An Inventory of Pinckney and Waterloo Recreation Areas to Identify Significant Aquatic Natural Features

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Cover photos: by Amy L. Derosier: top left Doyle Lake; top right, Portage Creek; bottom from left to right: pocketbook, freshwater sponge on rock, blackstripe topminnow, musk turtle, giant floater.

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INTRODUCTION

Michigan Natural Features Inventory (MNFI) has conducted extensive surveys of many Michigan State Parks to reconfirm historical and/or describe new occurrences of rare and unique plants, wildlife, and exemplary or otherwise notable examples of natural communities. The State Park Stewardship Program contracted with MNFI to perform these surveys in order to provide more detailed biological and ecological baseline data for Michigan State Parks and State Recreation Areas. The data resulting from these surveys will help to inform and direct decisions regarding park and recreation area use, development, and resource management. This report presents the inventory results and management recommendations for Waterloo and Pinckney Recreation Areas (WPRA).

Preliminary inventory results from multiple Michigan State Parks and Recreation Areas indicate that these areas serve as important sanctuaries that support numerous occurrences of significant natural features (i.e., rare plants, wildlife, or natural communities). For example, within the WPRA, more than 90 significant natural features occurrences are known. In some cases globally rare species have been documented within park and recreation area boundaries. For example, the only known site in the world for the Lake Huron leafhopper (*Flexamia huroni*) exists within Holly State Recreation Area. These are just a few examples, although they illustrate the importance of the Michigan State Parks system as a resource that supports and conserves significant portions of Michigan's biodiversity and natural heritage.

Michigan Natural Features Inventory is a partnership between Michigan State University Extension and the Michigan Department of Natural Resources and is part of the Natural Heritage Network (NHN). The NHN includes programs in all 50 states, Puerto Rico, Navajo Nation, 5 Canadian provinces, 13 Latin American countries, and several U.S. Bioreserves and National Parks. MNFI maintains a database of over 14,000 occurrences of state-listed as endangered, threatened, or special concern species and high quality terrestrial natural communities in Michigan. MNFI scientists use survey methodology developed by The Nature Conservancy and standardized by the NHN and its parent organization, NatureServe, to incorporate occurrences into the MNFI Biological and Conservation Database (Biotics). Biotics is Michigan's only comprehensive source for biodiversity information, and it is routinely used by multiple agencies and other organizations to aid in management, conservation, and development decisions.

The Waterloo and Pinckney Recreation Areas are rich in aquatic ecosystems. An understanding of the types of ecosystems and the species that rely on them is important in informing management. Michigan does not currently have an aquatic natural community classification. Yet, we do have classification frameworks that can be used to inform park managers.

The main goals for this work were to 1) identify aquatic ecosystem types based on available landscape-level classification frameworks, and 2) assess the overall quality and importance of the aquatic ecosystems in WPRA. Three steps were taken to accomplish these goals. First, landscape context was examined to determine potential quality for all water bodies using GIS and aerial photo interpretation. Second, a rapid aquatic community assessment (RACA) was developed based on a combination of visual assessments and direct measurements of in-stream and in-lake habitat (channel morphology, substrate, available cover, macrophytes), water chemistry, riparian and surrounding land cover and vegetation, and visible threats to aid in determining ecosystem type and quality. And third, field surveys were conducted using the RACA at lakes and stream reaches that had the greatest potential quality based on the aerial photo interpretation.

This report provides an overview of the landscape context and distribution of significant aquatic natural features in the WPRA. For a detailed description of the terrestrial landscape context, historical (circa 1800) vegetation, and distribution of significant terrestrial natural features refer to Cooper et al. (2000).

METHODS

Classification of Streams and Rivers

Because rivers and streams are longitudinal ecosystems it is difficult to determine where a stream reach or type stops and where the next one begins. To identify individual stream reaches or units of river, river valley segments (VSECs, Seelbach et al. 1997) were used as defined by the DNR Fisheries Division as of August 2007. VSECs are relatively large stretches of river that have similar hydrology, limnology, channel morphology, and riparian dynamics. VSECs often change at stream junctions or landform boundaries. VSECs use catchment size, hydrology, water chemistry, water temperature, valley character, and channel character as the basis for delineation.

To classify rivers or VSECs size, water temperature, and gradient were used. Physical, chemical, and biological changes occur on a longitudinal gradient from the headwaters to very large rivers (Vannote et al. 1980). Headwaters and small tributaries tend to be shaded and rely on energy inputs from riparian vegetation; their macroinvertebrate communities tend to be dominated by shredders, i.e. bugs that break down leaf matter. Medium rivers tend to be less shaded and rely on energy inputs from primary production; their macroinvertebrate communities tend to be dominated by grazers, i.e. bugs that feed on algae. And large rivers tend to rely on energy inputs from upstream and their macroinvertebrate communities tend to be dominated by collectors, i.e. bugs that feed on fine particulate matter in the water column. Fish, mussel, and aquatic plant communities also vary dependent on size of river. Rivers do vary from this general model (the river continuum concept), however it provides insight into how watershed size is an important factor in determining and defining river communities. Water temperature is also important because species have optimum temperature preferences. Gradient provides a measure of channel morphology which correlates to valley shape, sinuosity, water velocity, and substrate size. Hence, all three factors are important in determining species compositions in rivers.

Four size classes were defined using drainage areas of VSECs, following the Wildlife Action Plan (Eagle et al. 2005): headwaters and small tributaries are less than 40 mi^2, medium rivers are between 40 and 179 mi^2, large rivers are between 180 and 620 mi^2, and very large rivers are greater than 620 mi^2. Three classes of temperature were defined for each VSEC: cold (<19°C), cool (19-21°C), and warm (>21°C). And three classes of gradient were defined, where low were those VSECs with an average gradient less than 0.001, moderate was between 0.001 and 0.006, and high was greater than 0.006. Gradient classes were defined using the 25th and 75th percentiles of all stream reach gradients in Michigan, so less than the 25th percentile was low, greater than the 75th percentile was high, and the rest were defined as moderate. VSEC gradient is the average gradient of the reaches that make up a VSEC.

Limitations

Overall, classification requires discrete boundaries yet riverine ecosystems are a continuum. Hence river classification is inherently difficult. The main limitation to using VSECs is that the current VSEC framework is still under construction. We used the most current version (August, 2007), yet the Fisheries Division is continuing to refine and evaluate the framework. They are working on finalizing version 3. We do not expect major changes in the boundaries of the VSECs we used compared to version 3, however we do provide the reach identifier (pugap_code) so that any changes between the version that we used in this work and the final version of the VSECs can be evaluated.

Another limitation to this classification system is that stream or river habitat (in-stream cover amount and types, water quality attributes such as alkalinity, etc) are not accounted for in this classification. Streams of the same type can have very different species and habitats, which may depend on the land cover the stream flows through. For example, a cool, low gradient, headwater stream flowing through forested land cover will likely have lots of woody structure. Yet, the same type of stream flowing through a prairie fen will likely have very little woody structure, with most of the in-stream cover from overhanging vegetation. Hence, this classification is just the start to better classifying stream and river natural communities.

Classification of Ponds and Lakes

We classified lake ecosystems using Higgins et al. (1998), which was based on available GIS data. Most of the data used in this classification were queried from or calculated using queried information from available data layers. We classified lakes based on size, connectivity, and shoreline complexity; we also classified at a finer level by adding proximate geology as a factor.

These particular variables were used based on available data, literature, and expert review. Size provides a measure of the availability and types of habitat in a lake (Eagle et al. 2005). For ponds, most are shallow, un-stratified, have relatively high nutrient concentrations, and are somewhat likely to have low oxygen levels in winter. Additionally, they can either be turbid due to wind re-suspension with no rooted plants or dominated by rooted plants with clear water. Succession is also a factor with these ecosystems because over time they fill in with sediments and slowly become marsh. Small lakes can range in level of stratification from not stratified to fully stratified throughout the summer and winter oxygen levels can vary. In lakes that stratify, a true pelagic or open-water zone develops and is distinct from the shallow littoral (or nearshore) zone. Medium lakes are variable in their stratification and winter oxygen levels. They tend to have more complexity in their shoreline (lakes with many bays) and basin (lakes with more than one deep hole). Large lakes tend to be more homogenous in their chemical and biological makeup but more diverse in their habitats than smaller lakes and are dominated by the pelagic zone. Connectivity refers to if there are stream connections coming in or out of the lake. Streams can influence a lake through the input or removal of water and nutrients, as well as an exchange of species. Shoreline complexity becomes more important as lake size increases, creating more varied habitats. Proximate geology was used as a surrogate for lake hydrology. Hence, all of these factors can influence species composition and communities. Typically ponds have one community of fish, however with increasing lake size the pelagic habitat become more abundant and a pelagic community will also be present.

Size classes that Higgins et al. (1998) used were modified as follows: ponds are >2 and <= 10 acres, small lakes are >10 and <100 acres, medium lakes are >= 100 and < 1000 acres, and large lakes are >1000. These size classes generally follow Michigan's Wildlife Action Plan (ponds <5 acres, small lakes 5-99 acres, medium lakes 100-999 acres, and large >1000 acres), however we increased the size range of ponds because water bodies less than 10 acres are often treated differently than larger lakes in management; they are not traditionally surveyed or monitored.

Limitations

This classification is based on coarse available digital map data. To date there has been no ground-truthing and little analysis to determine accuracy and precision of assigned lake types in this classification. There are also many "single occurrence" lake types in this classification that may not be ecologically meaningful but artifacts of the classification process. So although there are some critical issues with using this classification, it is currently the only lake classification for Michigan that classifies all lakes and is GIS based. MDNR Fisheries Division and Michigan State University are currently working on a lake classification for Michigan, which will be broad scale in nature and based on available GIS data, as well as some in-lake water quality data.

Quality Assessment using Air Photos

Quality of stream reaches and lakes were assessed using aerial photography interpretation in the office to target surveys. Surrounding landscape and upstream areas were visually assessed using the 1998 and 2005 air photos. For rivers and streams, the GIS modeled quality assessment conducted by Wang et al. (2006) was also used to help determine quality.

Development of Rapid Aquatic Community Assessment

We used our ongoing natural community work to inform the development of a rapid aquatic community assessment (RACA). This assessment follows a similar format to that used to assess terrestrial natural communities. During the aquatic community assessment we gather information on landscape and riparian context, condition, threats, and management recommendations. We also gather biotic and abiotic data that aids in determining ecosystem type such as water temperature, size, substrate composition for streams and alkalinity, stratification, and littoral width for lakes. Although the emphasis during these ecological reconnaissance surveys was on natural communities, animal species were documented when observed.

Field Methods

Higher quality stream reaches were targeted for survey efforts. At each stream reach, water quality measurements were taken: pH, specific conductivity, alkalinity, hardness, water temperature and dissolved oxygen. The stream reach was surveyed to determine average stream width and depth, composition of macrohabitats (riffle, run, pool), substrate composition, in-stream cover types, and stream bank stability. Detailed descriptions of landscape context, condition, threats, and management recommendations were recorded. Aquatic and terrestrial species seen were also noted. A detailed site map was drawn at each stream to describe the overall habitat of the stream and surrounding area. Additionally, photographs and GPS waypoints were taken in each reach to document habitats, threats, and special notes. If mussels were present, a mussel survey was conducted to determine species composition.

Higher quality lakes were targeted for survey efforts. At each lake, water quality measurements were taken at the deepest area of the lake. Water quality and habitat parameters measured were: maximum depth, Secchi depth, pH, specific conductivity, alkalinity, hardness, and a water temperature / oxygen profile was taken to determine stratification. The littoral zone was surveyed to determine width of littoral zone, macrophyte species composition, substrate, and types and relative amount of in-lake cover. A detailed site map was drawn at each lake to describe the overall habitat of the lake and surrounding area. Photographs were taken at each lake. Aquatic and terrestrial species seen were also noted. Detailed descriptions of landscape context, condition, threats, and management recommendations were recorded.

LANDSCAPE / WATERSHED CONTEXT

Like terrestrial ecoregions, there are aquatically based regionalization frameworks to aid in understanding and managing aquatic ecosystems. Below three frameworks of different scale are described: Ecological drainage units (TNC 2001, Higgins et al. 2005), watersheds, and sub-watersheds.

