Streams, Lakes, and Rivers

Survey of the Lower Wisconsin State Riverway Floodplain Lakes

Unnamed Slough of Blue Mounds Creek

Sponsor

Trout Unlimited Driftless Area Restoration Effort

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Introduction

This grant is a continuation of a sampling effort begun by the Wisconsin Department of Natural Resources (WDNR.) WDNR conducted surveys of floodplain lakes along the Lower Wisconsin State Riverway (LWSR) between 1999 and 2004. Sampling was continued through state grants sponsored by Sauk County Land Conservation Department (2008), SP River PAL (2007-08), Crawford County Land Conservation Department (2009), Dane County Department of Land and Water Resources (2009-10), River Alliance of Wisconsin (2010), and Richland County Land Conservation Department (2010). These surveys have all sought to bring light on the often overlooked floodplain lakes of the LWSR.

This survey focused on seven floodplain lakes and sloughs which were morphologically and ecological distinct from one another. Sites were selected due to associations with cold water streams. Some of these associations were direct, as in at or near the mouth of the streams. Others were only loosely allied with the trout streams through suspected groundwater connectivity. Cold water streams chosen for this project include; Blue Mounds, Lowery, Morrey, Rush, Trout, Blue River, and Marsh creeks. The survey represents an initial effort to identify effects of longitudinal connectivity between streams, lakes, and the LWSR.

An attempt was made to sample a diverse array of sites. Three sloughs and four floodplain lakes were included. To simplify the report, the term lake will be used loosely in reference to all sites. Six of the lakes sampled occur in Iowa county and the remaining lake in Grant (figure 1). The two largest lakes, Helen and Avoca, are the only named lakes in the survey, and both are locally important recreational fisheries.

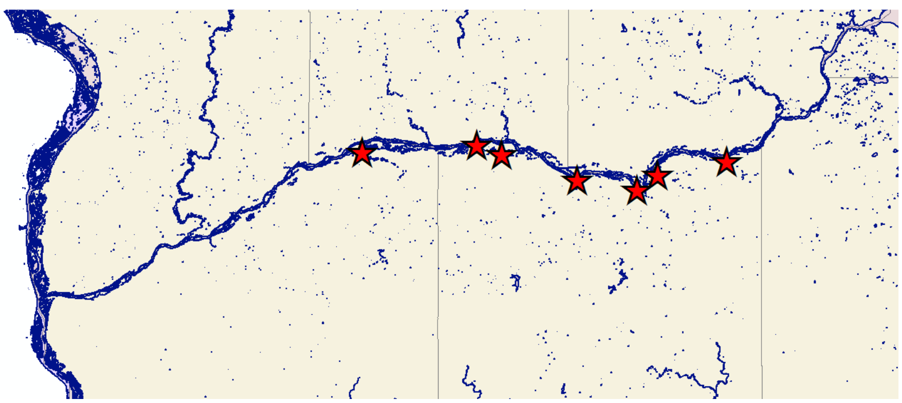


Figure 1: Site locations

As expected, each lake yielded unique results. This displays the extreme environmental heterogeneity present in these floodplain lake ecosystems. Due to this diversity, data from each lake will be presented separately. Then comparisons will be made, and commonalities will lead to generalized management recommendations for all floodplain lake environments along the LWSR.

Methods

Field data was collected between 7/1/10 and 8/10/10. An effort was made to identify the deepest point of each lake. GPS coordinates were taken from this point using a Garmin GPSMap76Cx. All water quality measurements were also done from this point. To allow for comparison, transparency was gauged using a secchi transparency tube, due to the shallow nature of some of the lakes. Turbidity was measured using a HACH 2100P Turbidimeter. Water quality measurements of pH, specific conductivity, dissolved oxygen, and temperature were made using a YSI 556 MPS. Water samples were collected immediately below the water surface. Samples were sent to the State Lab of Hygiene (SLOH) for a nitrogen series, total phosphorous, chlorophyll A fluorescence, and color. Trophic State Index (TSI) calculations were performed using Carlson's TSI equations; TSI = 9.81 ln(Chlorophyll a (ug/L)) + 30.6, TSI = 14.42 ln(Total phosphorus (ug/L)) + 4.15. Calculated TSI values are between 0 and 100, with values over 50 indicating eutrophication.

A qualitative habitat survey was conducted along the perimeter of each lake. Aquatic vegetation was estimated using a rating system of high, moderate, low, or absent. Total fish cover was estimated for an 8" fish using the same scale. Specimens of submerged macrophytes were collected, identified, pressed, and presented to the University of Wisconsin Madison Herbarium. Using WDNR protocol, metaphyton (floating macrophytes and filamentous algae) cover was estimated using a floating 0.25 m^2 grid. Samples of metaphyton were taken using a modified fine mesh net. The samples were frozen and analyzed at UW Soil and Plant Analysis Lab. Tissue analysis results of were interpreted by a WDNR Mississippi River Water Quality Specialist for signs of nutrient limitation.

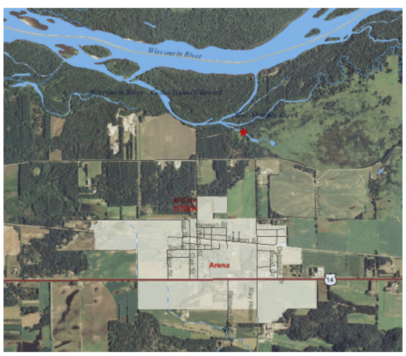
Near shore fish were collected using a combination of gears. A tow shocker was used unless terrain rendered it infeasible. A backpack shocker was used when a tow shocker could not be. Seine nets were used in areas without many obstructions. This was only possible in a few areas due to the common occurrence of deadfalls and thick beds of macrophytes. Dipnets were used to preferentially capture topminnows, as shocking has limited affect on them. Fish were collected, identified, recorded, and returned unharmed.

Index of Biotic Integrity (IBI) calculations were used to assess relative health of fish communities within the streams. In most cases, IBI's for coldwater stream reaches were attained from the WDNR's fisheries management database. Warmwater stream reaches were sampled following WDNR electrofishing protocol. Data was loaded into a WDNR provided IBI warmwater calculator for the central southern region. In a few instances it was necessary to calculate a coldwater IBI. This was done using WDNR calculator for coldwater streams.

