-	-	X	X	X	X
Neurocordulia	-	-	-	-	-	-	-	X	-
Nigronia serricornis	-	-	-	-	-	X	X	-	-
Nilotanypus	X	X	X	-	-	-	X	X	-
Nyctiophylax	-	X	-	-	-	-	-	-	-
Oecetis	-	-	-	-	X	-	-	-	-
Orconectes	X	-	X	X	X	X	X	X	X
Orconectes neglectus	-	-	X	X	X	-	-	-	X
Orthocladiinae	-	-	-	-	-	-	-	X	-
Paracymus	-	-	X	-	-	-	-	-	-
Paraleptophlebia	X	X	X	X	X	X	X	X	-
Paramerina	X	-	-	-	-	-	-	-	-
Parametriocnemus	X	-	X	-	-	X	X	-	-

Paratanytarsus	-	X	-	-	X	X	X	X	X
Paratendipes	X	X	X	X	X	-	-	X	X
Peltodytes	-	-	X	-	-	-	-	-	X
Pentaneura	-	-	X	-	-	-	-	X	X
Perlidae	-	-	-	X	-	X	X	-	X
Physa	-	-	X	-	-	X	-	X	X
Planariidae	X	X	X	X	X	-	X	-	X
Polycentropus	X	-	-	-	-	-	-	-	-
Polypedilum aviceps	X	-	X	X	-	X	X	-	-
Polypedilum convictum group	X	-	X	X	X	X	X	X	X
Polypedilum fallax group	-	-	-	X	-	-	-	X	-
Polypedilum illinoense group	X	X	X	X	X	X	X	X	X
Polypedilum scalaenum group	X	-	-	X	X	-	-	X	X
Procladius	-	-	-	-	X	X	X	X	X
Procloeon	-	-	-	X	-	X	-	X	X
Psephenus	-	-	-	X	X	-	X	X	X
Pseudochironomus	-	-	-	-	-	-	-	-	X
Pseudocloeon	X	-	-	-	-	-	-	-	-
Pycnopsyche	-	X	-	-	-	-	-	-	-
Rhagovelia	X	-	-	-	X	X	-	-	-
Rheocricotopus	-	-	X	-	-	X	-	-	X
Rheotanytarsus	X	X	X	X	X	X	X	X	X
Rheumatobates	-	-	-	-	-	-	-	-	X
Scirtidae	X	X	-	X	-	-	X	X	X
Sialis	X	X	-	-	-	X	X	-	-
Silvius	-	-	-	X	-	-	-	X	X
Simulium	X	-	X	X	X	X	X	X	X
Somatochlora	-	X	-	-	-	-	-	-	-
Sphaeriidae	X	X	-	-	X	X	X	-	X
Stempellina	-	-	-	-	-	X	-	-	-
Stempellinella	-	-	X	X	X	X	-	X	-
Stenacron	X	X	X	-	X	X	X	X	-
Stenelmis	X	X	X	X	X	X	X	X	X
Stenochironomus	X	-	-	-	X	-	-	-	X
Stenonema	-	X	X	X	X	X	X	X	X
Stenonema femoratum	X	X	X	X	X	X	X	X	X
Stenonema mediopunctatum	-	-	-	X	X	-	X	-	-
Stenonema terminatum	-	-	-	-	X	X	-	-	-
Stictochironomus	-	X	X	X	-	X	X	-	-
Stylogomphus albistylus	X	-	-	-	-	X	X	-	X
Tanypodinae	-	-	X	X	X	-	-	X	-

Tanypus	-	-	-	-	-	-	X	-	-
Tanytarsus	X	X	X	X	X	X	X	X	X
Thienemanniella	-	-	X	X	X	X	-	-	-
Thienemannimyia group	X	-	X	X	X	X	X	X	X
Tipula	-	-	X	-	-	X	-	-	-
Trepobates	-	-	-	X	-	-	-	-	-
Triaenodes	-	X	X	X	X	X	X	X	X
Tricorythodes	-	-	-	X	X	-	X	X	X
Tubificidae	X	X	X	X	X	X	X	X	X
Tvetenia bavarica group	-	-	X	-	-	X	-	X	-
Zavrelimyia	X	X	-	-	-	X	-	-	-

Appendix H

Correlation coefficients for habitat variables and biotic stream condition indices (RAM/MO IBI and SCI).

Habitat Value	RAM IBI	MO IBI	SCI
Stream order	0.606314364	0.506259271	0.492658952
Wetted width (m)	0.806310957	0.759801353	0.688803441
Bankfull width (m)	0.856476468	0.807587533	0.763209018
Bankfull height (m)	0.578806190	0.447566779	0.498226707
Incised height (m)	0.411858868	0.208560329	0.134633491
Bank angle (°)	0.210392614	0.190731787	0.162499775
Undercut distance (m)	0.423699560	0.501902924	0.470845448
Depth (m)	0.828606075	0.785571205	0.746596490
Slope (%)	0.140939680	0.273409184	0.429247235
Large woody debris in channel (m3)	0.270778281	0.328225075	0.402949969
Large woody debris above channel (m3)	0.093831402	0.195681991	0.287920932
% bank canopy cover	-0.383101701	-0.267920127	-0.167726061
% mid-channel canopy cover	-0.611279682	-0.564382705	-0.476563901
% Filamentous algae	0.453403234	0.308209012	0.332910857
% Aquatic macrophytes	0.470334650	0.486444899	0.522491812
% Large woody debris	0.596957083	0.568620759	0.656865189
% Brush/Small debris	-0.318446026	-0.343896264	-0.270178964
% Overhanging vegetation	0.199011962	0.399334995	0.514344500
% Undercut banks	0.652142494	0.551297920	0.617534781
% Boulder	0.289642009	0.395755462	0.550770882
% Artificial structure	0.000000000	0.000000000	0.000000000
% Pool	0.638815564	0.520481897	0.421344523
% Glide	-0.352528402	-0.225375920	-0.153371432
% Riffle	-0.645774517	-0.646937529	-0.579256849
% Dry	0.000000000	0.000000000	0.000000000
% Fines	0.003122494	-0.078972141	-0.261975348
% Sand	0.191467694	0.259480103	0.142857143
% Fine gravel	-0.317161044	-0.359749288	-0.486724799
% Coarse gravel	-0.692136967	-0.845920222	-0.836233486
% Cobble	0.194363984	0.324020847	0.372727909
% Boulder	0.379086693	0.404672324	0.510308422
% Bedrock	0.364518171	0.422454141	0.464970742
% Hardpan	-0.220870136	-0.220870136	0.703330187
% Wood	-0.156178040	-0.217928626	-0.122976053
% Embeddedness	0.246381211	-0.026590040	0.064792188