Ecological Drainage Units (EDUs) are similar in concept to terrestrial ecoregions, except that they are defined by how water moves across the landscape. They are aggregates of watersheds based on hydrologic units that share similar ecological characteristics such as climate, hyrologic regime, physiography, and zoogeographic history (Table 1). Michigan has nine EDUs (Figure 1). This is the broadest scale framework described here.

Watersheds are the intermediate scale. A watershed is defined as the area of land, enclosed by a topographic divide, from which direct surface runoff from precipitation normally drains by gravity into a wetland, lake, or river. A more simplified definition is the land mass that all drains to one point. Watersheds described here are based as the 8-digit hydrologic unit (HUCs). There are 57 watersheds in Michigan, all draining to the Great Lakes (Figure 2).

Sub-watersheds, the finest regionalization, are defined here as the 12-digit HUCs, sometimes referred to as sub-basins. There are 2,319 sub-watersheds in Michigan (Figure 3). Sub-watersheds were initially delineated to break the states up into similarly sized units based on hydrology. However, they are not hydrologically accurate. A true watershed is defined by all waters draining from an area to a particular point. Sub-watershed HUCs often break up true watersheds such that a point in a sub-watershed HUC can actually get all of its water from a completely different sub-watershed HUC. We use sub-watershed HUCs as a way to summarize the data with full knowledge that the use of these units does not provide a full picture of the area needed to protect or manage for important species or ecosystems. For a detailed description of the terrestrial landscape context including ecoregions and subsections, pre-settlement context, and land use change refer to Cooper et al. (2000).

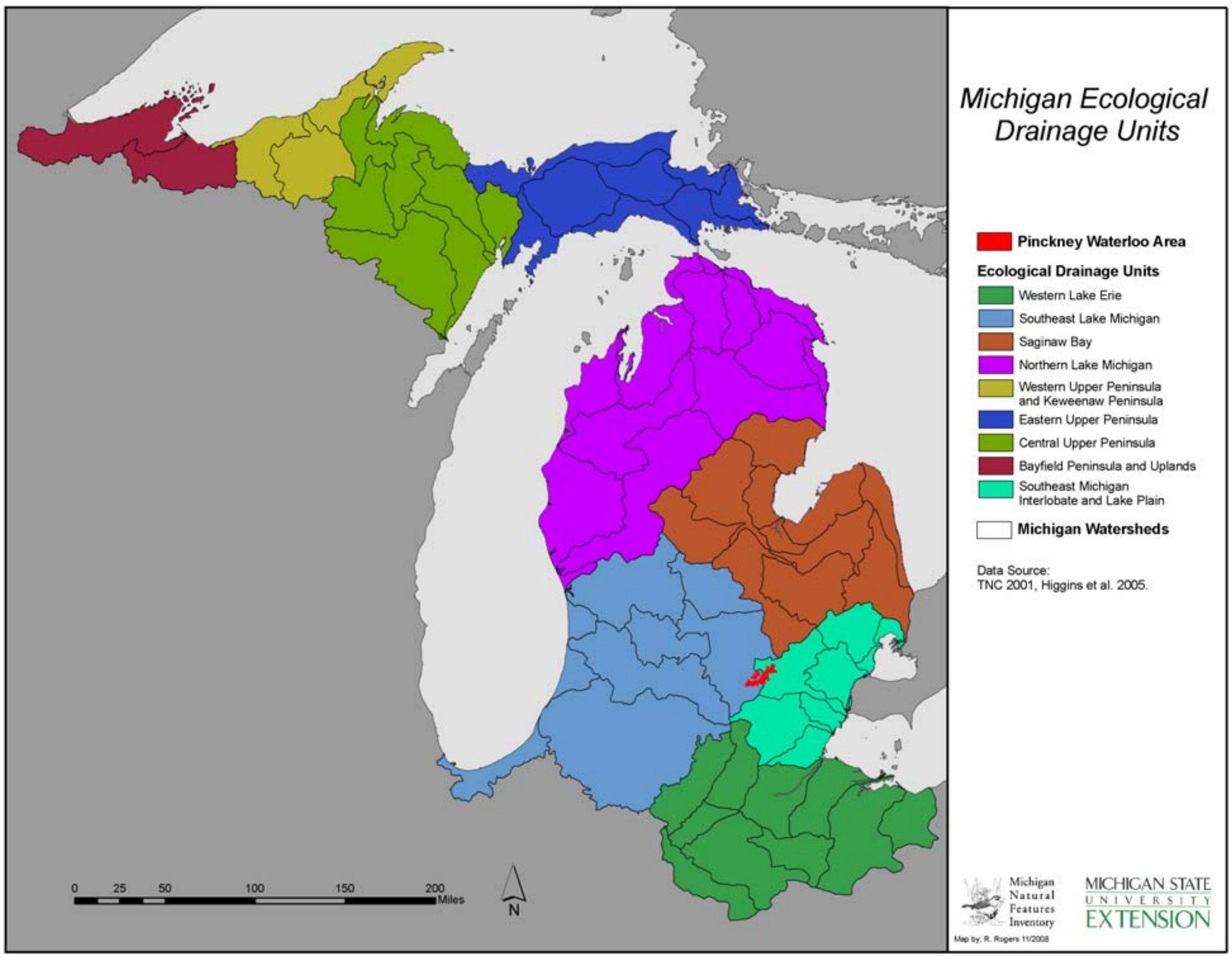

Figure 1. Ecological Drainage Units and Major Watersheds of Lower Michigan.

Table 1. Ecological Drainage Units in Michigan (TNC 2001, Higgins et al. 2005).

EDU name	Major landforms	Surface water features
Western Lake Erie	predominately lake plain and fine till plain with broad, low ridges (end moraine); localized peat deposits	low gradient surface-water fed streams, except along the glacial boundary/interlobate region where moderate gradient streams occur; most of drainage unit is part of the Maumee drainage
Southeast Lake Michigan	In north: moraine ridges; alternating bands of mostly medium textured end and ground moraines. In south: outwash with coarse textured end and ground moraine; thin strip of lacustrine sands along western Michigan (big dunes)	three major rivers: Grand, Kalamazoo, and St. Joseph all flowing east to west; kettle lakes in interlobate at east, which forms headwaters of all three systems
Saginaw Bay	predominately lake plain around Saginaw Bay and into thumb, rimmed by moraine ridges: alternating bands of mostly medium textured end and ground moraines	many intermittent streams; most perennials are part of the Saginaw River system (Cass, Bad, Tittabawassee); mostly low gradient streams with some medium gradient in headwaters
Northern Lake Michigan, Lake Huron, and Straits of Mackinac	outwash plains and ice contact features; coarse textured end and ground moraines; drumlin fields in west; lacustrine sands in east and near Great Lakes shoreline; diverse in landform and climate	kettle lakes in outwash plains; some large lakes, lakes of many geneses, intermittent streams in lake plain, many groundwater fed streams in outwash surrounded by coarse moraines and ice contact
Western Upper Peninsula and Keweenaw Peninsula	lake shore and dissected lake plain inland, shale and sandstone outcrops along Superior shore, thin till over bedrock outwash sand and gravel, bedrock outcrops also common in uplands	kettle lakes in outwash plains
Eastern Upper Peninsula	lacustrine sand plains with extensive peatlands; outwash plains and thin till over bedrock; open hills along Lake Superior shoreline, irregular plains in remainder of group	small and medium sized, low gradient streams, many of which are wetland connected; streams are underlain by deep sandy outwash deposits or sedimentary rock (limestone, sandstone, shale)
Central Upper Peninsula	level to gently rolling lowland (glacial ground moraine) overlain by undulating end moraines; outwash and lacustrine plains, limestone outcrops along Lake Michigan, sandstone outcrops on Lake Superior	numerous lakes and streams, spring ponds, springs, and wetlands; immature low density, dendritic drainages; high flows in spring and fall and low flow in summer; low gradient streams underlain by sandy outwash, limestone, or shale; kettle lakes common
Bayfield Peninsula and Uplands	clay plains along lake shore, coarse textured sandy loamy till moraines and flat to steep outwash plains with ice contact features in uplands	no lakes along clay plains, kettle lakes common and poorly developed stream drainages in uplands
Southeast Michigan Interlobate and Lake Plain	irregular plains and low hills inland; smooth, glacial lake plain toward Lake Erie and Lake St. Clair	many kettle lakes, ponds, and wetlands complexes in interlobate headwaters, few lakes on lake and till plains low gradient streams common

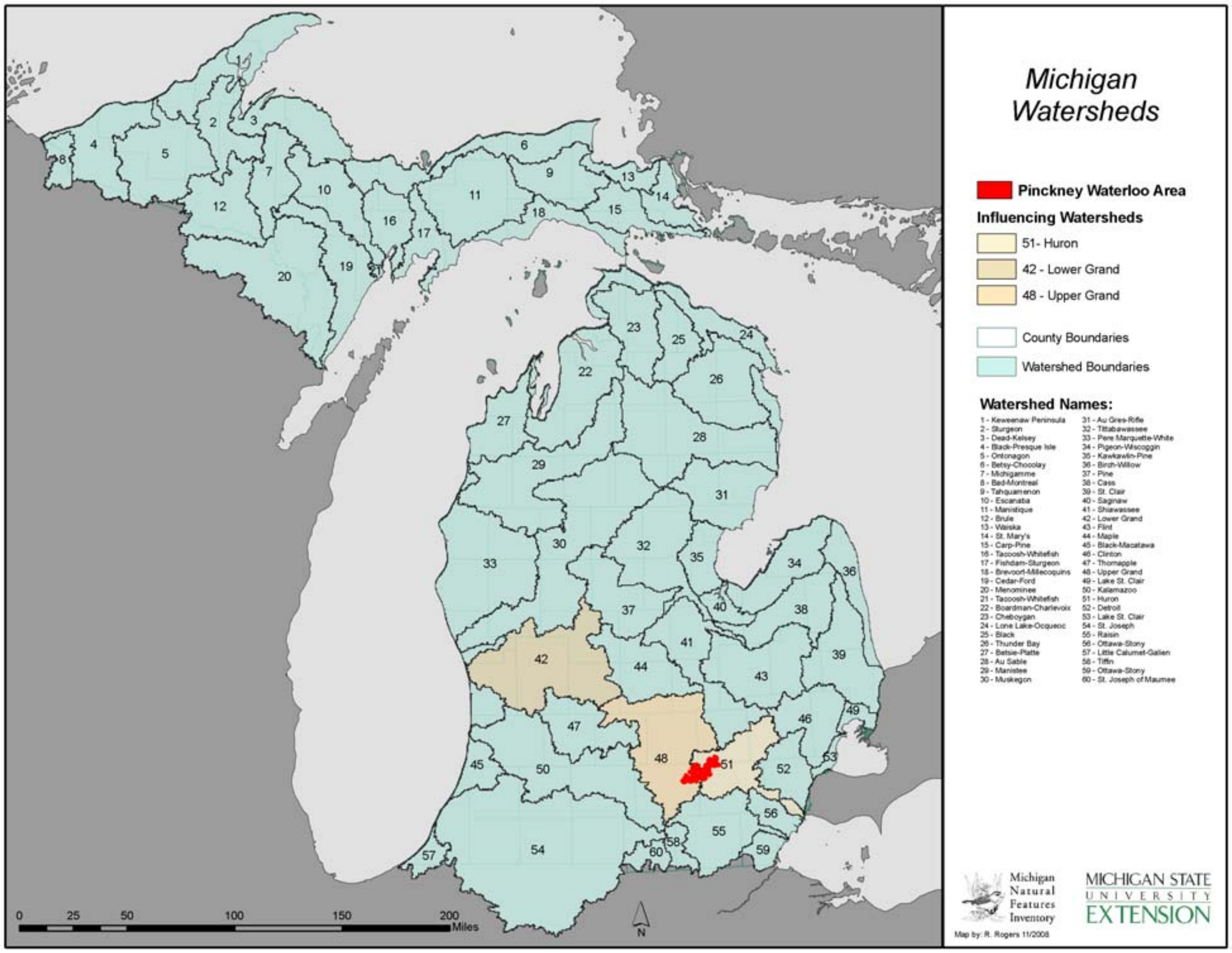

Figure 2. Watershed context of Waterloo and Pinckney Recreation Areas.