The WDNR Surface Water Data Viewer was used to delineate the watershed and land use practices of each lake through use of the Purdue University's Long-Term Hydrologic Impact Analysis. This data was then loaded into Wisconsin Lake Management Suite (WiLMS) to estimate phosphorous loading. Water discharge data was obtained from the USGS National Water Information System: Web Interface.

Findings

Site 1: Slough of Blue Mounds Creek
WBIC: 5034392




Site 1: 43° 10' 46" N, 89° 54' 17" W

Table 1:Species observed in warm water segment of Blue Mounds Creek.

Species	State Status
Grass Pickerel (*Esox americanus*)	
White Sucker (*Catostomus commersoni*)	
Mudminnow (*Umbra limi*)	
Banded Darter (*Etheostoma zonale*)	
Mud Darter (*Etheostoma asprigene*)	Special Concern
Rainbow Darter (*Etheostoma caeruleum*)	
Johnny Darter (*Etheostoma nigrum*)	
Weed Shiner (*Notropis texanus*)	Special Concern
Starhead Topminnow (*Fundulus dispar*)	Endangered

Biotic integrity calculations indicate that Blue Mounds is a healthy stream. A coldwater IBI survey was performed by the WDNR as a Natural Community Reference Site in 2008. This survey was conducted in the middle reach of the stream and resulted in a good IBI score of 60. Sampling of the streams lower, warm, section resulted in a fair IBI score of 34. Two state species of special concern and one state endangered species were documented in this warm segment (table 1). This site was unusual in that four separate species of darter were observed (table 1).

The lake sampled is perennially connected to Blue Mounds Creek through above ground flow. Water was only slightly stained with a transparency tube reading of 90 cm, a turbidity of 3.09

NTU, and a color of 40 SU. Chlorophyll A concentrations were 21.2 µg/l (TSI= 60.6). Phosphorus concentrations were 60 µg/l (TSI= 63.2). Land use data fed into WiLMS estimated phosphorous loading at 83.5 kg/year. Nitrogen concentrations were as follows; NH_3-N 0.037 mg/l, NO_3+NO_2 0.332 mg/l, and TKN 1.02 mg/l. Metaphyton tissue analysis indicated a slight phosphorus limitation.

Picture 1: Pirate perch (*Aphredoderus sayanus*)

Macrophytes documented in the lake include; elodea (*Elodea canadensis*), coontail (*Ceratophyllum demersum*), common water milfoil (*Myriophyllum sibiricum*), greater duckweed (*Lemna major*), lesser duckweed (*Lemna minor*), and flowering rush (*Butomus umbellatus*). Total aquatic vegetation was scored as low and total fish cover was scored as high. The level of fish cover was dramatically increased by rip-rap placed below a bridge over River Road in Arena. This site did not appear to have the large populations of juvenile fish present at other sites, but did have a dense population of the state special concern pirate perch (*Aphredoderus sayanus)*, found in cover among the rip-rap (picture 1).

Site 2: Floodplain Lake near Lowery Creek
WBIC: 5574267

Site 2: 43° 8' 37" N, 90° 3' 53" W

Lowery creek had the highest coldwater IBI ratings. Three coldwater IBI surveys were conducted at different stations along Lowery in 2008. The surveys reported an excellent 90 and 100, and a good 80. The warmwater section chosen for the IBI survey was between the outflow of Taliesin Lake and Lowery's mouth. Warmwater IBI calculation for this section resulted in the second highest score in the survey, a fair 42. This area had an extremely well developed submerged macrophyte community, providing plenty of cover for juvenile fish. Though no listed species were caught, the area appeared to be well used as a nursery for popular game fish; bluegill, largemouth bass, smallmouth bass, black crappie, and yellow perch.

The lake chosen to sample is west side of the Highway 23 bridge in Iowa county. Though Surface Water Data Viewer indicates the lake has a channel to the river, one could not be identified. The lake's water was turbid with a transparency reading of 31 cm, a turbidity of 3.43 NTU, and a color of 70 SU. Chlorophyll A concentrations were 16.7 µg/l (TSI= 58.2). Phosphorus concentrations were 150 µg/l (TSI= 76.4). WiLMS estimated total phosphorous loading as 3.2 kg/year. Nitrogen concentrations were as follows; NH_3-N 0.068 mg/l, NO_3+NO_2 0.026 mg/l, and TKN 0.94 mg/l. Metaphyton tissue analysis indicated a nitrogen limitation.

Macrophytes present at this lake included; elodea (*E. canadensis*), coontail (*C. demersum*), small pondweed (*Potamogeton pusillus*), forked duckweed (*Lemna trisulca)*, lesser duckweed (*L. minor*), greater duckweed (*L. major*), *Wolffia sp.*, and white water lily (*Nymphaea odorata*). A moderate rating was given for total aquatic vegetation and a low rating for fish cover. A relatively low diversity of fish were found at this site when compared to others in the survey (appendix A). This was likely due to diurnal hypoxia, as even when measured at 12:30 pm on a sunny day the dissolved oxygen was relatively low (3.66 mg/l at the surface). This site did not seem to have any groundwater input. A possible reason for this was the elevated LWSR had formed a side channel, which encircled the lake. This side channel likely captured any upland groundwater flow before it could enter the lake. Diversion of groundwater likely exacerbated the already low oxygen levels.

Site 3: Slough at the mouth of Morrey Creek
WBIC: None

Site 3: 43° 12' 14" N, 90° 21' 31" W

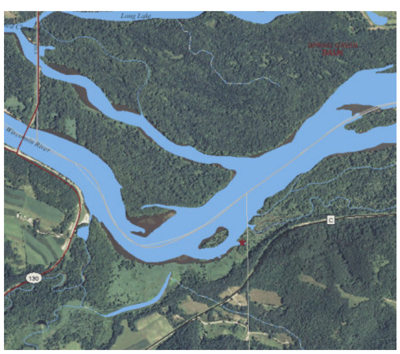
Two coldwater IBI surveys were conducted on Morrey creek in 2010. The coldwater IBI calculation for the first survey was a good 60, and the second was a poor 20. A warmwater survey of Morrey Creek was done upstream of a channel connecting it with Marsh Creek. The survey resulted in a fair score of 35. Spotfin shiners were extremely abundant in this area (appendix B).