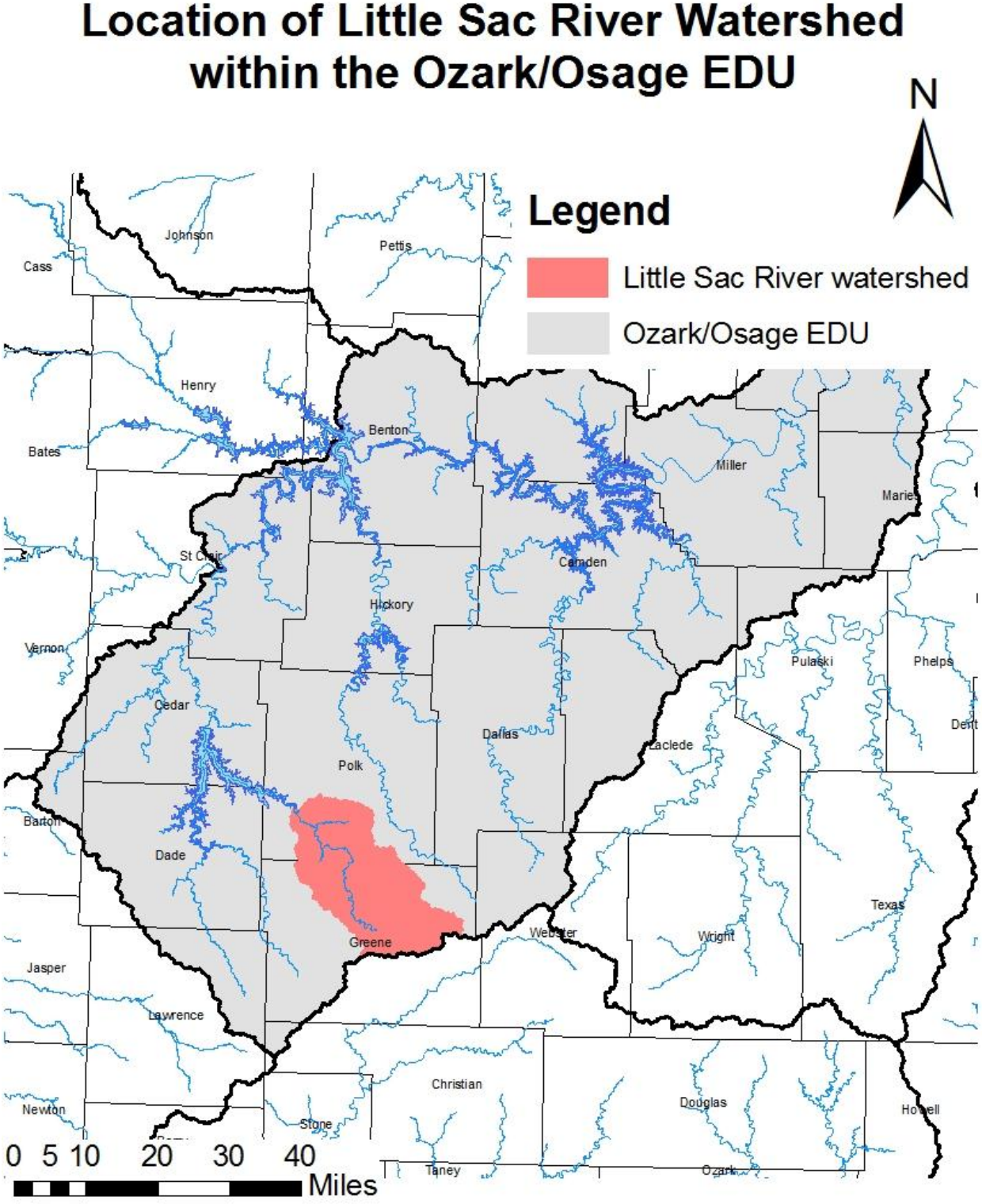

Location of Little Sac River Watershed within the Ozark/Osage EDU
N
Legend
Little Sac River watershed
Ozark/Osage EDU
Johnson
Pettis
Cass
Henry
Benton
Bates
Miller
Maries
St Clair
Camden
Hickory
Vernon
Pulaski
Phelps
Cedar
Dallas
Laclede
Polk
Barton
Dade
Texas
Greene
Webster
Wright
Jasper
Lawrence
Christian
Douglas
Newton
Stone
Howell
Taney
Ozark
0 5 10 20 30 40
Miles

Figure 1.