Ecological Drainage Units

The WPRA spans across two EDUs, the Southeast Michigan Interlobate and Lake Plain (SMEILP) and the Southeast Lake Michigan (SELM) EDU (Figure 1). Pinckney Recreation Area is within the SMEILP EDU, whereas Waterloo Recreation Area spans both EDUs. As such, management actions that occur in Waterloo can affect very different downstream waters. Below describes the two EDUs in more detail.

The Southeast Michigan Interlobate and Lake Plain contains most of the Lake Erie drainage in Michigan. The mean annual temperature is 48.6˚F (sd 1.1) and it has a mean annual precipitation of 30.5 inches (sd 4.8). This EDU contains many kettle lakes, ponds, and wetland complexes in the interlobate headwaters region. In the lake and till plains, there are few lakes but many low gradient streams. Historically, all streams flowed to the Ohio River via the Teays River but today they all flow into western Lake Erie and Lake St. Clair.

The Southeast Lake Michigan EDU is the southern portion of the Lake Michigan basin. Mean annual air temperatures range from 48.6 (sd 1.15) to 47.4 (sd 1.11) ˚F and mean annual precipitation is 35.1 (sd 4.9) to 31.7 (sd 4.56) inches with the rain shadow from west to east. This EDU has three major river systems (Grand, Kalamazoo, and St. Joseph) which flow east to west. There are many kettle lakes in the interlobate region to the east, which forms the headwaters of all three river systems. Historically, all waters in this region drained west out the Grand River into Lake Chicago, today all rivers flow west to southern Lake Michigan.

Watersheds

Most of the water bodies in the Waterloo Recreation Area drain into the Upper Grand River Watershed, although as small number in the north east portion of the park drain into the Huron River Watershed. The Grand River Watershed is the second largest drainage system in the State. The Upper Grand River Watershed drains about 1,750 mi^2, which then drains into the Lower Grand River Watershed and then eventually empties into Lake Michigan. The northern part of this watershed is dominated by medium textured glacial till and end moraines. These end moraines are not typically well-defined but are more low ridges and swampy depressions (Albert 1995). The southern portion of the watershed is dominated by glacial outwash sand and gravel and postglacial alluvium. The rest is made up of a mixture of coarse textured glacial till, end moraines of coarse textured till, and ice contact outwash sand and gravel. There are some extensive wetlands in this area that feed the streams and lakes in the Waterloo Recreation area, which are the headwaters to the main stem of the Grand River.

All of the water bodies in the Pinckney Recreation Area drain into the Huron River Watershed (Figure 2). The watershed drains about 900 mi^2 and empties into Lake Erie; it falls within the SMEILP EDU. This watershed was formed by the last glacial retreat and has many end moraines with associated till plains and outwash deposits. The upper basin has extensive coarse and sand materials associated with till plains and outwash deposits that provide stable base flows with lots of groundwater inputs (Anon 1977). Portions of the Huron River are designated as a Natural Rivers in Michigan. The streams and lakes in the Pinckney Recreation Area are the headwaters to the main stem of the Huron River.

Sub-Watershed Ecological Context

Waterloo and Pinckney Recreation Areas span across nine and four sub-watersheds respectively (Figure 3). Waterloo Recreation Areas falls across the following sub-watersheds: 14 12 (Portage River above Honey Creek), 14 13 (Portage River at gage #04103500), 14 14 (Portage River above Orchard Creek), 14 20 (Portage River at Wooster Road), 15 24 (North Fork at Mouth) and small portions of the following watersheds 14 5 (Grass Lake Drain), 14 6 (Grass Lake Outlet), 14 17 (Orchard Creek at gage #04110000), and 15 20 (Portage Creek at gage #04172500). Pinckney Recreation Area falls mainly in sub-watershed 15 20 (Portage Creek at gage #04172500) with smaller portions across the following sub-watersheds: 15 17 (Honey Creek at mouth), 15-21 (Huron River at gage #04173000), and 15 24 (North Fork at mouth).

The following sub-watershed analyses were conducted for the Biodiversity Assessment of Michigan Technical Report. The work examined land cover, fragmentation, and pollution metrics to describe threats to aquatic ecosystems statewide and to allow for comparisons by sub-watershed. Additionally, information on species diversity was summarized by sub-watershed to provide supplementary ecological context. Each sub-watershed was scored between a 1 and 5 using quantiles, 1 being the least disturbed or few threats and 5 being the most disturbed or sever threats. The land cover analysis was based on a combination of natural land cover for the entire sub-watershed and natural land cover within the riparian zones only. The fragmentation analysis is based on two major fragmentation issues for streams: the number of road and stream crossings and the number of dams. The pollution analysis is based on percent of impervious surfaces, number of active mines, and number of DEQ permitted point source facilities in the sub-watershed. A single metric was then pooled to describe the overall threats of a sub-watershed; a score of 3 is ranked as very good with few threats and score of 15 is ranked as poor with many threats. For more information on the methods of this analysis see Paskus et al. 2008. Below describes the details of this analysis for the sub-watersheds that the Waterloo and Pinckney Recreation Areas span.

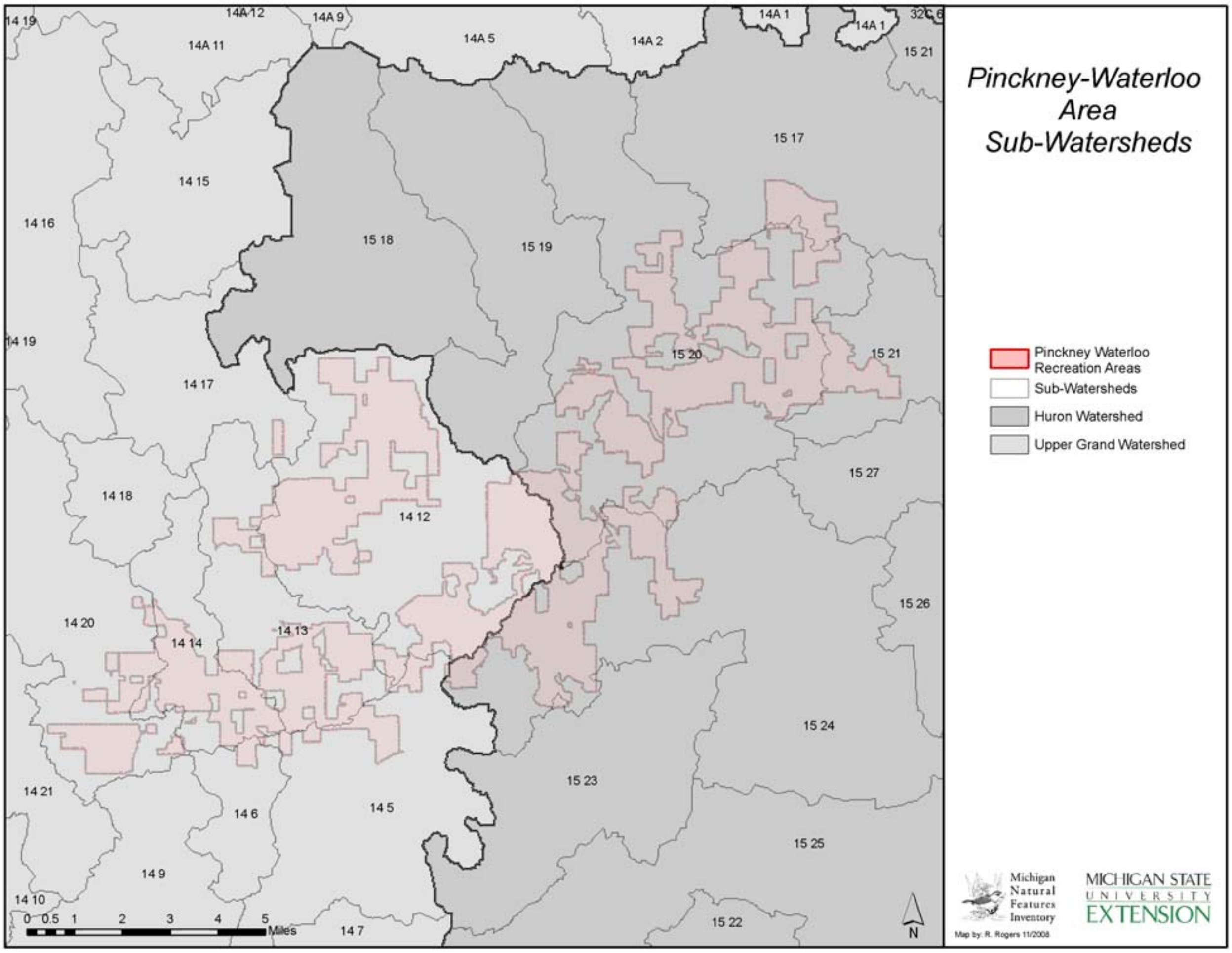

Figure 3. Sub-watershed context of Waterloo and Pinckney Recreation Areas.

Sub-watershed 14 5 (Grass Lake Drain) has an area of 19.37 mi^2. Only about 42% of the sub-watershed has natural land cover, yet when examining just riparian buffers 77% is of natural land cover. When looking across the state this sub-watershed ranks moderate-high (land cover score 3.5) in terms of threats for this factor. This sub-watershed ranked as having high threats of fragmentation and pollution (fragmentation and pollution ranks of 4.5 and 4.2, respectively). Stream and road crossings scored in the highest category with 3.24 road crossings per river mile. This sub-watershed had a high overall threat score of 12.17. No rare or species of greatest conservation need have been found in this sub-watershed.

Sub-watershed 14 6 (Grass Lake Outlet) is small and has an area of 4.62 mi^2. This sub-watersheds does not have any river miles according to the GIS data used, and hence this analysis could not be assessed.

Sub-watershed 14 12 (Portage River above Honey Creek) has an area of 26.94 mi^2. This sub-watershed has a relatively high natural land cover, with 73% total natural and 91% natural within riparian buffers. The overall land cover class was moderately good (land cover score of 2.5). This sub-watershed also scored well in the pollution analysis (pollution score 1.83). However it scored poorly in the fragmentation analysis. Stream and road crossings were low, only 0.77 per mi with a score of 2. But for dams this sub-watershed ranked a high threat with 3.86 dams per mi (score 3.5). This sub-watershed received an overall threat score of 7.83, which suggests threats are relatively low. One rare aquatic species and 5 species of greatest conservation need are known to occur in this sub-watershed.

Sub-watershed 14 13 (Portage River at gage #04103500) has an area of 12.45 mi^2. This sub-watershed also has a relatively high natural land cover, with 74% total natural and 92% natural within riparian buffers. The overall land cover class was moderately good (score of 2.5). This sub-watershed also scored well in the pollution analysis (overall score of 2.5). But it scored poorly in the fragmentation analysis due to the number of stream and road crossings (1.19 road crossings per mi, score 4). This sub-watershed received an overall threat score of 8.5, which suggests threats are moderately low. No rare aquatic species are known to occur in this sub-watershed, but 1 species of greatest conservation need has been found.

Sub-watershed 14 14 (Portage River above Orchard Creek) has an area of 12.14 mi^2. This sub-watershed has a relatively high natural land cover, with 71% total natural and 81% natural within riparian buffers. This sub-watershed had poor scores for stream and road crossings per river mile (2.11, score 5), dams per river mile (0.91, score 5), and DEQ permitted point source facilities per river mile (0.6, score 5). Hence the fragmentation analysis ranks this sub-watershed as poor or highly fragmented. The overall pollution score was 3.67, between moderate and moderately poor. The overall threat score for this sub-watershed was 11.67, which suggests that this sub-watershed has a moderately high degree of threats. No rare aquatic species are known to occur in this sub-watershed but 2 species of greatest conservation need have been found.

Sub-watershed 14 17 (Orchard Creek at gage #04110000) is relatively small, with an area of 7.89 mi^2. This sub-watershed has a relatively poor land cover context (score of 4). Only 37% of the sub-watershed has natural cover, and only 57% natural cover within riparian buffers. Yet the fragmentation and pollution analyses rank good or low threat, both scoring a 2. On the whole, this sub-watershed ranked moderately good with a score of 8 for the overall threat analysis. No rare or species of greatest conservation need have been found in this sub-watershed.