The slough at the mouth of Morrey and Marsh was chosen for the lake survey. Water was stained (60 SU). Transparency was 42 cm with the second highest observed turbidity in the survey (9.98 NTU). The chlorophyll A concentration was 62.5 µg/l (TSI= 71.2), and the concentraion of phosphorus was 225 µg/l (TSI= 82.2). WiLMS estimated phosphorous loading at 2471.8 kg/year, which was the highest of the survey. Nitrogen concentrations were as follows; NH_3-N 0.077 mg/l, NO_3+NO_2 0.131 mg/l, and TKN 2.29 mg/l. Metaphyton tissue analysis did not indicate a single nutrient was limiting.


Picture 2: Juvenile longnose gar (*Lepisosteus osseus*)

Four species of macrophytes were collected for the herbarium from this lake; coontail (*C. demersum*), eurasian water-milfoil (*Myriophyllum spicatum*), large-leaved pondweed (*Potamogeton amplifolius*), and small pondweed (*P. pusillus*) (appendix C). A rating of moderate was given to both total aquatic vegitation and fish cover. A notable catch at this lake was a juvenile longnose gar (*Lepisosteus osseus*) (picture 2). Game fish present included largemouth bass and bluegill. The number of fish species at this site was high in comparison to other lakes in the survey (appendix 1).

Site 4: Slough slightly downstream of Rush Creeks mouth
WBIC: None



Site 4: 43° 9' 26.3" N, 90° 10' 24.4" W

Rush Creek was IBI sampled by the WDNR four times in 2007. Two of the surveys resulted in a very poor score of 0, and the remaining two resulted in a poor score of 10. The site selected for the warmwater survey was the lowest reach accessible, downstream from the confluence of Rush and Sneed creeks. A warmwater IBI score of fair, 34, was attained. Brown trout persisted, even this far down Rush (appendix 2). The trout were confined to small pools next to seeps of cold groundwater.

The slough selected for the survey is immediately downstream of the mouth of Rush Creek. This site is off of a LWSR side channel and has an extremely steep bank to its south. Water was stained and had a color of 50 SU. Transparency was 66 cm and the turbidity was the lowest observed, 2.26 NTU. The chlorophyll A concentration was 2.97 µg/l (TSI= 41.3), and the concentraion of phosphorus was 151 µg/l (TSI= 76.5). WiLMS estimated phosphorous loading at 3.1 kg/year. Nitrogen concentrations were as follows; NH_3-N 0.166 mg/l, NO_3+NO_2 0.159 mg/l, and TKN 0.97 mg/l. Metaphyton analysis did not indicate any nutrient limitation.


Picture 3: Lake chubsucer (*Erimyzon sucetta*)

Macrophytes observed at the lake included; *Wolffia sp.*, eurasian water milfoil (*M. spicatum*), coontail (*C. demersum*), and water bulrush (*Scirpus subterminalis*). Total aquatic vegetation and total fish cover both received a moderate rating. This lake had the highest Fish species richness in the survey, 12 spp. The site was being used as a nursery by both largemouth and smallmouth bass, bluegill, and yellow perch. A notable species present in the lake was the state special concern lake chubsucker (*Erimyzon sucetta*) (picture 3). There was also a solitary brook stickleback (*Culaea inconstans*) which had likely washed down from Sneed Creek (appendix 1).

Site 5: Helen Lake
WBIC: 1242400


Site 5: 43° 9' 50" N, 90° 1' 39" W

Trout Creek was chosen due to its trout fishery and its location upstream of Helen Lake. A coldwater IBI survey was done on Trout in 2009 resulting in a good score of 60. The warmwater segment had to be done on Mill Creek of which Trout is a tributary, as Trout does not have a warmwater reach. The site had the highest warmwater IBI, fair 47. The score was boosted by a number of burbot (appendix B).

Helen Lake is unique among the floodplain lakes. Helen is probably the deepest and largest floodplain lake in the LWSR. Due to its depth, this lake had prominent stratification (figure 2). Helen is also used extensively for recreational fishing. The lake was stained and had a color of 50 SU. Helen had a transparency of 68 cm. Its turbidity was measured as 6.78 NTU. The chlorophyll A concentration was 31.8 µg/l (TSI= 64.5), and the concentration of phosphorus was 89 µg/l (TSI= 68.9). WiLMS estimated phosphorous loading at 5 kg/year. Nitrogen concentrations were as follows; NH_3-N 0.017 mg/l, NO_3+NO_2 0.369 mg/l, and TKN 1.11 mg/l. Metaphyton tissue analysis indicated a phosphorous limited system.