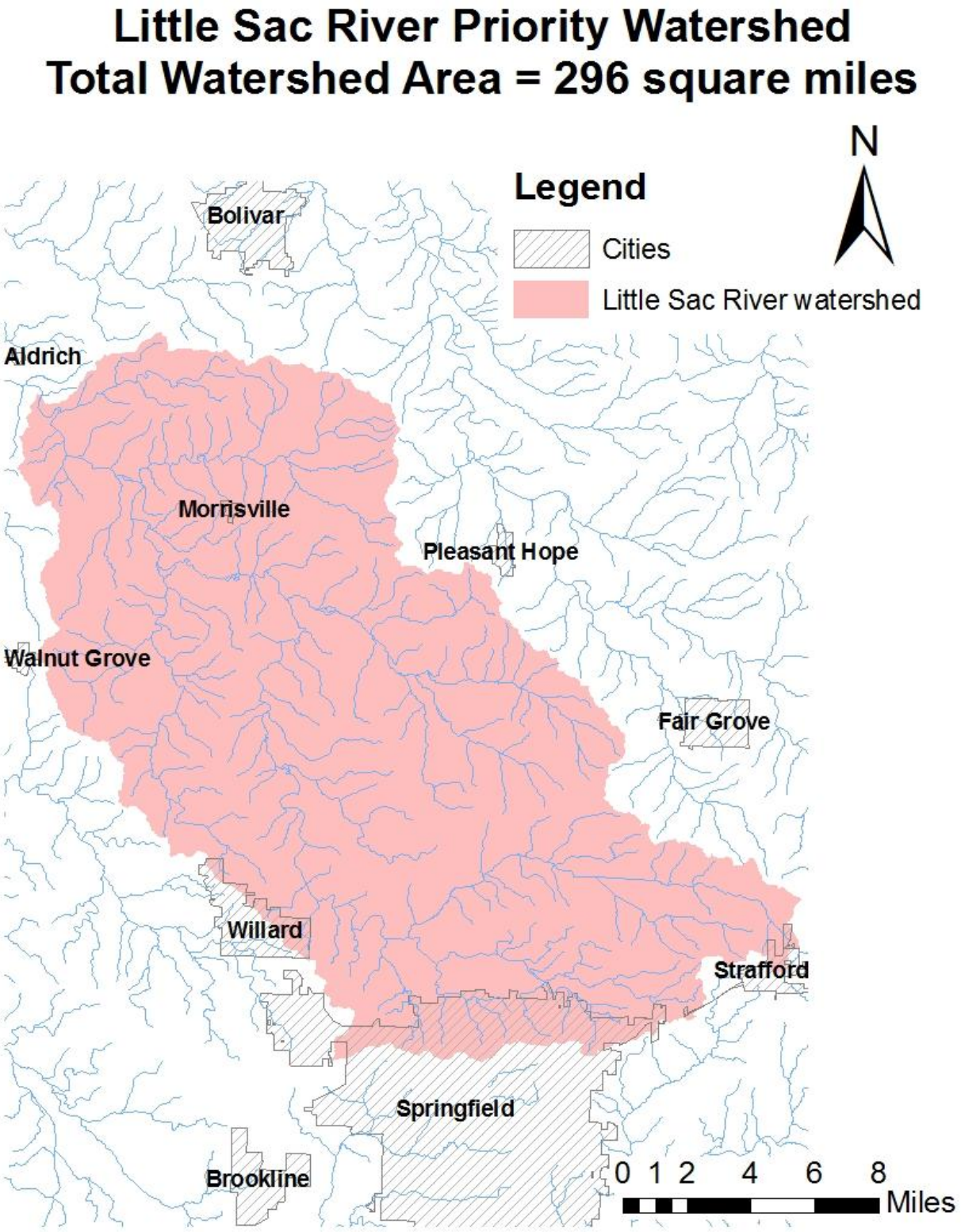

Little Sac River Priority Watershed
Total Watershed Area = 296 square miles
N
Legend
Cities
Little Sac River watershed
Bolivar
Aldrich
Morrisville
Pleasant Hope
Walnut Grove
Fair Grove
Willard
Strafford
Springfield
Brookline
0 1 2 4 6 8
Miles

Figure 2.

Little Sac River Priority Watershed Landcover

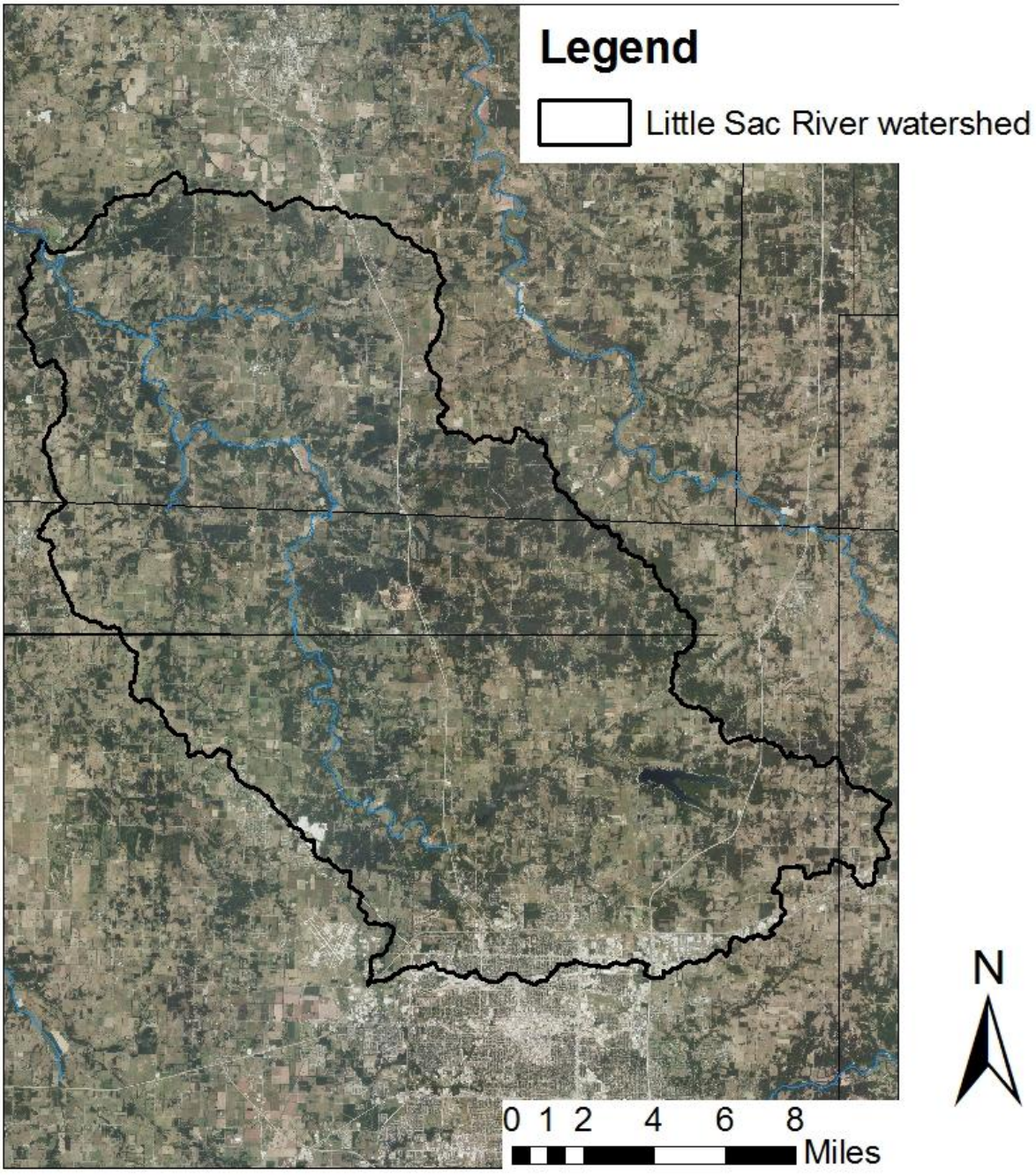


Figure 3.