Sub-watershed 14 20 (Portage River at Wooster Road) has an area of 22.06 mi^2. The sub-watershed has moderately natural cover, with an overall score of 3; just 60% of the overall sub-watershed is natural cover and it only increases to 76% when looking at riparian buffers. Yet the fragmentation and pollution analyses scored good to very good, with an overall fragmentation score of 1.5 and an overall pollution score of 1.17. This is the best ranking sub-watershed within the Waterloo and Pinckney area with an overall threat score of 5.67. No rare or species of greatest conservation need have been found in this sub-watershed.

Sub-watershed 15 17 (Honey Creek at mouth) has an area of 27.2 mi^2. Overall this sub-watershed ranked as having moderate threats. Only 66% of the land cover is natural, yet it increases to 82% when examining only the riparian buffers, with an overall land cover score of 3. Stream and road crossings and dams both ranked high with scores of 4 and an overall pollution score of 3.67. The overall threat analysis score for this sub-watershed was 10.67 or moderately poor. Yet, three aquatic rare species and 8 species of greatest conservation need occur in this sub-watershed.

Sub-watershed 15 20 (Portage Creek at gage #04172500) is relatively large with an area of 39.83 mi^2. Scores varied quite considerably between the three types of analyses. The sub-watershed ranked as a 3 for land cover context with 73% natural cover in the whole sub-watershed and 83% in riparian buffers only. Both road and stream crossings (5.72 per mi, score 5) and number of dams (2.86 per mi, score 5) were quite high and suggests quite a bit of fragmentation in this sub-watershed. Yet the pollution analysis ranked moderately good with a score of 2.33. The overall threat analysis score for this sub-watershed was 10.33, which suggests moderately high threats. Four aquatic rare species and 10 species of greatest conservation need are known to occur in this sub-watershed.

Sub-watershed 15-21 (Huron River at gage #04173000) is quite large and has an area of 51.97 mi^2. All analyses scored moderately poor to poor. Natural land cover in the sub-watershed is 67% and only increases to 69% within riparian buffers, a very small increase. Both road and stream crossings (1.44 per mi, score 5) and number of dams (0.21 per mi, score 5) were quite high suggesting considerable fragmentation in the sub-watershed. The pollution analysis scored moderate (3.33). The overall threat analysis score for this sub-watershed was 11.83, which suggests moderate to high threats. Nine rare aquatic species and 19 species of greatest conservation need occur in this sub-watershed.

Sub-watershed 15 24 (North Fork at mouth) is also relatively large, with an area of 39.8 mi^2. Only 53% of the sub-watershed has natural land cover but it does increase to 74% for riparian buffers only. DEQ permitted point source facilities were also relatively high in this sub-watershed (0.24 per mile, score 4). Fragmentation was moderately high (score 3.5). The overall threat analysis score for this sub-watershed was 9.33, or moderate threats. One rare aquatic species and 6 species of greatest conservation need are known to occur in this sub-watershed.

Overall the sub-watersheds spanning the WPRA range from relatively undisturbed to somewhat heavily-disturbed. Impervious surfaces are a major issue for aquatic ecosystems and some suggest that watersheds with greater than 10% impervious surface land cover are severely degraded. The sub-watersheds within the WPRA ranged from 5.25% to 8.39%, suggesting that these sub-watersheds are below that threshold and hence need to be managed to ensure these sub-watersheds do not cross over the threshold.

RESULTS

Aquatic Natural Community Inventory

The Waterloo and Pinckney Recreation Areas are rich in aquatic resources (Figure 4 and Figure 5), especially ponds and lakes. There are 7 types of lake ecosystems in the WPRA (Table 2): unconnected round ponds, connected round ponds, unconnected round small lakes, connected round small lakes, connected complex shoreline small lakes, unconnected round medium lakes, and unconnected complex shoreline medium lakes. The majority of the lakes within the WPRA appear to be of higher quality based on the aerial photography interpretation. However, this analysis does not capture one of the major threats to lake ecosystems, invasive species. In general, those lakes with drive up boat launches typically have a higher threat of invasive species issues than lakes with only a hand launch. And those ponds and lakes without easy access are likely to have very low threats to their overall quality, especially due to invasive species.

Table 2. Number of lakes by type in Waterloo and Pinckney Recreation Areas.

General lake type	Lake type	Pinckney	Waterloo
untyped	untyped	2	1
1_0_1	unconnected, round pond	8	6
1_1_1	connected, round pond	1	1
2_0_1	unconnected, round small lake	10	15
2_1_1*	connected, round small lake	3	3
2_1_2	connected, complex shoreline small lake	1	0
3_0_1	unconnected, round, medium lake	2	2
3_0_2	unconnected, complex shoreline, medium lake	0	1

* uncommon type both statewide and within EDU within this group.

The majority of lotic, or running water ecosystems in the WPRA are headwater and small streams. There are 6 types of streams and rivers in WPRA (Table 3): cool low-gradient headwater or small streams, cool medium-gradient headwater or small streams, cool low-gradient medium rivers, warm low-gradient headwater or small streams, warm low-gradient medium rivers, and warm moderate-gradient medium rivers. Lotic ecosystems are more difficult to determine quality based on aerial photography interpretation because of their linkage and reliance on upstream inputs. Overall, those headwater and small streams that fall within the recreation area boundaries are of high quality. But those larger rivers that run through the recreation areas are typically of poorer quality due to the accumulation of threats from upstream.

Quality rankings are coded A through D, where A is high quality and D is poor quality.

Table 3. Number of river reaches by type in Waterloo and Pinckney Recreation Areas.

River type	River type	Pinckney	Waterloo
untyped	untyped	10	3
1_Cool_1	cool, low-gradient headwater or small stream	1	3
1_Cool_2	cool, moderate-gradient headwater or small stream	6	13
2_Cool_1	cool, low-gradient medium river	1	0
1_Warm_1	warm, low-gradient headwater or small stream	1	1
2_Warm_1	warm, low-gradient medium river	2	0
2_Warm_2	warm, moderate-gradient medium river	1	0

Waterloo Recreation Area – Lake Ecosystems

Seven lakes were visited and ranged in size from 10.03 to 77.82 acres (Table 4). Combining our photo interpretation with knowledge of boat access provides a more thorough picture of quality. However, during high water years it can be difficult to distinguish a lake from a marsh via air photos. Three of the seven lakes visited were marsh.

Lakes field surveyed were all round and unconnected. Water quality parameters didn't vary much between lakes. The pH ranged from 7.53 to 8.29 and the alkalinity ranged from 116 to 264. None of the lakes are stratified. Lakes were moderately clear with Secchi depth ranging from 2.2 to 3.1 m. The littoral zones varied in size between 15 to 40 m in width. This difference does provide for different amounts of fish and macroinvertebrate habitat within the lakes. Only 2 lakes (Walsh Lake and Doyle Lake) are ranked as higher quality based on the field surveys. Presence of invasive species or threats not identified during the air photo interpretation was the rationale for down-grading the field quality from the air photo quality. Of the four lakes, Walsh had no invasive macrophyte species observed, Cedar Lake and Doyle Lake had occasional Eurasian milfoil (*Myriphyllum spicatum*) plants, and Little Cedar Lake was dominated by Eurasian milfoil.

For a table with details on air photo quality rankings by lake see Appendix A1. For lake specific detailed accounts of field surveys and management recommendations see Appendix A3.

<u>Noteworthy Lake Communities</u>

Walsh Lake (7066) is a small, unconnected lake with a relatively narrow littoral zone that was ranked as an A/B field quality. Twelve species of dominant macrophytes were seen. Common emergent species included cat-tail (*Typha spp.*), waterwillow (*Justicia americana*), pickerelweed (*Pontederia cordata*), spatterdock (*Nuphar spp.*), and white water-lily (*Nymphaea spp.*). The dominant submergent macrophyte was coontail (*Ceratophyllum demersum*). No invasive macrophytes were seen.

Table 4. Lakes surveyed in Waterloo and Pinckney Recreation Area.

Rec Area	Lake name	Lake ID	Size (acres)	Lake type	Secchi depth (m)	pH	Alkalinity	Hardness	max depth (m)	Avg. width of littoral (m)	Air photo quality	Field quality	Comments
Pinckney	Eagle Lake	7012	6.63	1_1_1	3.0	7.82	180	200	7	12	A	A/B	
	Gosling Lake	6953	13.76	2_0_1	2.5	7.87	180	260	5	18	A	A/B	
	Losee Lake	6992	12.18	2_0_1	4.3	8.22	160	240	10	15	B/C	?	
	Pickerel Lake	6994	19.31	2_1_1	3.9	8.23	184	300	17	13	A/B	B	
	Sullivan Lake	7007	24.75	2_0_1	2.8	8.00	200	240	6	8	B?	A/B	
	Snyder Lake	7015	16.38	2_1_1	4.0	7.77	240	300	9	7	A	A/B	
	South Lake	7002	203.41	3_1_1	-	8.33	156	220	-	80	A/B	B	
	unnamed lake	6995	~3	1_1_1	2.5	7.69	228	280	4.5	12		A	
Waterloo	Baldwin Flooding	3517	32.49	2_1_1	-	-	-	-	-	-	B/C	D	Marsh
	Cedar Lake	7079	62.51	2_0_1	3.1	8.22	116	180	6	40	B?	B/C?	
	Doyle Lake	7080	15.97	2_0_1	2.6	7.80	264	320	3.5	20	A	B?	
	Little Cedar Lake	7077	10.07	2_0_1	2.2	7.53	130	160	3.5	25	A	B/C?	
	Mud Lake	3495	77.82	2_0_1	-	-	-	-	-	-	B	D	Marsh
	Walsh Lake	7066	10.13	2_1_1	-	8.29	343	200	-	15	A	A/B	
	unnamed lake	3527a	--	--	-	-	-	-	-	-	A/B	D	Marsh

*Lake type code: size_connections_shoreline complexity. Codes for size: 1 is pond, 2 is small lake, 3 is medium lake. Codes for connection: 0 is no stream connections, 1 is has stream connections. All shoreline complexities are round.

Table 5. River reaches surveyed in Waterloo and Pinckney Recreation Area. NI = noimpact, DET= detectable

Rec Area	River ID	River name	River type	Drainage Area (km^2)	Stream order	pH	Sp Cond	Alkalinity	DO	GIS quality analysis	Air photo quality	Field quality	Comment
Pinckney	Huron386	Livermore Creek	1_Cool_2	20.65	1	7.33	712	270	4.61	REF	A?	B/C	
	Huron342	Honey Creek	1_Warm_1	52.12	3	7.91	560	248	8.44	NI	B	C?	
	Huron441	Portage Creek	2_Cool_1	205.69	3	8.18	487	196	9.88	NI	A/B?	B?	
	--	trib to snyder			1	7.74	591	252	7.39	-	A	A	
	Huron-7002	unnamed				-	-	-	-	-	A?	D	no open water
Waterloo	Grand3444a	unnamed			1	-	-	-	-		A	D	stagnant
	Grand3444b	unnamed			1	-	-	-	-		A	D	wetland
	Grand3459	unnamed	1_Cool_1	73.77	2	-	-	-	-	REF	A	D	stagnant
	Grand3500	unnamed	1_Warm_1	48.95	2	7.97	740	470	7.44	NI	A/B	B	
	Grand3517	unnamed	1_Cool_2	5.53	2	-	-	-	-	NI	A/B	D	stagnant
	Grand3523	unnamed	1_Cool_2	9.92	2	8.09	758	320	10.07	DET	B	B	
	Grand3549	unnamed	1_Cool_2	4.05	1	-	-	-	-	DET	B	D	wetland
	Grand3556	unnamed	1_Cool_2	2.11	1	7.91	752	288	8.89	NI	B	A/B	
	Grand3561	unnamed	1_Cool_2	36.87	2	-	-	-	-	NI	A/B	D	stagnant
	Grand3571	unnamed	1_Cool_2	11.81	1	7.69	1124	424	8.25	NI	A	A/B	
	W7 - river	unnamed			-	-	-	-	-		A	D	stagnant

* river type code: size_temperature_gradient. Codes for size: 1 is headwater or small stream, 2 is medium stream. Codes for gradient: 1 is low gradient, 2 is moderate gradient.