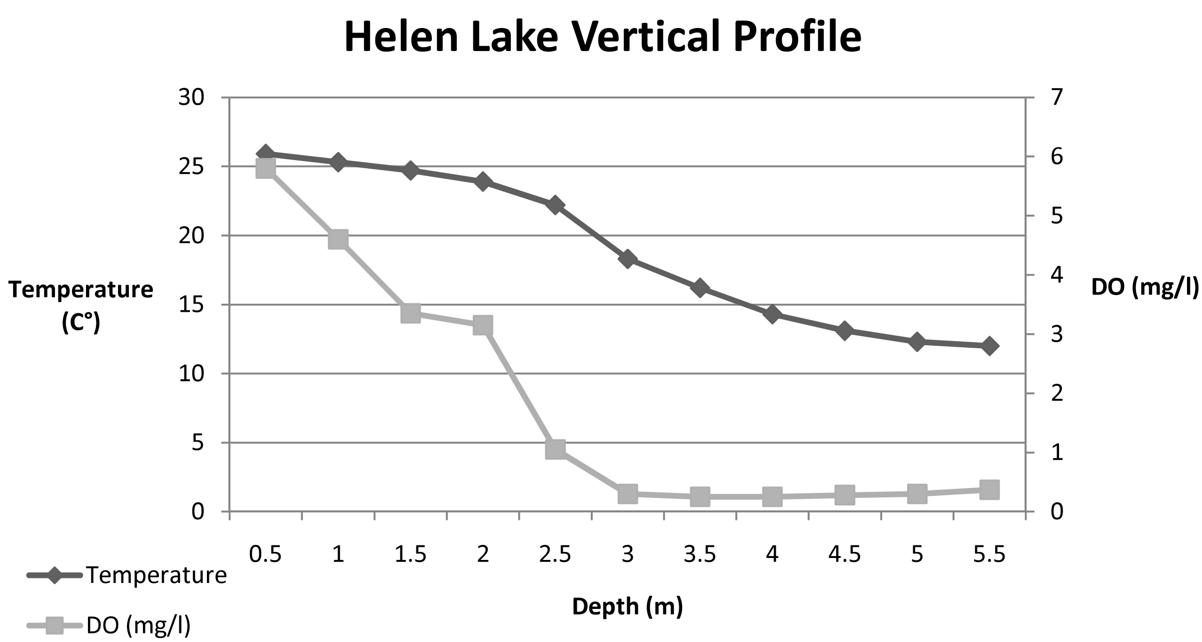
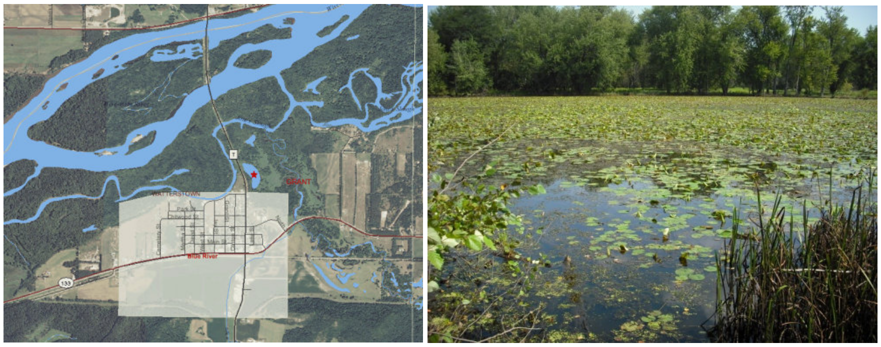


Figure 2: Vertical profile of Helen Lake, 7/19/2010

Helen lake had the largest number of macrophyte species in the survey. Macrophytes observed included; coontail (*C. demersum*),elodea (*E. canadensis*), curly pondweed (*Potamogeton crispus*), eurasian watermilfoil (*M. spicatum*), water celery (*Vallisneria americana*), flat-stem pondweed (*Potamogeton zosteriformis*), water star-grass (*Zosterella dubia*), *N. odorata*, spatterdock (*Nuphar variegata*), pickerel-weed (*Pontederia cordata*). Total aquatic vegetation was ranked as moderate, and total fish cover was ranked as high. A shallow area near the dock was selected for sampling the near shore fish community. The state special concern pirate perch (*Aphredoderus sayanus*) was documented. Game species include bluegill, largemouth bass, and black crappie (appendix A).

Site 6: Floodplain Lake near Blue River
WBIC: 5588642



Site 6: 43° 11' 33" N, 90° 33' 58" W

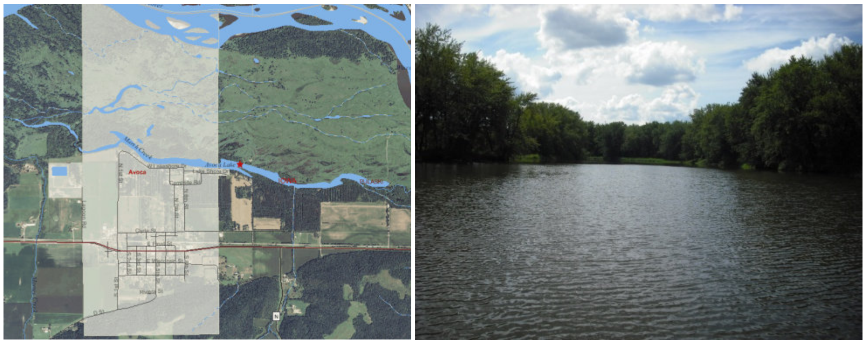
WDNR coldwater IBI surveys were done on Blue River in 2007, resulting in a very poor 0 and a poor 20. The Nohr chapter of Trout Unlimited just completed restoration work on Blue River in 2009, so current values in restored segments may be higher. The warmwater segment of Blue chosen for an IBI survey was done near its mouth. A warmwater IBI of poor, 22, was the result. This was the lowest warmwater IBI score in the survey (figure 3).

The lake was chosen due to perceived groundwater flow; however, difficult terrain rendered finding upwelling infeasible. The shore was only accessible for a few meters, and there was no way to navigate a boat through the thick macrophyte beds. Transparency readings were tied for the lowest in the survey at 29 cm. The turbidity was high at 9.53 NTU. Water in the lake was also stained with a color of 60 SU. The chlorophyll A concentration was 45.2 µg/l (TSI= 68), and the concentraion of phosphorus was incredibly high at 536 µg/l (TSI= 94.8). Strikingly, WiLMS estimated this site as the lowest phosphorous loading in the survey at 0 kg/year. Nitrogen concentrations were as follows; NH_3-N 0.016 mg/l, NO_3+NO_2 not detectable, and TKN 1.48 mg/l. Metaphyton tissue analysis corresponded well with the nutrient levels, confirming that nitrogen was the limiting nutrient.

Picture 4: Central mudminnow (*Umbra limi)*

The macrophyte community at this site was extremely dense, consisting almost entirely of coontail (*C. demersum*) and white water lily (*N. odorata*). A rating of high was given for total aquatic vegetation. Total fish cover was also scored as high due to the amount of vegetation. The only fish species captured was the central mudminnow (*Umbra limi*), a hypoxic resistant fish (picture 5).

Site 7: Avoca Lake
WBIC: 1220200



Site 7: 43° 11' 27" N, 90° 18' 43" W

Marsh Creek was chosen because it is listed as a coldwater stream, and empties directly into Avoca Lake. There was no cold water IBI in WDNR's database for Marsh, so it was surveyed. The location chosen was west of Bigelow road adjacent to Highway 133. The stream was very narrow and enclosed by vegetation. Only one largemouth bass was captured after 100 meters, which did not yield enough fish for an IBI calculation. Upon scouting upstream, it was discovered that the stream was impounded by two large farm pounds. The ponds had destroyed any coldwater habitat which may have been present. The survey of the warmwater segment was conducted immediately above the point at which Marsh Creek becomes Avoca Lake. This survey resulted in a fair IBI score of 35.