Little Sac River Priority Watershed
2013 Sample Sites and Stream Order

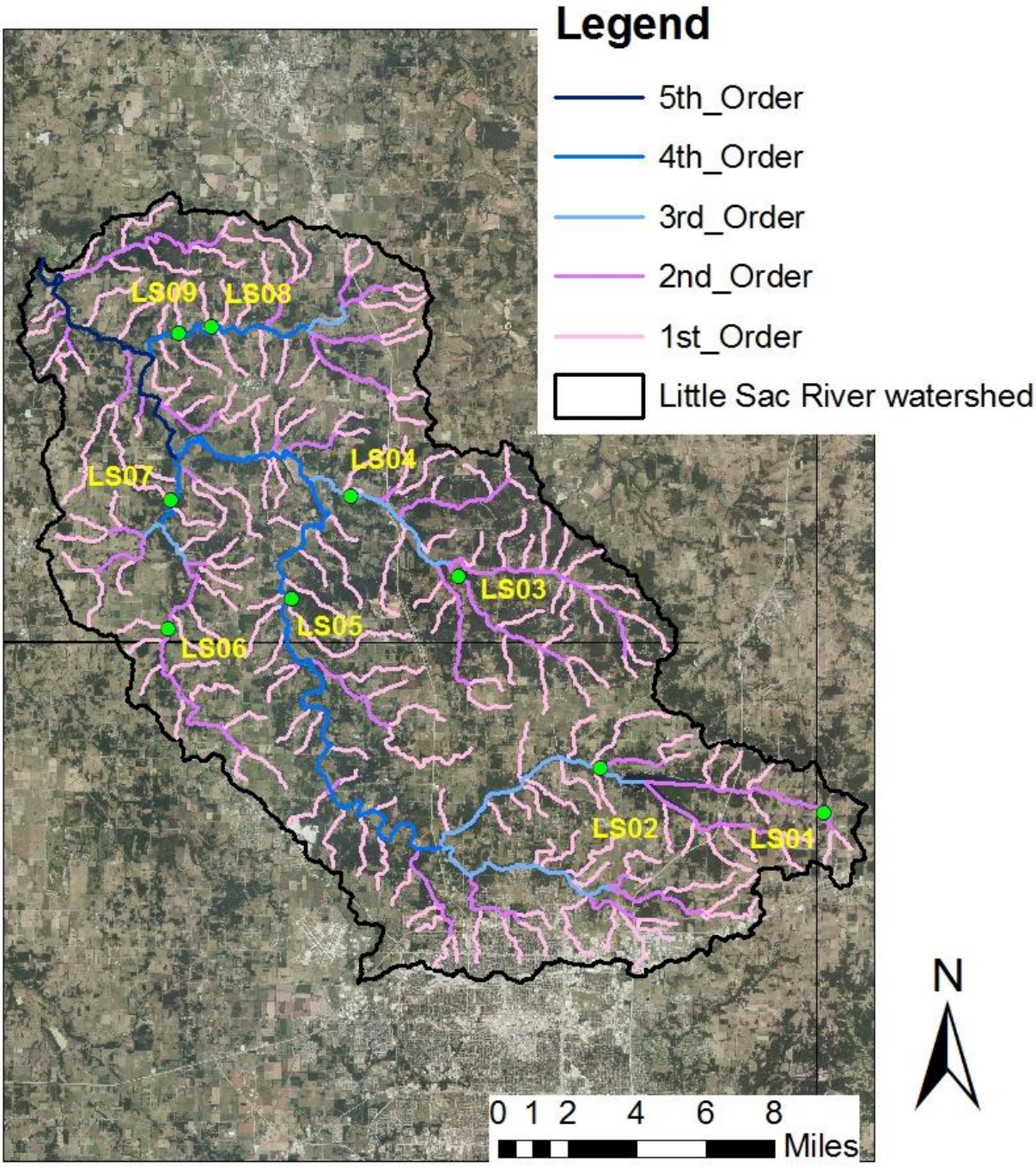


Figure 4.

Little Sac River Priority Watershed
Perennial and Intermittent Stream Segments

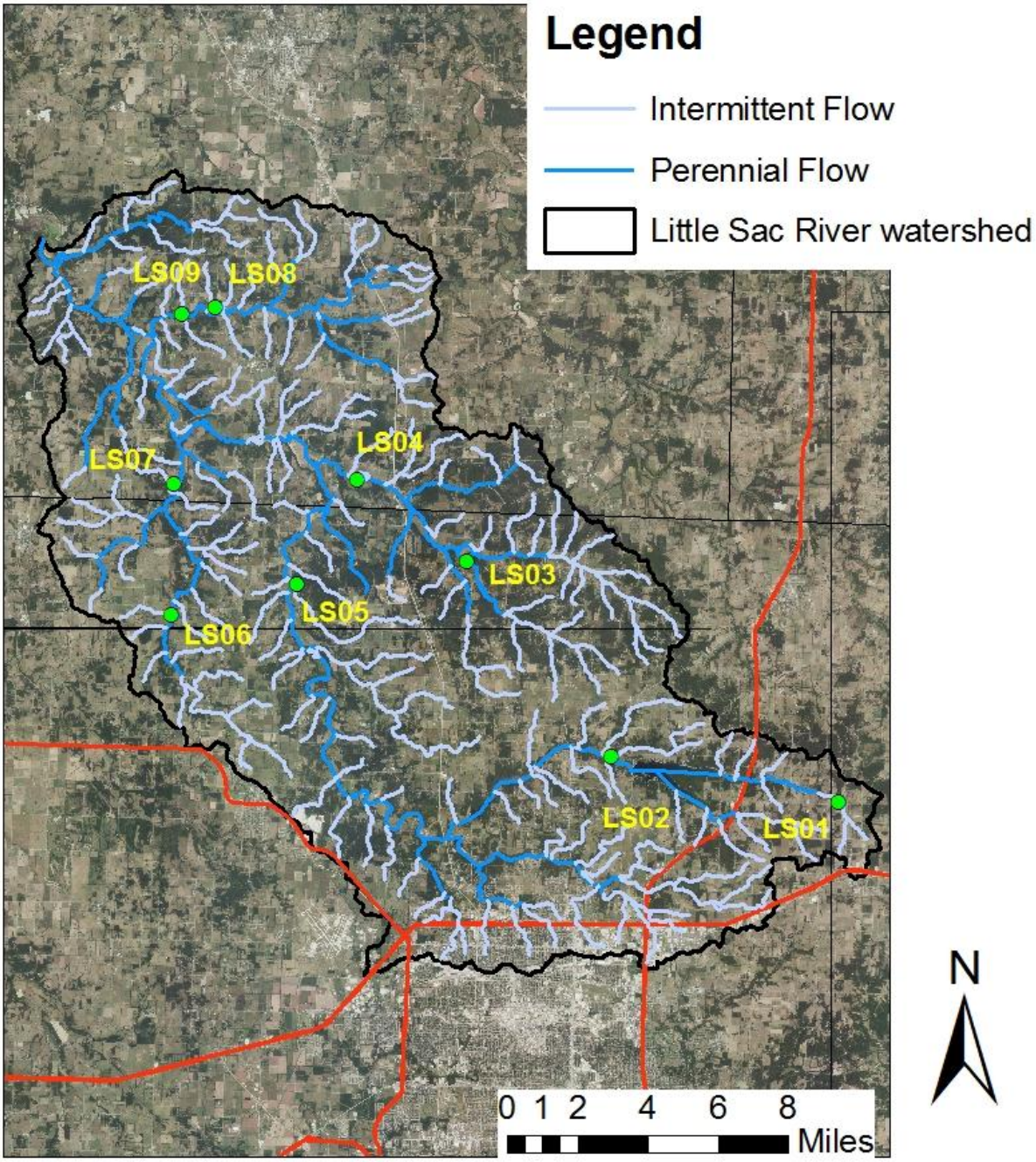


Figure 5.