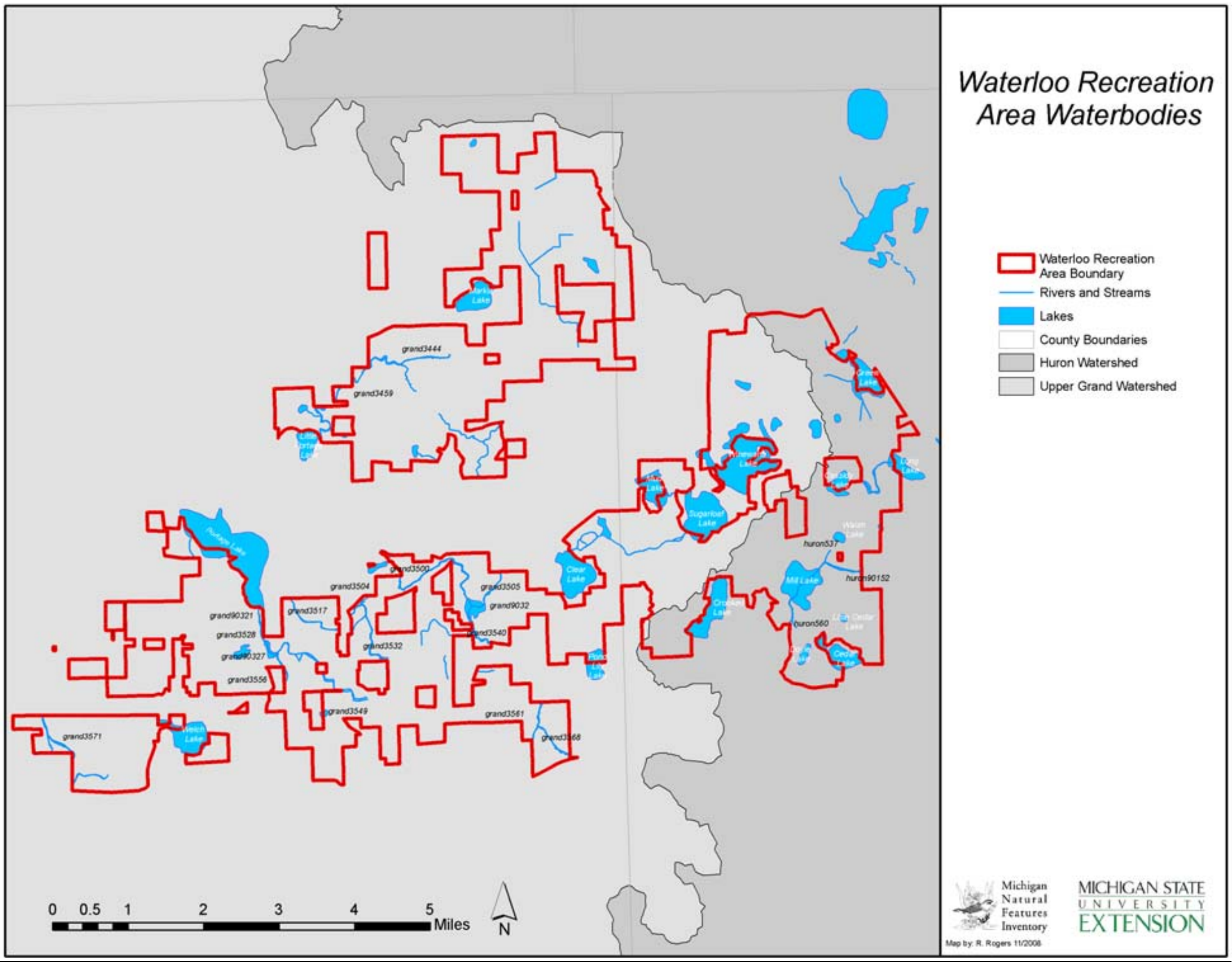

Figure 4. Locations of lakes and streams in Waterloo Recreation Area.

Doyle Lake (7080) is a pretty little, unconnected lake that is not very deep and has very low oxygen levels. Throughout the water column oxygen levels did not exceed 6 mg/l at the time of the survey. Fish need a minimum of 5 mg/l to survive and grow; and trout typically need oxygen levels above 7 gm/l. Thirteen species of common macrophytes were observed. The dominant emergent species include cat-tail, waterwillow, spadderdock, and white water-lily. The dominant submergent species include bladderwort (*Utricularia spp.*), coontail, big leaf pondweed (*Potamogeton amplifolius*), sago pondweed (*Stuckenia pectinata*), and *Chara*. Eurasian and common milfoils (*Myriophyllum spp.*) are occasionally present in this lake as well. But given the diversity of native macrophytes and the only occasional presence of Eurasian milfoil this lake is still of higher quality.

Waterloo Recreation Area - Stream Ecosystems

Eleven river reaches were field surveyed to determine in-stream quality (Table 5). They included 3 river types (cool, low-gradient, headwater or small streams, cool moderate-gradient headwater or small streams, warm low-gradient headwater or smalls streams) and were 1st or 2nd order streams. Four of the streams were of moderate to high quality. These streams had similar water quality measurements. The pH of the streams ranged from 7.69 to 8.09; alkalinity ranged from 288 to 424 µm; and dissolved oxygen content ranged from 7.44 to 10.07 mg/l. Although the water quality parameters didn't vary considerably, the available stream habitats did vary.

For a table with details on air photo quality rankings by stream see Appendix A2. For stream specific detailed accounts of field surveys and management recommendations see Appendix A3.

Noteworthy Stream Communities

Grand3500 is a warm, low gradient, small stream that flows through forested, shrub, and prairie fen-like habitat and receives some significant flows. This stream has shallow riffles, under cut banks, overhanging vegetation, woody structure, and slow moving runs with macrophytes as structure and cover. The substrate is dominated by sandy/mucky and gravel/cobble areas. Much of the substrate is covered by silt and algae cover the rocks. This stream has a lot of energy during high flows. Stream banks throughout the reach are scoured and have bare dirt and exposed roots. Important species found in this stream include seven species of native mussels, native crayfish, and freshwater sponge. Mussel species found include: fat mucket (*Lampsilis siliquoidea*), giant floater (*Pyganodon grandis*), creeper (*Strophitus undulates*), Wabash pigtoe (*Fusconaia flava*), rainbow (*Villosa iris*, special concern), round pigtoe (*Pleurobema sintoxia*, special concern), cylindrical papershell (*Anodontoides ferussacianus*, species of greatest conservation need (SGCN)). This stream was ranked as a B quality based on the field survey.

Grand3523 is a cool, moderate gradient, 2nd order stream that gently meanders through prairie fen and shrubby wetland. Substrates mainly consist of sand with some gravel and muck; silt was minimal. Structural habitat in the stream mainly consists of overhanging vegetation and shrubs, with some undercut banks and sparse macrophytes. This stream is likely groundwater fed from the fen and appears stable throughout the year. Three species of native mussel shells were found but no live individuals: cylindrical papershell (SGCN), fat mucket, and creek heelsplitter (*Lasmigona compressa*, SGCN). This stream was ranked as a B quality based on the air photos and the field survey.

Grand3571 is a very small iron seep headwater stream that drains a fen-like shrub wetland. This stream has very little and stable flows. The stream habitat in part of the stream is mainly controlled by the downed woody structure between 1 and 2 inches. Substrates are mucky with some sand and detritus. Throughout the whole reach, in-stream structure is moderate and consists of overhanging vegetation, woody structure, and sparse undercut banks. Crayfish holes were seen. This stream was ranked as an A/B quality based on the field survey.

Grand3556 is a small, cool, moderate gradient headwater stream with sandy substrates and stable flows. This stream flows through a shrubby wetland and has a tangle of shrubs along the riparian corridor. The surrounding wetland inputs quite a bit of water. The stream is likely fairly stable all year. Dominant in-stream structure mainly consists of overhanging vegetation and shrub branches, and by sparse undercut banks.

Pinckney Recreation Area – Lake Ecosystems

Eight lakes were surveyed and ranged in size from 6.63 to 203.41 acres (Table 4). Lakes surveyed ranged in quality from a B to A/B. In Snyder Lake and an unnamed lake no invasive species were observed, Sullivan Lake had a small patch of the invasive, curly pondweed (*Potamogeton crispus*), and the remaining lakes (Eagle, Gosling, Losee, Pickerel, and South lakes) had occasional patches of Eurasian milfoil.

Water quality parameters were quite similar between the lakes. The pH of the lakes sampled ranged from 7.69 to 8.33 and alkalinity ranged from 156 to 240. Lakes were relatively clear, with Secchi depths ranging from 2.5 to 4 m. Snyder and Pickerel lakes were very clear with Secchi depths of 4.0 m and 3.9 m, respectively. Littoral zone width varied between 7 m and 80 m.

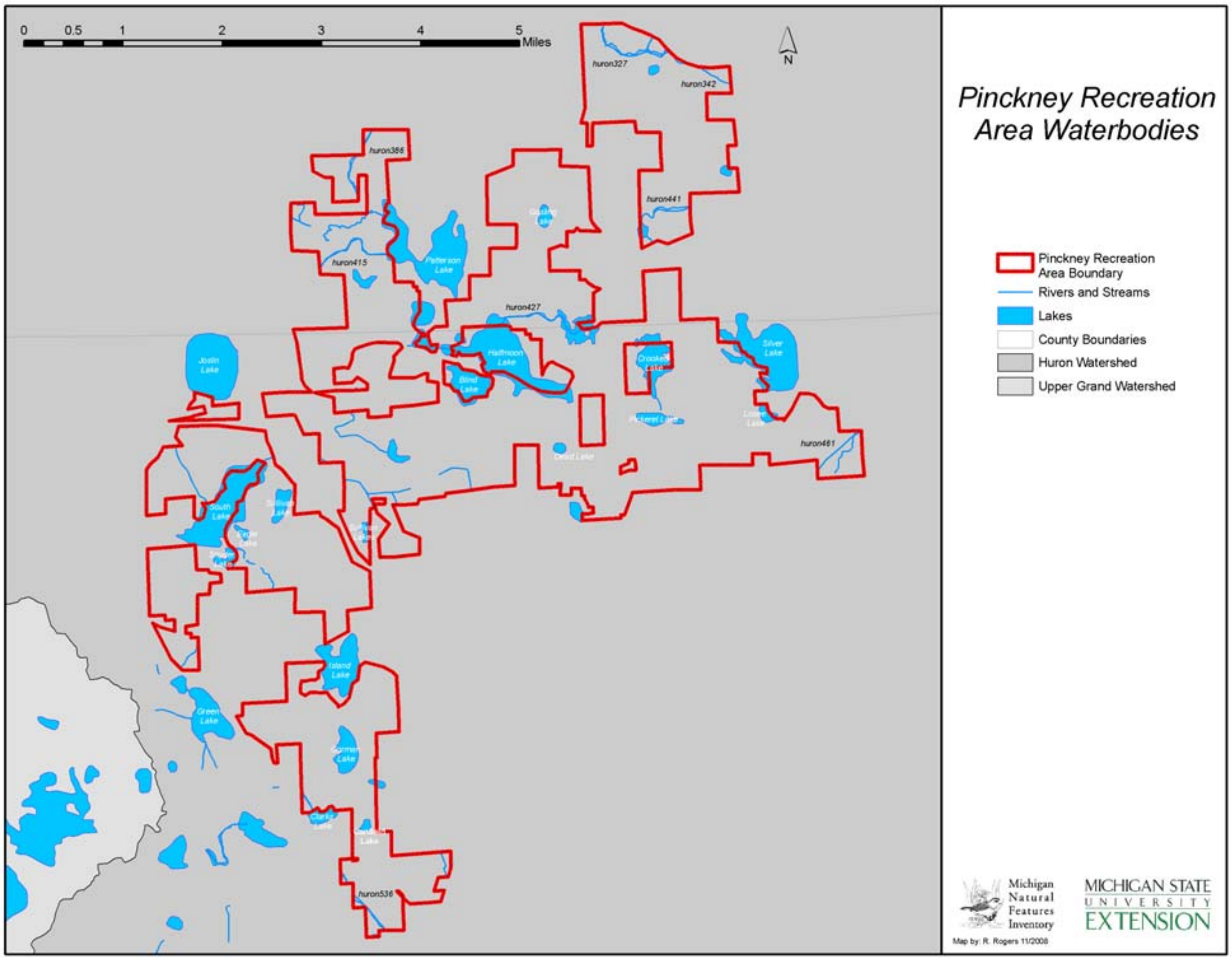

Figure 5. Locations of lakes and streams in Pinckney Recreation Area.