Avoca lake is a popular fishing location, and was the only lake in the survey with residential development along its shore. Avoca had the highest turbidity (11.1 NTU). The transparency readings suffered as a result. Avoca was tied for the lowest transparency reading at 29 cm (figure 5). This lake also had the lowest color (30 SU). The chlorophyll A concentration was 32 µg/l (TSI= 64.6), and the concentraion of phosphorus was 80 µg/l (TSI= 67.3). WiLMS estimated phosphorous loading at 704.8 kg/year. Nitrogen concentrations were as follows; NH_3-N 0.4 mg/l, NO_3+NO_2 0.233, and TKN 1.52 mg/l. Metaphyton analysis was not performed on Avoca, because there simply wasn't enough collectable filamentous algae and floating macrophytes.

Picture 5: Sunning blandings turtle (Emydoidea blandingii)

Macrophyte levels were very low. The only observed macrophyte was *M. spicatum.* There was also a bloom of blue-green algae in the lake at the time sampling occurred. The lack of macrophytes led to a low rating for total aquatic vegetation, but total fish cover was given a moderate rating due to the presence of woody debris.

Largemouth bass appeared to be quite abundant in the lake. The largest bass captured throughout the survey came from Avoca, with two fish greater than 40 cm. While conducting this survey the state threatened blandings turtle (*Emydoidea blandingii*) was spotted near the water collection point sunning itself on a deadfall (picture 5).

Compiled data

Figure 3: IBI comparisons. Site 5 Note: Trout Creek used for coldwater, and Mill used for Warmwater. For sites with multiple cold water IBI ratings, the mean of the surveys was used. Coldwater IBI for Marsh=0.

The relative health of the stream fish communities varied greatly. Coldwater IBI values from the WDNR ranged from 0 to 100 (figure 3). Marsh Creek was a standout. No records existed for a coldwater IBI in the WDNR database for Marsh, so a survey was conducted. The reach of this stream sampled for a coldwater IBI was the most unhealthy stream, in terms of fish community, despite a large prairie buffer. Though Marsh is listed as a coldwater stream by the WDNR, there were no signs of trout Two large farm ponds are obstructing the flow of this stream, warming it and reducing it to a trickle. Only one fish was found, a largemouth bass. This fish was probably displaced from one of the ponds. There was much less variation in the warmwater IBI calculations, 22-47. All the streams fell within 13 points of one another, except Blue river (22).

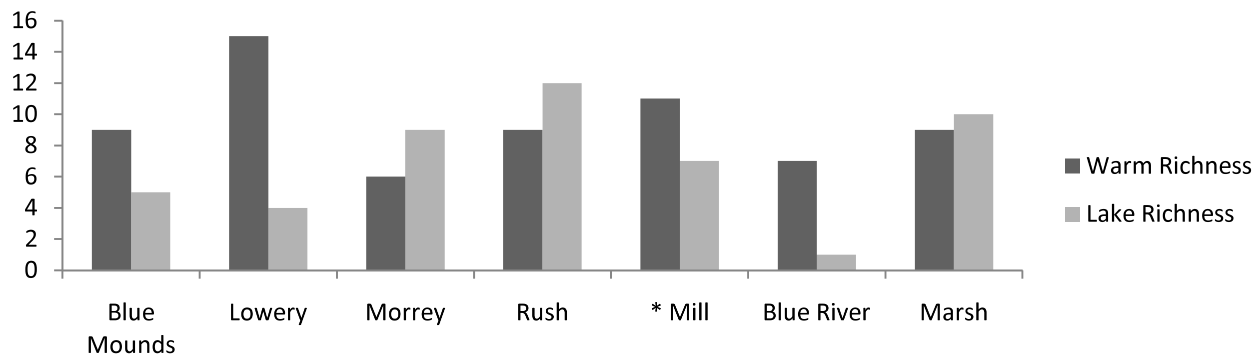


Figure 4: A comparison of species richness between warm water stream reaches and sampled floodplain lakes. *Mill creek used in place of Trout Creek, as Trout is a tributary of Mill and has no warm segment of it's own.

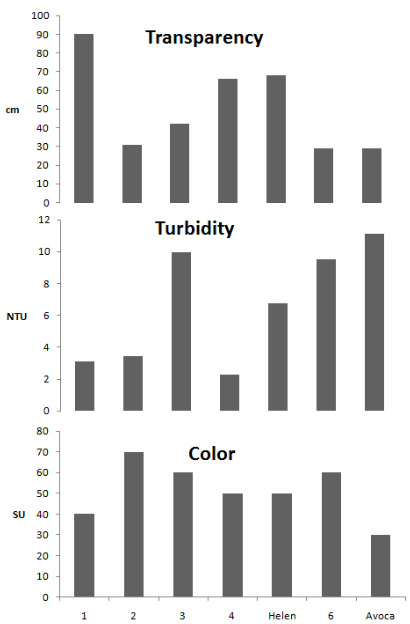


Figure 5: Light characters of water.

Secchi transparency tube readings varied greatly. The slough adjacent to Blue Mounds (site 1) had the highest transparency, and correspondingly one of the lowest turbidities. Turbidity also varied greatly between sites, with a low of 2.26 (site 4) and a high of 11.1 (Avoca). Low transparency readings tended to correspond well with high turbidities (Figure 5). An exception to this is the lake near Lowery (site 2) which had low transparency and low turbidity. The lake did have the highest color of the survey, and this is likely responsible. All of the lakes were at least slightly stained. This was expected, because of the association with the stained water of the LWSR.

All of the lakes showed signs of eutrophication. Many had high densities of submerged macrophytes. Site 6 near Blue River had the highest observed macrophyte densities (appendix C). This site was completely filled with coontail, and white water lily.