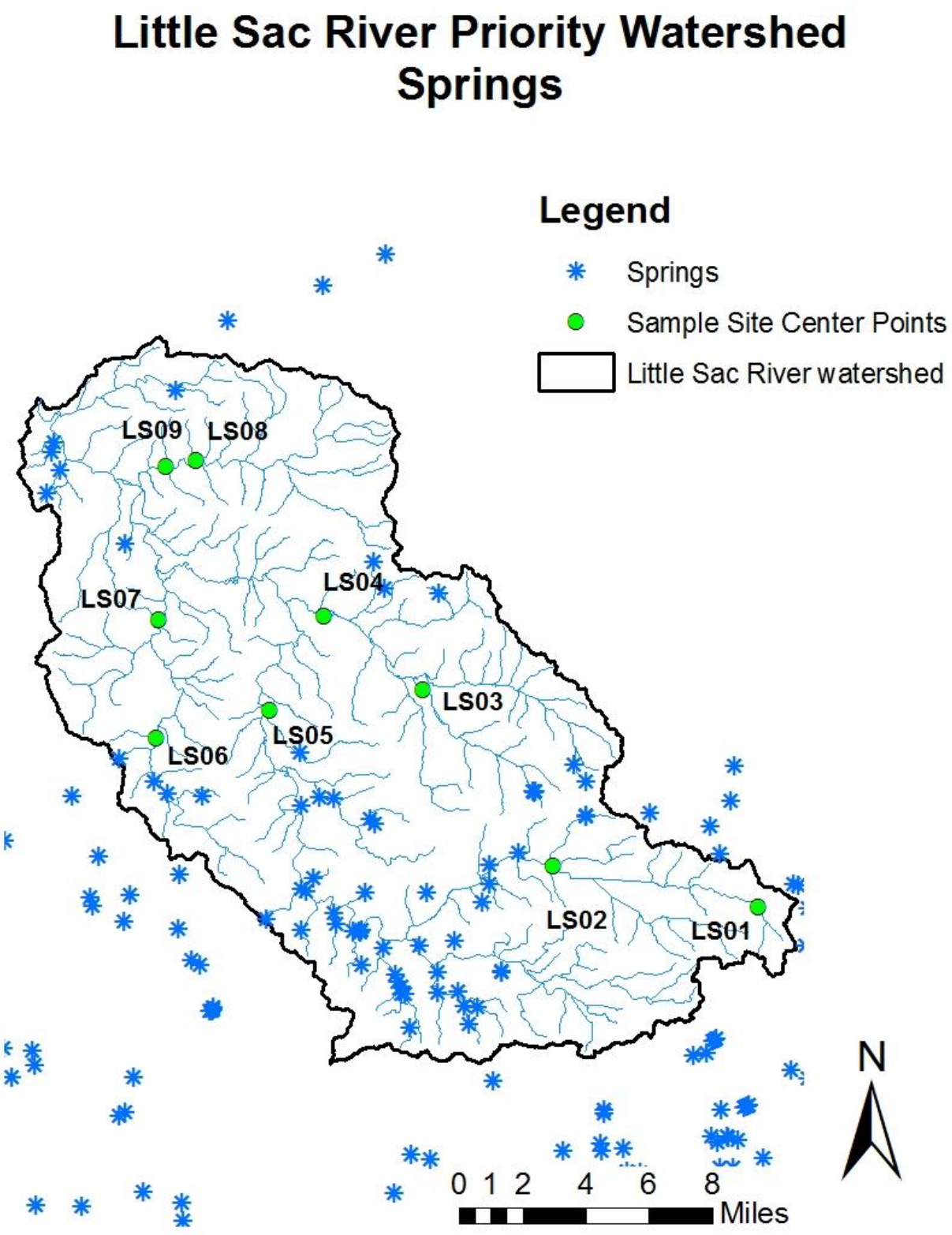

Little Sac River Priority Watershed
Springs
Legend
Springs
Sample Site Center Points
Little Sac River watershed
LS09
LS08
LS07
LS04
LS03
LS05
LS06
LS02
LS01
N
0 1 2 4 6 8
Miles

Figure 6.

Little Sac River Priority Watershed Relief Map

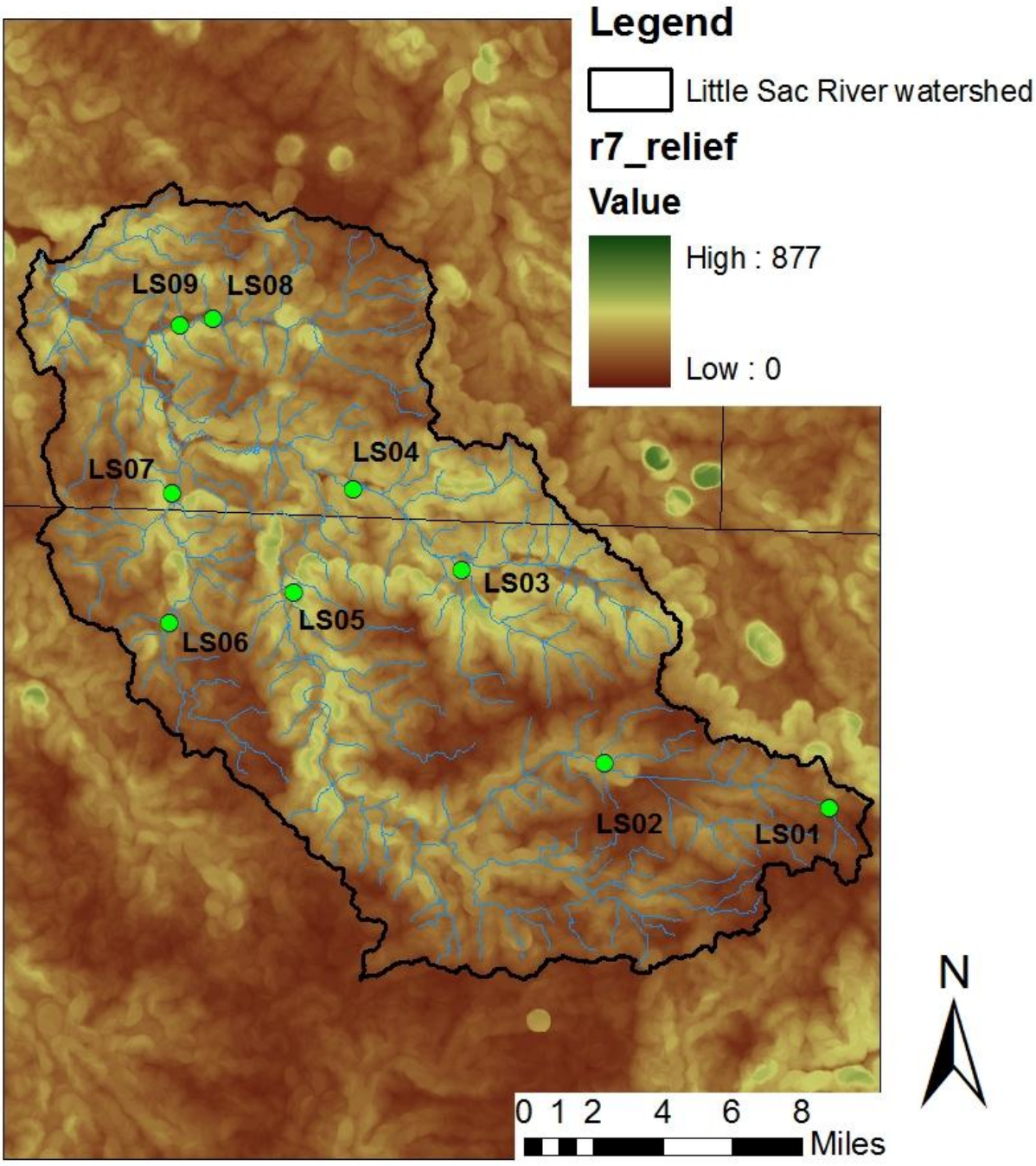


Figure 7.