For a table with details on air photo quality rankings by lake see Appendix A1. For lake specific detailed accounts of field surveys and management recommendations see Appendix A4.

Noteworthy Lake Communities

Gosling Lake (6953) is a small, round, unconnected lake with an average littoral zone width (average 18 m). Fourteen macrophyte species were seen in the lake. The common emergent macrophytes are white water-lily, cat-tail, and waterwillow. Common submergent macrophytes include *Chara*, common milfoil, sago pondweed, bladderwort, coontail, and Naiad (*Najas spp.*). Eurasian milfoil was present but uncommon. Field quality was A/B.

Sullivan Lake (7007) is a small, unconnected, round lake with a narrow littoral zone, especially on the east and west shores. Fourteen species of common macrophytes were seen in the lake. The common emergent macrophytes include white water-lily, pickerelweed, hard-stem bulrush (*Schoenoplectus acutus*), waterwillow, and cat-tail. Common submergent macrophytes include *Chara*, sago pondweed, big leaf pondweed, and coontail. Curly pondweed was the only invasive species seen in the lake. This invasive macrophyte was only seen in one area of the lake and hence hand pulling may still be an effective control method. Bluegill (*Lepomis macrochirus*) and blackstriped topminnow (*Fundulus notatus*) were seen in lake. Field quality was A/B.

Eagle Lake (7012) is an oblong lake connected to South Lake. The lake has a relatively narrow and dense littoral zone and drops off quickly. Sixteen macrophyte species were observed in the lake. The common emergent macrophytes in the lake include hardstem bulrush, white water-lily, pickerelweed, and waterwillow. The common submergent macrophytes in the lake include *Chara*, common milfoil, bladderwort, and big leaf pondweed. Eurasian milfoil is present in the lake but it is rare. Field quality was A/B.

Snyder Lake (7015) is a lobed lake that drains a marsh and has quite a bit of shoreline complexity for such a small lake. This lake drains into South Lake. The lake is quite clear and has a Secchi depth of 4 m. The littoral zone is narrow and the bottom drops off quickly. Twenty species of macrophyte were seen in the lake. The common emergent macrophytes include pickerelweed, hardstem bulrush, waterwillow, spatterdock, and white water-lily. The common submergent macrophytes include coontail, common milfoil, bladderwort, big leaf pondweed, and *Chara*. Eurasian milfoil is present but it is rare. Bluegill and yellow perch (*Perca flavescens*) were common fish seen in the lake. Freshwater sponge was occasionally seen in this lake. Field quality was A/B.

South Lake (7002) is a large lake with a wide littoral zone mainly consisting of shallow, marly, sand flats. This lake drains into Joslin Lake. This lake has diverse habitats of macrophytes beds and sandy, marly flats. Eighteen species of macrophytes were found. Common emergent macrophytes include white water-lily, pickerelweed, hardstem bulrush, softstem bulrush (*Schoenoplectus tabernaemontani*), waterwillow, and cat-tail. Common submergent macrophytes include spikerush (*eleocharis spp.*) *Chara*, bladderwort, big leaf pondweed, sago pondweed, and common milfoil. Eurasian milfoil is present but uncommon in the lake. Giant floater mussels are common in the sand, marl flats. A small bit of freshwater sponge was found at the north end of the lake. This lake has more obvious threats due to the improved boat launch and the residential houses. Field quality was a B.

Unnamed Lake (6995) is a tanic-colored pond with a narrow littoral zone (average width 12 m) and a bottom that drops off fairly quickly. This lake is connected to Pickerel Lake and has low oxygen levels that drop to below 5 mg/L within the first meter of the surface. Fifteen macrophyte species were found in the lake. The common emergent macrophytes are spatterdock, white water-lily, pickerelweed, and hardstem bulrush. Common submergent macrophytes include *Chara* and bladderwort. No exotic species were seen in this lake. Of special note, this lake had the largest population of freshwater sponge of all the water bodies sampled in Waterloo and Pinckney Recreation Areas. Field quality was an A.

Pickerel Lake (6994) has a narrow littoral zone. Twelve macrophyte species were seen in the lake. The common emergent macrophytes include spatterdock, white water-lily, and hardstem bulrush. The common submergent macrophytes include *Chara*, common milfoil, and coontail. Field quality was a B.

Pinckney Recreation Area – Stream Ecosystems

Five stream reaches were visited in Pinckney Recreation Area; streams were either headwater streams or 3rd order (Table 5). The pH of the streams ranged from 7.33 to 8.18; alkalinity ranged from 196 to 270; and dissolved oxygen ranged from 4.61 to 9.88. Water quality parameters were quite similar, except Livermore Creek (huron386), which had quite low oxygen levels. Water flow in this stream was very slow, but also quite cold suggesting groundwater inputs. One of the streams was more of a marsh than a stream with macrophytes filling the channel. Only two of the stream reaches were of moderate to high quality.

For a table with details on air photo quality rankings by stream see Appendix A2. For stream specific detailed accounts of field surveys and management recommendations see Appendix A4.

Noteworthy Stream Communities

Portage Creek (huron441) is a cool, low gradient, 3rd order stream that has varied habitat and can have some significant flows. The stream substrate consists of sand, gravel, cobble, and some clay. In-stream structure consists of overhanging vegetation and shrubs, macrophytes, and wood. *Vallisneria spp*. and *Cladophora spp*. were common and sago pondweed and arrowhead (*Sagittaria spp.*) were found occasionally. The stream banks of this stream are heavily scoured with roots exposed.

This stream gets significant flows during high water. Significant animals seen include eastern spiny softshell turtle (*Apalone spinifera spinifera*), the following native mussels: pocketbook (*Lampsilis ventricosa*), spike (*Elliptio dilatata*), kidneyshell (*Ptychobranchus fasciolaris*, SGCN), fat mucket. Unfortunately, zebra mussels (*Dreissena polymorpha*) and Asian clams (*Corbicula fluminea*) were also common.

This small tributary (W-7) to Snyder Lake is a cool headwater stream that flows through a very saturated southern hardwood swamp. Much of the surrounding land was water-logged. The stream has mucky, organic substrate. In-stream structure is dominated by overhanging vegetation and shallows, but macrophytes and wood are also present. This stream appears to have very stable flows.

Rare Animal Inventory

Twenty-nine occurrences of 10 different rare animal species had been previously documented in or around the WPRA (Figure 6 and Table 6), only three, blanding's turtle (*Emys blandingii*), spotted gar (*Lepisosteus oculatus*), and wavy-rayed lampmussel (*Lampsilis fasciola*), have been documented in the last 15 years. During this survey the rainbow mussel was re-documented and one mussel species of special concern (round pigtoe), and three SGCN mussels (kidneyshell, cylindrical papershell, creek heelsplitter) were found. For detailed accounts of rainbow and round pigtoe, see Appendix 5 for special animal abstracts.

DISCUSSION

General Management Recommendations

Based on the actual and potential threats to aquatic natural features in the WPRA, general and specific management recommendations are discussed below. These recommendations are directed at preserving, enhancing, or restoring aquatic ecosystems to provide a representation of the native aquatic natural communities and species in southern Michigan.

Invasive species

The biggest threat to Michigan inland lakes is the introduction of invasive species and boat traffic is the leading vector. This threat and vector can also negatively impact connected streams. It is difficult to eradicate aquatic invasive species once established and hence curbing their introduction is crucial. Boaters need to be vigilant about removing aquatic macrophytes from boats, motors, and trailers, as well as washing or drying boats between water bodies. Educational signs, reminding boaters of these threats and what they can do, are the first line of defense. At all of the lakes sampled in the WPRA, signs describing the threats of invasive species were inadequate. At some lakes no signs were present and at others only zebra mussels were highlighted as a problem. Zebra mussels, invasive macrophytes, invasive zooplankton, and Viral Hemorrhagic Septicemia (VHS) are all potential threats to all aquatic ecosystems.

Eight of the fifteen lakes surveyed in the WPRA had Eurasian milfoil present. Eurasian milfoil is a hardy species that forms thick beds with dense canopies and mats. This species can occur in a wide range of water chemistry conditions and can over-winter in northern climates unlike native species. Eurasian milfoil reproduces rapidly by seeds and by plant fragments; a single fragment can take root and form a new colony. Because of this, once Eurasian milfoil is introduced to a lake, even small fragments of the plant caught in boat motor propellers, live wells, or other gear, can drop from the boat in other areas of the lake, speeding the spread and establishment of this plant.

Eurasian milfoil can out-compete native macrophyte species by surviving over winter and getting a head start on growth in the spring such that they block sunlight to native species just emerging. This change in species composition also changes the physical structure within a lake, which reduces the available habitat for fish that rely on native macrophytes. Additionally, Eurasian milfoil can change water quality in lakes. As these dense mats of vegetation decay they cause significant declines in oxygen resulting in anoxic conditions and leading to fish kills, as well as increased amounts of sediment. This invasive plant can also be a nuisance to recreational uses of lakes by getting tangled in boat props, and decreasing the fishing and swimming potential.

As with many invasive species, Eurasian milfoil is often first introduced in areas that have been disturbed. Individual plants are often first seen around boat launches and in disturbed areas before the plant become established. Hand pulling and removing them from the water, if all parts of the plant including fragments that break off are captured, can be an effective control method in small areas. For those lakes where there is currently no evidence of Eurasian milfoil, monitoring of boat launches and other areas of use should be a high priority to ensure Eurasian milfoil or other invasive macrophytes do not become established. Once it does become established there are a variety of management and control methods, however they all have drawbacks. Mechanical harvesting or removal is not suggested as a control method for Eurasian milfoil since it can reproduce via fragments. Drawdowns have proven effective to controlling Eurasian milfoil however this method can have negative affects on other species such as reptiles and amphibians. Several herbicides have also proven effective, but there are many non-target

Table 6. Previously known aquatic element occurrences in Waterloo and Pinckney Recreation Areas.

Map Number	State Status	First Obs.	Last Obs.	Scientific Name	Common Name
1	SC	2001-05-04	2001-05-04	Emys blandingii	Blanding's Turtle
2	T	1970	1970	Clemmys guttata	Spotted Turtle
3	SC	1994	1994-06-10	Emys blandingii	Blanding's Turtle
4	T	1970	1970-07	Clemmys guttata	Spotted Turtle
5	SC	1995	1995-05-13	Emys blandingii	Blanding's Turtle
6	SC	2003-06-22	2003-06-22	Emys blandingii	Blanding's Turtle
7	SC	2003-06-22	2003-06-22	Emys blandingii	Blanding's Turtle
8	SC	1997	1997	Lepisosteus oculatus	Spotted Gar
9	SC	1994-06-27	1994-06-27	Emys blandingii	Blanding's Turtle
10	SC	1996	1996-05-07	Emys blandingii	Blanding's Turtle
11	SC	1996	1996-06-19	Emys blandingii	Blanding's Turtle
12	SC	1994	1994-06-13	Emys blandingii	Blanding's Turtle
13	T	1965	1979	Clemmys guttata	Spotted Turtle
14	T	1973	1987	Coregonus artedi	Cisco or Lake Herring
15	T	1935	1935-05-19	Clemmys guttata	Spotted Turtle
16	T	1989?	1989?	Clemmys guttata	Spotted Turtle
17	SC	1995	1995-05-31	Emys blandingii	Blanding's Turtle
18	T	1946	1985	Coregonus artedi	Cisco or Lake Herring
19	T	1974	1974-07-28	Clemmys guttata	Spotted Turtle
20	T	1942	1983	Coregonus artedi	Cisco or Lake Herring
21	T			Clemmys guttata	Spotted Turtle
22	T	1948	1982	Coregonus artedi	Cisco or Lake Herring
23	SC	1978	1996-05-02	Emys blandingii	Blanding's Turtle
24	T	1931	1996-08-21	Lampsilis fasciola	Wavy-rayed Lampmussel
25	SC	1920-07-03	1977-07-25	Noturus miurus	Brindled Madtom
26	SC	1977	1977	Alasmidonta marginata	Elktoe
27	SC	1977-07-01	1977	Villosa iris	Rainbow
28	T	1977-07-01	1977	Lampsilis fasciola	Wavy-rayed Lampmussel
29	E	1931	1977-07-01	Epioblasma triquetra	Snuffbox