TSI values were all indicative of eutrophic systems (figure 6). The TSI values for phosphorous indicated eutrophication in every lake, with a low of 63 (site 1) and a high of 94 (site 6). Chlorophyll A TSI values indicated eutrophication for all but site 4 (TSI= 41). The high plant density and TSI values both indicate that these are highly productive systems.

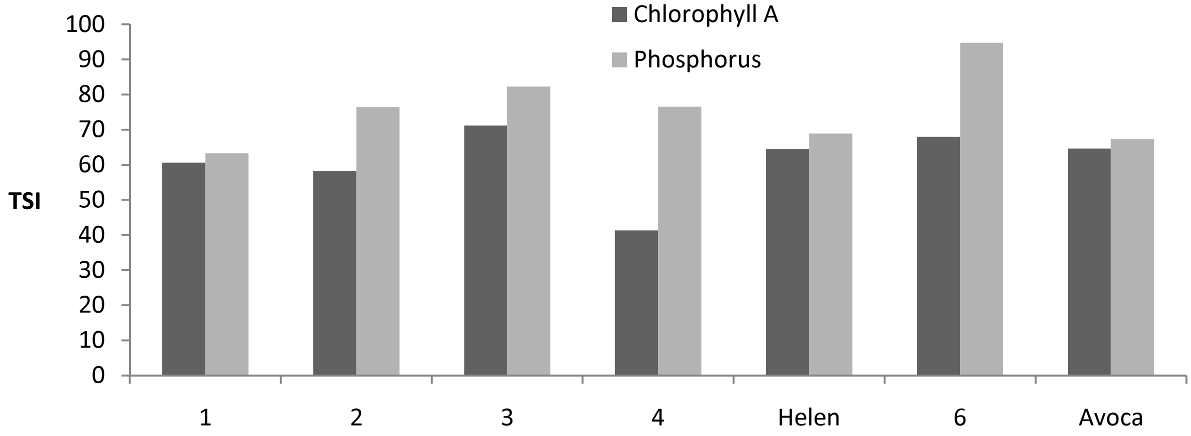


Figure 6: TSI values calculated for chlorophyll A and phosphorous using Carlson's equations.

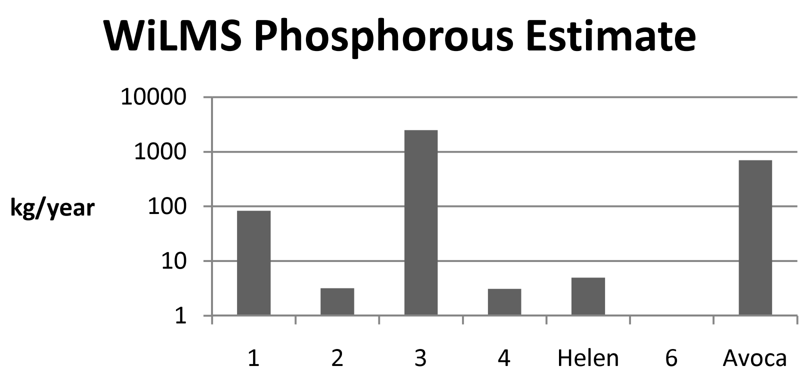


Figure 7: WiLMS likely phosphorous loading predictions, logarithmic scale. Calculations for site 6 resulted in a value of 0.

Phosphorous loading estimates generated by WiLMS demonstrate how highly varied these streams are (figure 7). There currently no way to possibly model the dynamics of a floodplain environment. This is evident in site 6, which WiLMS predicted as the lowest phosphorous loading site. Actual measurements showed that this site had the highest phosphorous values. The model estimates do show that variations in basin sizes and land use can have a dramatic effect on nutrient levels. Though there is no way to predict the flood-pulse regime or control basin size, land uses can be altered to reduce nutrient loading.

<u>Recommendations:</u>

1. Expand Exceptional Resource Waters designation into floodplain lakes.
Floodplain lakes along the LWSR deserve the same protection afforded to the river itself through the ERW designation. This is because the health of the LWSR is dependent on the health of its floodplain. These lakes provide many ecosystem services which benefit the LWSR.

The sandy soil in the LWSR basin drains very quickly. Both nutrient inputs to crops and farmed animal waste has increased nitrogen and phosphorous concentrations in the groundwater and the LWSR. All of the lakes surveyed had TSI ratings which indicated eutrophication (figue 6). Floodplain lakes can help manage excess nutrient pollution into the LWSR, because they act as natural sinks for nitrogen through the work of denitrifying microbes (Forshay and Stanley, 2005.)

The Mississippi river has a number of problems related to overabundances of metaphyton. Fortunately the LWSR has avoided many of these problems, likely do to a more natural flood-pulse cycle. Flooding is critically important for maintaining the richness and health of macrophyte communities (Robertson, 2001). It is probable that denitrification in the floodplain is able to reduce the density of filamentous algae and floating macrophytes. This increases light able to reach the littoral zone. The nutrient reduction in the water column favors submerged and emergent macrophytes. Increased light and decreased dissolved nitrogen allow for a healthy macrophyte population. This sets up a positive feedback where the submerged and emergent macrophytes are able to inhibit over abundances of floating macrophytes. Many species of fish are likely beneficiaries. It's been shown that a healthy balanced macrophyte community leads to increased recruitment and survival of largemouth bass (Wiley, 1984).

Other than providing recreational fisheries in and of themselves, healthy fish stocks in the LWSR are dependent on the floodplain lakes. Floodplain lakes were recognized as important breeding grounds for game fish as early as 1887 when Stephen A. Forbes published, *The Lake as a Microcosm.* Sport fish often use them as spawning locations and feeding grounds (Kwak, 1988). These sites contained many forage species (ex. shiners) for adult fish to prey upon (table 1). The lakes are an important source for replenishing river populations of game fish such as crappie, bluegill, bass, and pike (Ross and Baker, 1983.) Almost all of the sites surveyed had an abundance of juvenile largemouth bass and bluegill. Juvenile smallmouth bass and black crappie were also observed in the survey. Another way in which the lakes benefit river fish communities is by providing critically important overwintering sites for several game species (Sheehan et al., 1994).

2. Support efforts of groups looking to restore streams in the LWSR watershed through funding and purchase of riparian buffers.