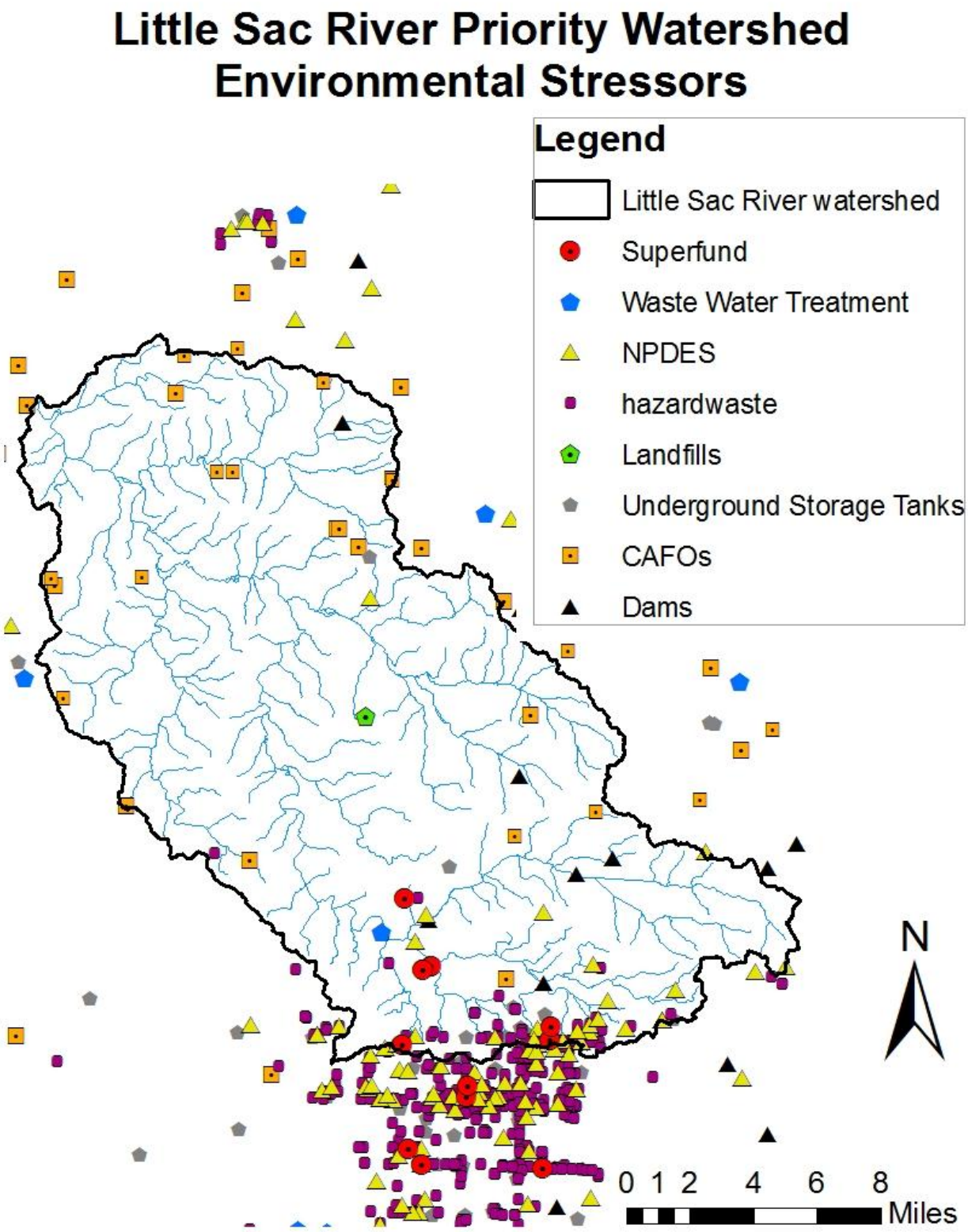

Little Sac River Priority Watershed
Environmental Stressors
Legend
Little Sac River watershed
Superfund
Waste Water Treatment
NPDES
hazardwaste
Landfills
Underground Storage Tanks
CAFOs
Dams
N
0 1 2 4 6 8
Miles

Figure 8.