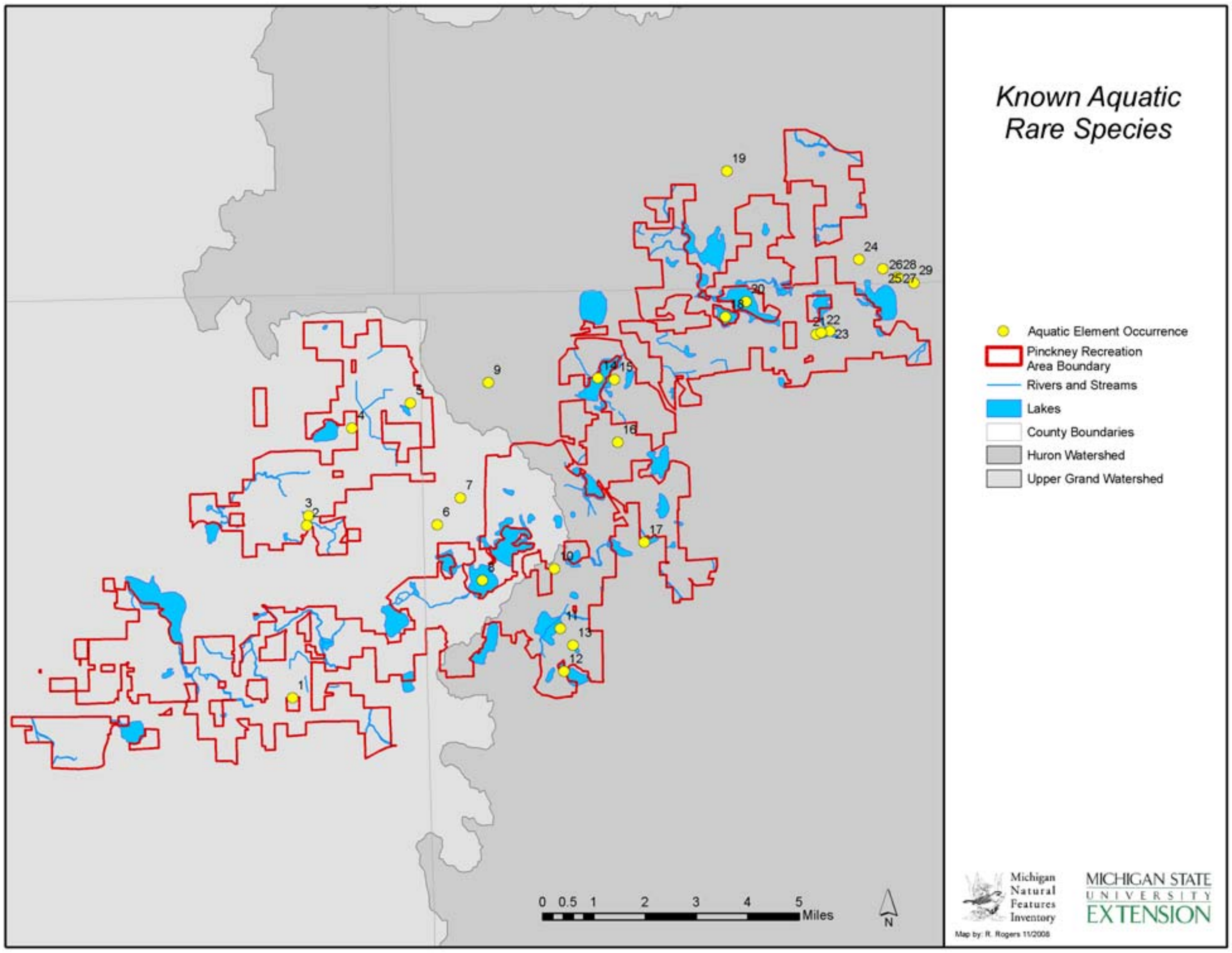

Figure 6. Locations of element occurrences within and in close proximity to Waterloo and Pinckney Recreation Areas. Specific information for each numbered occurrence is provided in Table 6.

affects to the use of chemicals. Recently, the use of the native American Weevil (*Euhrychiopsis lecontei*) has become popular. This species appears to prefer Eurasian milfoil over other available plants and spends their entire life feeding on the plant. Overall, the best way to keep Eurasian milfoil from becoming established is through education to boaters and fishers and keeping a constant vigilance towards early detection and control.

Curly pondweed was found in only one lake (Sullivan Lake) in the WPRA. This invasive species reproduces from seeds or turions (burr-like winter buds), not from fragments and so can be easier to control than Eurasian milfoil. Effective prevention relies on boaters and other lake users to be vigilant about removing plant fragments and turions from boats, motors, trailers, and gear. Since only a very small colony was found at Sullivan Lake in Pinckney Recreation Area, hand pulling may be an effective control method in this lake.

Zebra mussels are a threat to both lakes and streams. They are efficient filter feeders and can significantly alter the food web by changing water clarity and the composition of algal communities. Zebra mussels are often introduced by boat traffic and fishing gear. They can survive out of the water for up to five days. The veligers, or free-swimming larval stage, are microscopic and can go undetected in the water of bait buckets and live wells. No zebra mussels were observed in any lake sampled in the WPRA, however there is a population in Portage Creek in Pinckney Recreation Area. Zebra mussels are one of the biggest threats to native mussel species. Currently Portage Creek still has a healthy population of native mussels. However with zebra mussels in the system they are now competing for resources. Zebra mussels often use native mussels as substrate and can become so dense on the natives that they suffocate them. It is currently impossible to eradicate zebra mussels without also eradicating the native mussels. However there is new research that shows promise (Molly and Mayer 2007). In laboratory experiments this research shows that a native bacterial species found on roots of plants to protect them from rot and mildew is >90% effective at killing zebra mussels. More work is needed but this type of control may prove useful in the future. Until such a control is found, manual removal of zebra mussels from native mussel shells may be effective in helping native mussels persist.

There are a host of other aquatic invasive species that are likely present in small numbers and that will soon be coming into the state. Early detection and rapid response efforts are crucial to protecting the native aquatic resources of the WPRA and other State Parks. It is recommended that efforts focus on aquatic ecosystems that do not currently have invasive species to set up routine monitoring for early detection. It is also recommended that efforts are focused in sub-watersheds that ranked as having low threats and/or sub-watersheds with high rare and species of greatest conservation need richness.

Road crossings

Like terrestrial ecosystems, fragmentation is a major threat for streams and rivers (Jackson 2003). Dams are typically the first thing to come to mind for most people, when talking about river fragmentation, but inadequate road and stream crossings (crossings) can also be a major cause. Most crossings were installed to allow access for vehicles with little concern about the needs of stream ecosystems and biota such as natural hydrology, sediment transportation, movement of woody structure, and movement of species.

Many crossings negatively affect streams by restricting and altering hydrology, altering sediment movements, as well as creating barriers to fish and other wildlife. Over time, during different seasons, stream erosion, mechanical breakdown of the crossing, or changes upstream or downstream can change the level of impact crossings have on the stream and it's biota. Crayfish, fish, and mussels disperse and move via the stream channel. Some frogs, salamanders, and turtles (herps) spend much of their life cycle in or near streams and will travel up and down the stream corridor. If crossings are inadequate these animals will be forced to cross the road on land and are then vulnerable to traffic mortality.

Many of the streams surveyed in the recreation areas had round culvert crossings, which are not the best crossings for stream ecosystems. Many of the crossings in the recreation areas have quite a few issues, which include being undersized, too shallow, and perched. Undersized culverts can restrict flows especially during high flow events which can cause scouring and erosion of the channel. Further, this can alter hydrology in the stream and sediment movements. Culverts with very shallow water running through them can act as barriers to fish and herp movements. Perched crossings are where the culvert is above the level of the stream bottom at the downstream end. This can result from improper installation or from years of downstream erosion. In general, crossings should be open bottomed or sunk in the bed to allow for natural substrates to be available to animals in the culvert.

As a general rule, a good stream crossing will span the stream and banks, not change water velocity, have natural substrates (i.e. the streambed), and create no noticeable change in the river (MRP 2005). Closed culverts are not typically good options for stream ecosystems. Over time closed culverts, such as round culverts, can be undermined. Open arches (allowing access to substrate) or bridges are preferred over culvert crossings. These crossings, if constructed adequately, allow for functioning stream processes and require less maintenance. It is recommended that round culverts be replaced with open arches or bridges during new road projects.

When determining priorities for crossing replacements, focus efforts in sub-watersheds where fragmentation was scored low (sub-watersheds 14 17, 14 20) to help ensure fragmentation remains a minimal threat. Then focus efforts on sub-watersheds where fragmentation was scored high and rare species richness and species of greatest conservation need also ranked are high. This will focus efforts to benefit important species.

Horse crossings

Poorly designed horse and stream crossings can also be a threat to stream ecosystems. If allowed free access to the stream, horses can cause serious bank erosion and sediment issues. Horse crossings should be restricted and well designed and constructed to limit their affects on streams. Building small rock dams to create watering pools (like the one on grand3500) can be effective for watering horses and for allowing some sediment to settle before being carried downstream. It is always recommended to keep as much of the stream banks vegetated as possible. It is recommended to not de-vegetating more than 5 m of a stream bank for a horse crossing. A small amount of trampling and erosion due to horses can generally be easily absorbed by the stream but more can cause sediment load, substrate, and bar and island changes both up and downstream. Horse crossings and staging areas should maintain or replant native vegetation along the stream banks to limit erosion.

Figure 7. Horse crossing showing de-vegetated stream bank.

On grand3500, there is an inadequate horse crossing that will cause major stream bank erosion if not dealt with immediately (Figure 7 and 8). As mentioned above, the small rock dam created there appears to be well placed and small enough to not cause major changes to the stream channel. However, the stream banks at this horse crossing have been bulldozed to remove all vegetation for about 10 m on one side and 20 m on the other. This has created loose soil that will be eroded and transported downstream, especially during high flows. This practice will not only cause the loss of soil and land at the site but will change the sediment loads downstream, which may change the amount and distribution of substrates, islands, and bars in the stream channel. Replanting native vegetation along most of the stream bank at this site to limit erosion is recommended. Horse and stream crossings can be easily designed to benefit the users while not being a detriment to the stream ecosystem with just a little thought about how stream ecosystems function.

Figure 8. Horse crossing with stream bank vegetation removed. Erosion issues already visible.

Site-Specific Recommendations

For site specific recommendations, please see Appendix A3 and A4.

Monitoring and Research

It is recommended that a monitoring and early-detection program for invasive species be established at high quality lakes in WPRA. Again, invasive species are one of the biggest threats to aquatic ecosystems and species and once established they are very difficult to eradicate. Most invasive macrophytes first establish in disturbed sites. Monitoring efforts can be as simple as visiting boat launches and other access sites to look for newly introduced invasive macrophytes. Early detection is crucial to keep aquatic invasive macrophytes from becoming an issue in lakes. If invasive macrophytes are found early, hand removal can be an effective control mechanism.

For streams, monitoring of native and zebra mussel populations are important. Ideally, population estimates or some reliable index of abundance should be obtained for native mussel species in areas with zebra mussels, especially those areas where hand removal of zebra mussels is attempted as a control mechanism or stop gap until effective control methods are found.

Additional inventories are needed to locate and document more aquatic rare species and species of greatest conservation need. Rare plant and animal occurrences (e.g. herps) that use water bodies and riparian areas should also be sought during these surveys to provide a more complete context for the importance of the water bodies in the WPRA. Inventories targeting freshwater sponge are also needed.

GLOSSARY

Definitions modified from Armantrout 1998.

Alkalinity: A measure of the acid neutralizing capacity of water usually due to carbonates, biocarbonates, and hydroxide present in water.

Drainage lake: A lake with an inlet and/or outlet. Water is removed through surface connections.

Hardness: Total concentration of calcium and magnesium ions.

Secchi depth: A measure of the depth of light transparency in water.