Sedimentation can have a dramatic impact on floodplain lakes. The loess soil of the driftless area is extremely susceptible to erosion. Poor land use practices have led to infilling of floodplain lakes along the LWSR (Freeman et al., 2003). Many of the sloughs and lakes on the LWSR form on or near the mouths of tributary streams. Sediment loads have increased through channelization and riparian reduction. Channelization increases stream velocity which increases erosion; thereby, increasing sediment load (Woltemade, 1994). The riparian zone stabilizes soil reducing washload, and can act as a filter catching washload and processing excess nutrients before they have a chance to enter the aquatic system.

Sediment and nutrient loads can be greatly reduced by restoring the natural meander of streams and by increasing riparian buffer strips. An economical way to do this is by the supporting restoration efforts of groups like Trout Unlimited. The Nohr chapter of TU recently completed some restoration work on the lowest rated site, Blue River, in 2009. This site had the lowest coldwater and warmwater IBIs. The related lake had the highest levels of phosphorous, despite having the lowest calculated levels of phosphorous loading. This lake only had one species of fish, which is likely tied directly to the high nutrient levels. Blue river also had the highest level of sedimentation observed in the warmwater stream segment. Efforts such as this should be encouraged, as restoration of a degraded stream will have a proportionally much larger impact than the addition of habitat to an already healthy stream. It will be interesting to see to what degree restoration efforts in the coldwater segment affect the warmwater segment and the lake in years to come.

Data collected from the warm water segments of streams indicates that the lower reaches of cold water streams may harbor many of the same species as the floodplain lakes (appendix A). In the case of Blue Mounds, two state species of special concern and one state endangered species were found in the warm water segment (table 1). These species typically inhabit floodplain lake environments. The overlap in species between the lakes and the warm water stream segments indicates longitudinal connectivity of these systems. Enhancing the quality of the streams will allow these species to benefit in the streams and the lakes. Stream restoration can also create a positive feedback. Improvements to the cold water segments enhance the warm segments and the lakes. The enhanced productivity of the lakes has the potential to affect productivity of the cold water portions of the streams, through longitudinal fish migration. An obvious example of this is the presence of a forage fish, the spotfin shiner, throughout the entire system of both Morrey and Marsh Creeks. These fish are found in the lakes, warmwater segments, and coldwater segments.

3. Survey multiple floodplain lakes and sloughs to identify the most ecologically important. Though all of these sites are important habitat, it is essential to identify ecological hotspots in order to best utilize the limited resources available. Quick presence absence electrofishing surveys should be conducted on a number of the lakes. To aid in data collection, WDNR should take advantage of volunteer groups to survey birds, macrophytes, and herpetofauna; as these surveys do not require any special equipment. Preference should be given to sites which show high biodiversity, harbor species which are threatened or endangered, or which are preferred spawning sites for game fish. This survey was able to identify new populations of two species of special concern; lake chubsucker and pirate perch (appendix A). The survey also spotted the state threatened blandings turtle. Once ecologically important sites are identified, it would be beneficial to establish long term monitoring sites within these areas. This would reduce uncertainty and give managers a better understanding of the status of endangered resources, and the recruitment levels of popular game fish.

4. Monitor several representative floodplain lakes annually to establish a baseline.

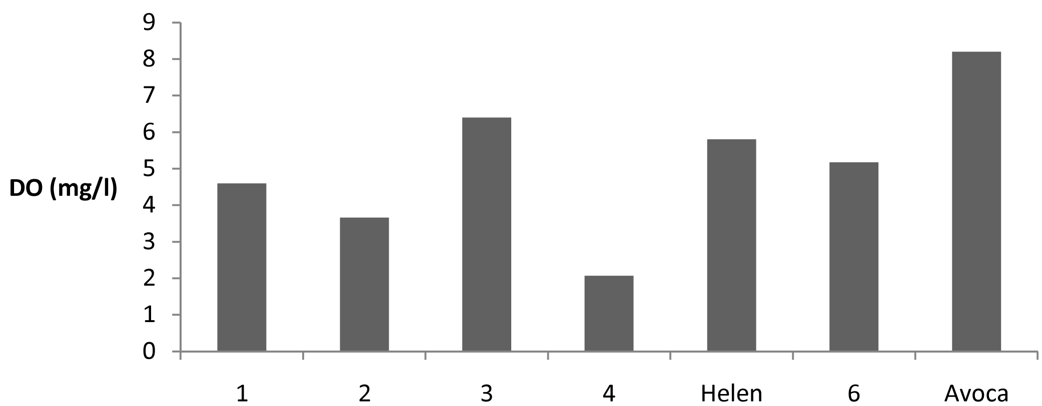


Figure 8: Surface dissolved oxygen levels.

This is the first time the majority of these lakes have every been sampled. There is no knowledge of trends in nutrient levels or other water quality measurements. Dissolved oxygen levels for this survey tended to be relatively low, considering measurements were taken around mid-day during the peak in photosynthetic activity (figure 8). A possible reason for this was the extremely high water during the survey (figure 9). Previous surveys have indicated that sustained high water levels can lead to a dramatic decrease in dissolved oxygen levels.

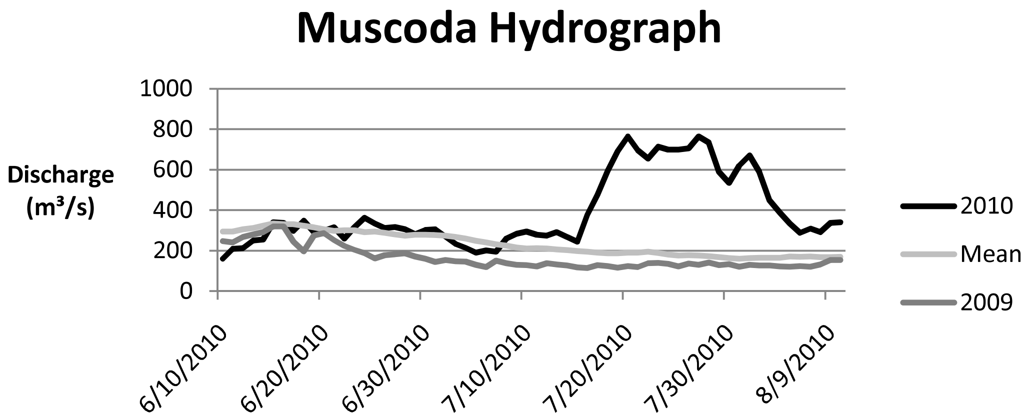


Figure 9: Muscoda hydrograph showing extremely abnormally high discharge levels in the LWSR.