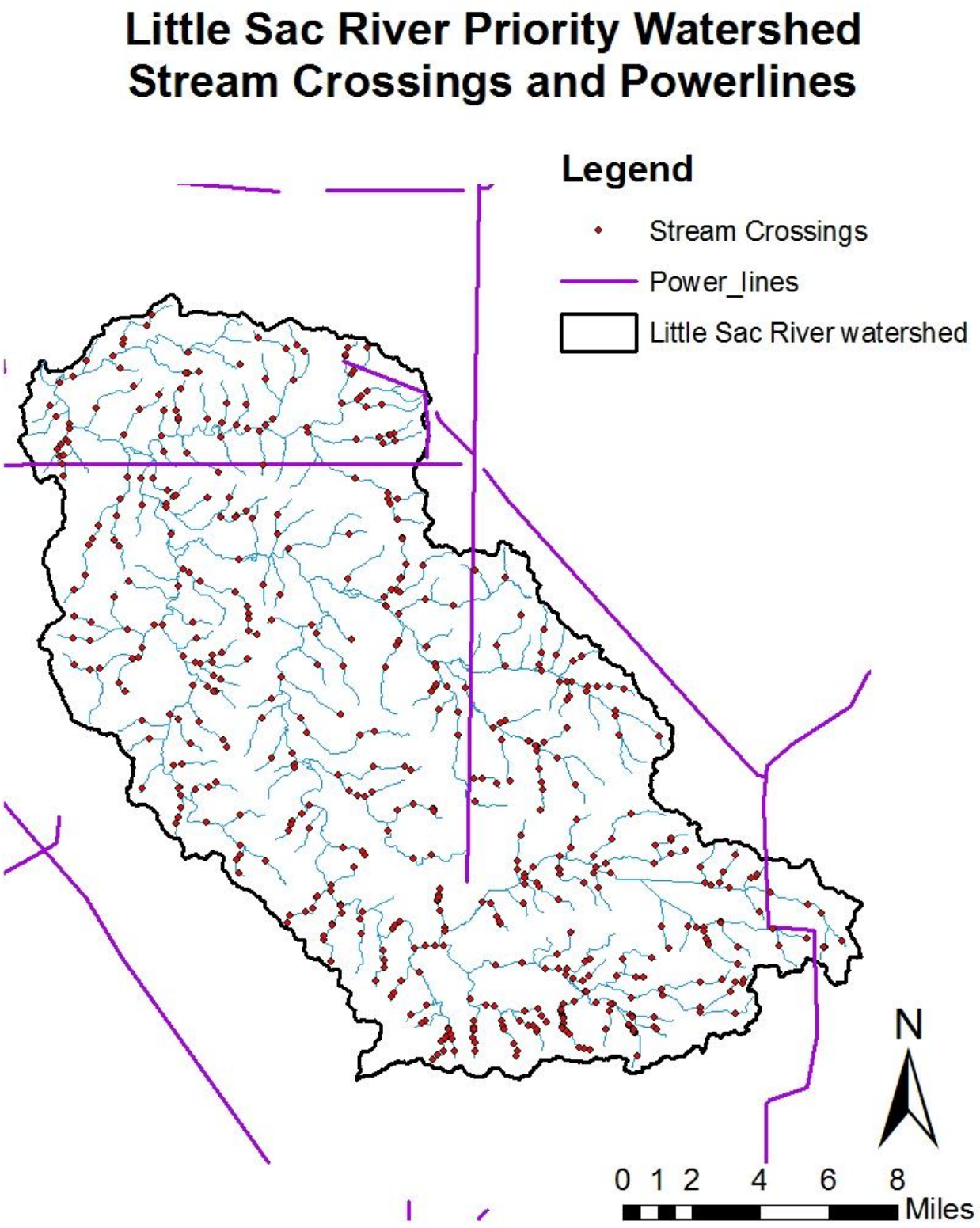

Little Sac River Priority Watershed
Stream Crossings and Powerlines
Legend
Stream Crossings
Power_lines
Little Sac River watershed
N
0 1 2 4 6 8
Miles

Figure 9.

Little Sac River Priority Watershed
RAM Index of Biotic Integrity Scores

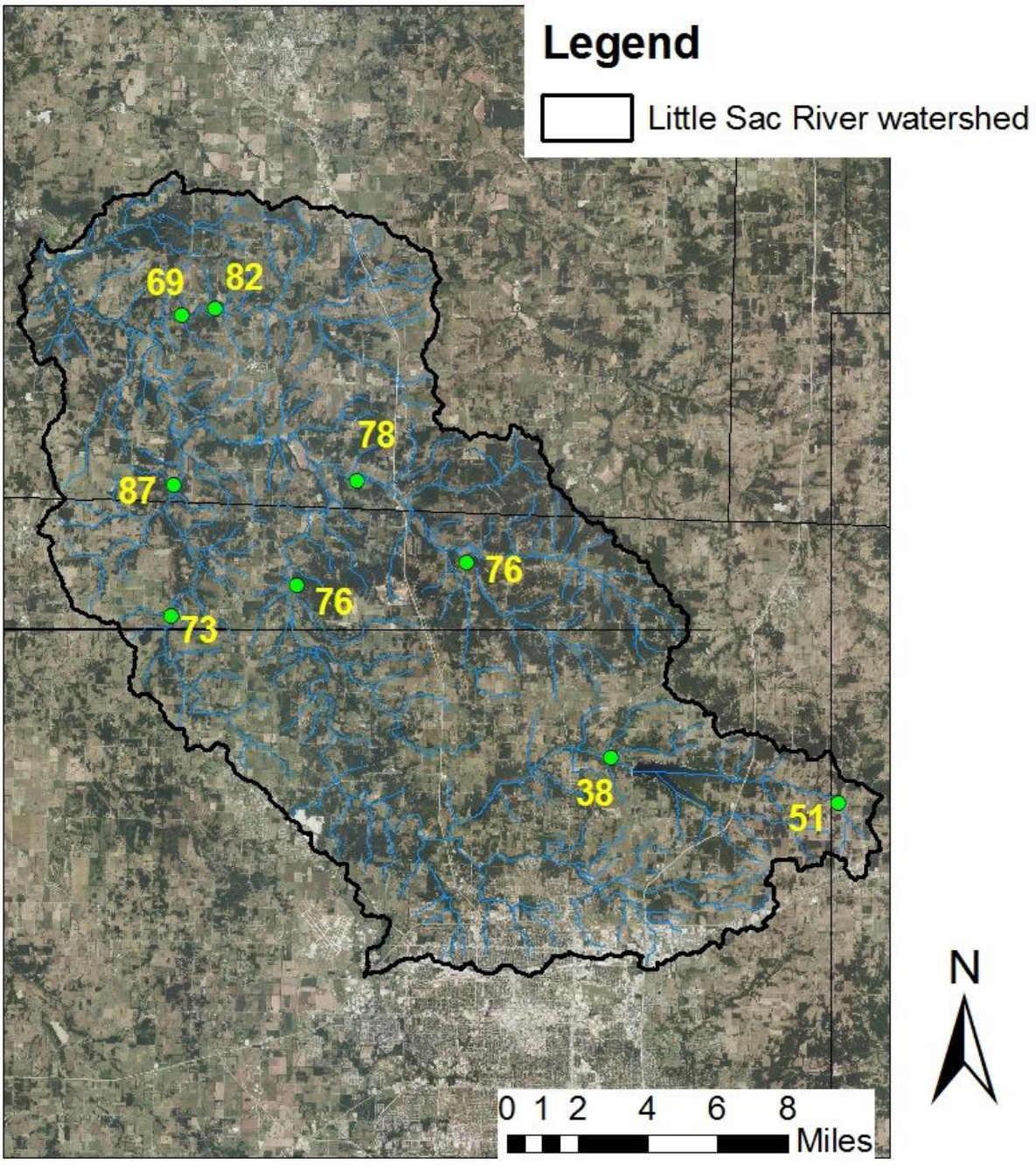


Figure 10.