A survey conducted in 2009 by the Crawford County Land Conservation Department found numerous instances of the state endangered starhead topminnow in similar lakes. Abundances of floodplain lake species are regulated by flood frequency and duration. In order to properly predict population sizes, the effect of flooding on these species must be ascertained. Until a baseline establishes natural fluctuations in fish populations, endangered resources cannot be appropriately identified or managed. Data collected can also be used to determine the effect flood cycle has on the recruitment of game fish. A baseline must be developed to properly manage endangered resources and game fish populations.

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Appendix A: Fish present by site, "X" indicates presence. "XX" indicates present in lake and corresponding warmwater stream segment, showing possibility of movement. Names in red indicate state species of special concern.

Site	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Habitat	**Slough**	**Lake**	**Slough**	**Slough**	**Helen Lake**	**Lake**	**Avoca Lake**
Richness	**5**	**4**	**9**	**12**	**7**	**1**	**10**
Grass Pickerel ***Esox americanus***	XX	XX	XX		X		
Central Mudminnow ***Umbra limi***	XX	XX	X		X	XX	
Large Mouth Bass ***Micropterus dolmieu***		XX	XX	X	X		XX
Small Mouth Bass ***Micropterus salmoides***				X			X
Bluegill ***Lepomis macrochirus***		XX	X	X	XX		XX
Black Crappie ***Pomoxis nigromaculatus***					X		XX
Warmouth ***Lepomis gulosus***					X		
Green X Bluegill	X						
Pirate Perch ***Aphredoderus sayanus***	X				X		
Brook Silverside ***Labidesthes sicculus***				X			X
Lake Chubsucker ***Erimyzon sucetta***				X			
White Sucker ***Catostomus commersoni***			XX				
Yellow Perch ***Perca flavescens***				X			
Common Shiner ***Luxilus cornutus***				X			
Emerald Shiner ***Notropis atherinoides***			X				
Channel Shiner ***Notropis wickliffi***				X			
Bluntnose Minnow ***Pimephales notatus***	X						X
Spotfin Shiner ***Cyprinella spiloptera***			XX	X			XX
Golden Shiner ***Notemigonus crysoleucas***			X	XX			X
Spottail Shiner ***Notropis hudsonius***				X			
Bowfin ***Amia calva***							X
Longnose Gar ***Lepisosteus osseus***			X				X
Brook Stickleback ***Culaea inconstans***				X			

Appendix B: Warmwater stream IBI summary. Red indicates state species of special concern and Green indicates state endangerged species.

Stream	Blue Mounds	Lowery	Morrey	Rush	Mill	Blue River	Marsh
IBI Score	**Fair 34**	**Fair 42**	**Fair 35**	**Fair 34**	**Fair 47**	**Poor 22**	**Fair 35**
Richness	**9**	**15**	**6**	**9**	**11**	**7**	**9**
Grass Pickerel ***Esox americanus***	15	3	1				1
Central Mudminnow ***Umbra limi***	40	2		5		1	1
Large Mouth Bass ***Micropterus salmoides***		11	10			21	16
Small Mouth Bass **Micropterus dolomieu**		1	4		4		
Bluegill ***Lepomis macrochirus***		15			1	7	8
Black Crappie ***Pomoxis nigromaculatus***		3	1			3	1
Green Sunfish ***Lepomis cyanellus***							1
Starhead Topminnow ***Fundulus dispar***	9						
Channel Catfish ***Ictalurus punctatus***					3		
White Sucker ***Catostomus commersoni***	15	16	1	17	12		1
Northern Hog Sucker ***Hypentelium nigricans***				1	7		
Shorthead Redhorse ***Moxostoma macrolepidotum***		2			1		
Silver Redhorse ***Moxostoma anisurum***		2					
Johnny Darter ***Etheostoma nigrum***	4	5				1	
Banded Darter ***Etheostoma zonale***	6	6		4			
Rainbow Darter ***Etheostoma caeruleum***	6	2					
Mud Darter ***Etheostoma asprigene***	6						
Fantail Darter ***Etheostoma flabellare***				8			
Blackside Darter ***Percina maculata***				12	3		
Yellow Perch ***Perca flavescens***		1					
Common Carp ***Cyprinus carpio***							1
Common Shiner ***Luxilus cornutus***					3	1	
Weed Shiner ***Notropis texanus***	2						
Spotfin Shiner ***Cyprinella spiloptera***			>100		25		1
Golden Shiner ***Notemigonus crysoleucas***				4		7	
Creek Chub ***Erimyzon oblongus***		1					
Burbot ***Lota lota***		1		3	4		
Gizzard Shad ***Dorosoma cepedianum***			5				
Mottled Sculpin ***Cottus bairdi***					1		
Brown Trout ***Salmo trutta***				18			

Appendix C: Macrophytes collected for herbarium specimens.

Site	1	2	3	4	Helen	6	Avoca
Macrophyte Density	**Low**	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**High**	**Low**
Coontail ***Ceratophyllum demersum***	X	X	X	X	X	X	
Elodea ***Elodea canadensis***	X	X			X	X	
Common water milfoil ***Myriophyllum sibiricum***	X						
Eurasian water-milfoil ***Myriophyllum spicatum***			X	X	X		X
Flowering rush ***Butomus umbellatus***	X						
Small pondweed ***Potamogeton pusillus***		X	X				
Large-leaved pondweed ***Potamogeton amplifolius***			X				
Curly pondweed ***Potamogeton crispus***					X		
Flat-stem pondweed ***Potamogeton zosteriformis***					X		
Spatterdock ***Nuphar variegata***					X	X	
White water lily ***Nymphaea odorata***					X	X	
Water bulrush ***Scirpus subterminalis***				X			
Water celery ***Vallisneria americana***					X		
Water star-grass ***Zosterella dubia***					X		