Little Sac River Priority Watershed
Missouri Index of Biotic Integrity Scores

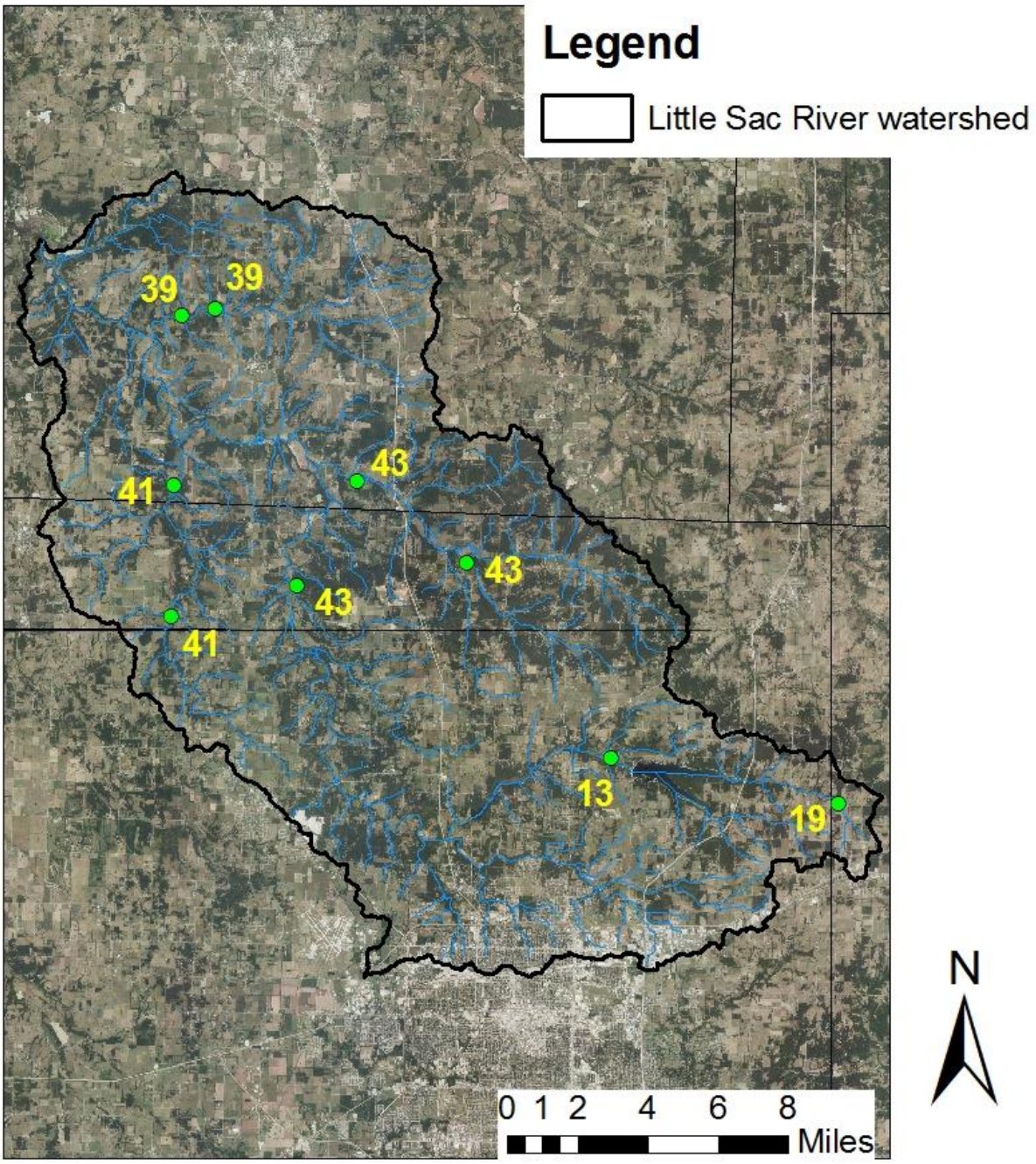


Figure 11.

Little Sac River Priority Watershed
Stream Condition Index Scores

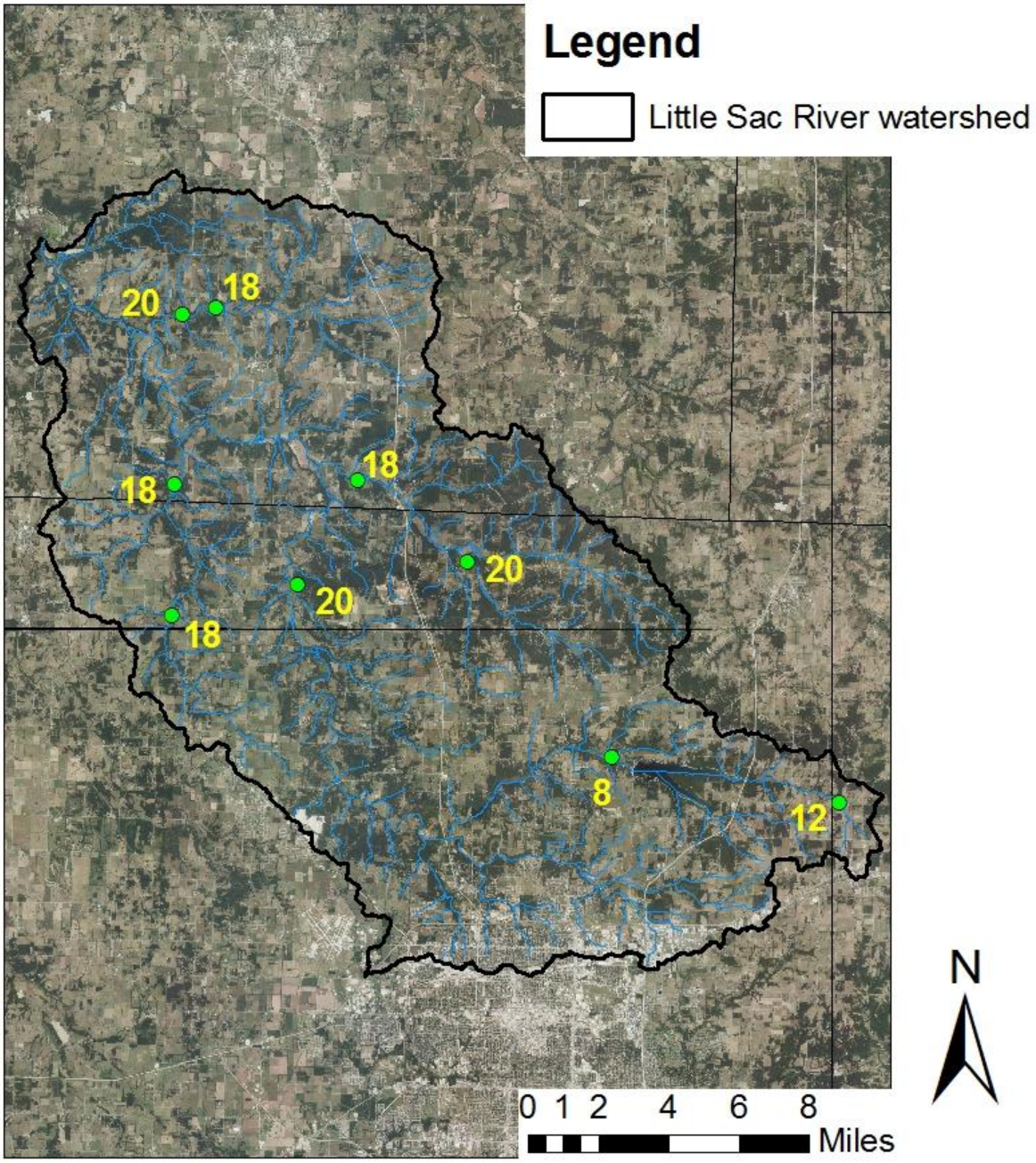


Figure 12.