Seepage lake: A lake without an inlet or outlet, fed by rainwater and/or groundwater. Water is lost through evaporation and groundwater.

Specific conductivity: An indirect measure of electrolytes in water, i.e. a measure of the water's ability to conduct an electric current.

Stream order: Hierarchical ordering of streams based on degree of branching. A first order stream unforked or unbranched. A second order stream is formed by two first order streams joining, and a third order stream is formed by two second order streams joining.

Stratification: The layering of water due to differences in density (e.g. temperature, salinity).

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Appendix A1

Summary of lake quality in the Waterloo and Pinckney Recreation Areas based on aerial photo interpretation

Quality analysis for lakes in the Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Lake name	TNC_ID	Acres	Road density within 500m buffer	Percent natural land cover with 500m buffer	EDU	Rarity within EDU	Rarity in State	Lake class	Airphoto_notes	Airphoto quality	Adjacent natural community	Threats
Waterloo	unnamed	3488	5.83	0.00	93.83	3	common	common	1_11_0_1	>95% of 500m buffer is natural - forested and wetland. Lake is connected to the grand3459 and in turn connected to TNC_ID 3494 (within <1.5km). Large natural community located on the north side of the lake.	hi	rich tamarack swamp - EOID 15946, EONUM 16 - surrounds 1/2 of lake	depends of stream connection. Any stocking that occurs in either grand3459 or lake 3494 this could affect the community within this lake. This stream connection could also be a conduit for invasive species. Landscape threats appear minimal.
Waterloo	unnamed	3496	5.96	0.23	90.32	3	common	common	1_11_0_1	Lake appears to be a marsh. Check?	na		
Pinckney	Canfield Lake	7049	5.44	2.31	89.85	16	common	common	1_21_0_1	This lake looks 100% natural within 250m buffer. Lake is surrounded by wetland - possibly swamp. Doesn't appear to have any access to lake.	A		minor
Pinckney	Dead Lake	6999	6.87	1.60	98.08	16	common	common	1_21_0_1	Small isoloated lake. >95% natural cover within 500 m. Mainly upland forest with a small bit of wetland. Likely difficult to access	A		none
Pinckney	Eagle Lake	7012	6.63	0.00	99.13	16	common	common	1_21_0_1	Natural surrounding landscape. Closely connected to South Lake (7002). 3/4 surrounding landscape is forested and 1/4 wetland close to South Lake.	A		7002 lake
Pinckney	Sullivan Lakes	7010	7.80	2.66	92.86	16	common	common	1_21_0_1	Over 80% of 500m buffer is natural - mainly forested and wetland. Looks Inaccessible.	A/B		road, ag? In 500m buffer
Pinckney	Sullivan Lakes	7010a	7.80	2.66	92.86	16	common	common	1_21_0_1	Over 80% of 500m buffer is natural - mainly forested and wetland. Looks Inaccessible.	A/B		road, ag? In 500m buffer
Waterloo	unnamed	3537	4.80	1.19	96.90	3	common	common	1_21_0_1	About 95% natural landcover, mainly forested in buffer. There appears to be either a stream or road to lake? The 1998 and 2005 photos show different water levels. 98 this looks like a lake in 2005 it appears to be a marsh.	A	na	the roads are the main threat and they are likely minimal impacts, the rest of the non-natural landcover is along the perimeter of the buffer
Pinckney	unnamed	6928	5.21	0.00	96.86	16	common	common	1_21_0_1	Using the 2005 air photos, the pond looks more like a marsh - no open water. Maybe able to get to it by a trail to check it out. But might not be worth it. 90-95% of 500m buffer is natural landcover. There is a road and trail within the buffer but likely a small threat.	A		low - road
Pinckney	unnamed	6943	6.03	2.55	90.52	16	common	common	1_21_0_1	Using the 2005 air photos, the pond looks more like a marsh - no open water. ~70% of 500m buffer is natural landcover. There is some ag and other (residential?) development within buffer.	B/C		ag, roads, other development

Quality analysis for lakes in the Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Lake name	TNC_ID	Acres	Road density within 500m buffer	Percent natural land cover with 500m buffer	EDU	Rarity within EDU	Rarity in State	Lake class	Airphoto_notes	Airphoto quality	Adjacent natural community	Threats
Pinckney	unnamed	6995	2.97	0.00	97.21	16	common	common	1_21_0_1	100% of 500m buffer is natural land cover. Forested and wetland. Appears to be a stream connection to Pickerel Lake (and thru to Crooked Lake)	A	Dry-mesic southern forest eoid 9296, num 34	threats are only from Pickerel Lake and Crooked Lake. Invasive species could be a proble
Pinckney	unnamed	7041	5.97	1.07	92.58	16	common	common	1_21_0_1	This lake has 2 lobes and the bigger lobe is outside of park boundaries. There appears to be a road or trail to lake on the private side. Not worth a visit			
Waterloo	unnamed	7043	4.84	1.98	98.51	3	common	common	1_21_0_1	This "lake" is sometimes connected to or affected by the Winewana Impoundment.			
Waterloo	unnamed	7074	4.50	0.00	100.00	16	common	common	1_21_0_1	Almost 100% of 500m buffer is natural - forested with some intermixed wetland(?). Doesn't appear to have any roads to lake.	A	na	none
Waterloo	Unnamed Pond near Welch Lk (little pleasant lake)	3540a	5.00			3			1_21_0_1	appears to be more of a marsh than a pond - check?	A	na	forested surrounding pond - no identifiable threats
Waterloo	Mirror Lake	7057	5.67	3.03	86.09	16	common	common	1_21_1_1	Near Cassidy Lake. Within 200 m of lake there are 2 roads and some significant development (not quite sure what it is).	C/D?		roads, development
Pinckney	unnamed	6955	7.63	5.13	98.98	16	common	common	1_21_1_1	About 25% of 500m buffer is non-natural cover (residentidal, roads). There apprears to be some residential development within 100m of lake. Difficult to determine impact to lake.	C?		residential development, roads within 500m buffer
Waterloo	Whitehead Lake	7001	3.86	1.66	86.80	3	common	common	1_42_0_1	About 1/4 of 500m buffer is non-forested, mainly ag - and this section is on the outside of the buffer. Tthis small pond in likely to have a smaller catchment area than a 500m buffer and likely the entire catchment is natural and forested, with some wetland. The pond	A		no major threats
	Blind Lake	6990	68.27	3.67	93.68	16	common	common	2_11_0_1	out of park boundaries			
Pinckney	Gosling Lake	6953	13.76	1.36	98.20	16	common	common	2_11_0_1	500m buffer is almost 100% natural landcover - forested and wetland. There is a road to access the lake and a boat launch.	A		boat launch and fishing assess
Waterloo	Markla Lake	3466	85.90	1.39	76.46	3	common	common	2_11_0_1	>95% of lake is outside of park boundary			

Quality analysis for lakes in the Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Lake name	TNC_ID	Acres	Road density within 500m buffer	Percent natural land cover with 500m buffer	EDU	Rarity within EDU	Rarity in State	Lake class	Airphoto_notes	Airphoto quality	Adjacent natural community	Threats
Waterloo	unnamed	3474	10.03	1.33	99.08	3	common	common	2_11_0_1	all of landcover withinn 500m buffer is natural - forested, wetland. There is one road on the north and east sides within the buffer but it is at the permeter of the buffer. There also appears to be a small road or trail that goes very close to the lake if not to the lake.	A	prarie fen around ~1/4 of the lake. EOID 2830, num 99	road to lake? Threats are most likley dependent upon access to the lake thru the road or path. No real threats within the landscape. May have some fishing pressure - and if so will have associated threats - introduction of exotic species, trash, shoreline modficiations due to boat launchings.
Waterloo	unnamed	3515	11.56	3.14	75.70	3	common	common	2_11_0_1	outside of park			
Waterloo	unnamed	3524	50.25	1.61	66.86	3	common	common	2_11_0_1	Unsure if this is a lake or marsh, Only about 1/2 is within park. A lof of excavation activities occurring within 500m buffer	C/D?	na	excavation activities
Pinckney	unnamed	6971	12.71	3.03	85.57	16	common	common	2_11_0_1	According to the 2005 air photos this lake has turned into a marsh. The 90's air photos showing this lake with a bit of water. Close to Kaiser Rd may be able to see it from road to determine whether it's a marsh or lake. ~80% of 500m buffer is natural land cover the rest is mainly roads and residiential development, with maybe a small bit of ag.	B/C?		road, residential development in buffer
Pinckney	unnamed	10103	14.67	1.76	95.65	16	common	common	2_11_0_1	Pretty much entire 500m buffer is natural or agriculture - not sure if this ag is just managed lands within the park or currently active ag? There is one road with in the 500m buffer - There appears to be a parking spot on Goodband Rd to the east of the lake.	B		ag maybe? Road , fishing access??
	unnamed	3494	50.37	1.25	92.53	3	common	common	2_11_1_1	not in park.			
Waterloo	unnamed	3517	32.49	1.27	88.86	3	common	common	2_11_1_1	This may not be a lake but a large marsh/stream complex. Check? About 1/5th of 500m buffer is non-natural - ag and residentail. Forested and wetlands.	mod/lo	na	ag, residential, roads
Pinckney	unnamed	6975	30.79	3.84	88.00	16	common	common	2_11_1_1	Half of lake outside of park boundaries. Although much of lake looks natural except the northern shoreline that has some development. Lake has an island.	B		residential development at northern end of lake

Quality analysis for lakes in the Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Lake name	TNC_ID	Acres	Road density within 500m buffer	Percent natural land cover with 500m buffer	EDU	Rarity within EDU	Rarity in State	Lake class	Airphoto_notes	Airphoto quality	Adjacent natural community	Threats
Pinckney	unnamed	6983	18.47	1.50	80.70	16	common	common	2_11_1_1	Connected to 6975. Maybe out of park?? Surrounding this lake land cover is natural - forested and wetland. Short stream connection to Bruin Lake	B?		Although this lake is surrounded by natrual landcover it is heavily connected to 6975 and 6976 (half moon lake) and both of these lakes have development around them. So the threats are mainly from connecting lakes.
Waterloo	Cassidy Lake	7055	38.97	2.38	96.67	16	common	common	2_21_0_1	Half of lake shoreline is residential development? Maybe a bit more than 10% within buffer is residential/developed and the rest is forested with some wetland.	C/D	na	residental/development - it takes up about half the shoreline and could have a major impact on the lake eocsystem.
Waterloo	Cedar Lake	7079	62.51	2.40	92.91	16	common	common	2_21_0_1	About 10% of buffer is residential development (southern end). There appears to be a road to the lake on the south west side. Much of the surrounding landscape is forested with some wetlands. Channel connecting 7077, no other connections can be seen.	B?	na	residential development, fishing pressure?, stocking?
Pinckney	Crooked Lake	10099	80.71	2.00	98.54	16	common	common	2_21_0_1	Only about 25% of 500m buffer is non-natural. Much of buffer is forested and wetland. There is some devleopment (resdiential) along western and s western side of the lake. But it doesn't appear to be heavy and the riparian buffer appears to be intact. For an 80 acre lake it is pretty natural.	B?	Dry-mesic southern forest, eoid 9296, num 34	residential development and roads.
Waterloo	Doyle Lake	7080	15.97	2.50	94.16	16	common	common	2_21_0_1	There is some residential within 500m buffer - but this is along a large lake (Cavanaugh Lake) - so it appears that within the catchment of this lake there is not distrubances, except a small road. Forested and wetland.	A	na	road? Does it go to lake?
Pinckney	Gorman Lake	7037	48.00	0.00	97.22	16	common	common	2_21_0_1	Greater than 95% of surrounding landcover is natural - much of it is forested but the area closer to the lake is more wetland. Coastal plain marsh at north end of lake. In the 2005 air photos very little of the lake (~1/5th) is open water. There may be walking trails to the lake?	A	coastal plain marsh, eonum 41, rank C	roads within water shed but likely minor
	Green Lake	7034	88.85	2.40	88.27	16	common	common	2_21_0_1				
Waterloo	Little Cedar Lake	7077	10.07	0.00	99.36	16	common	common	2_21_0_1	Looks to have ~100% natural vegetation within buffer. Mainly forested. There does appear to be a road to the lake (or a trail) on the north eastern side. Drains into 7079	A	na	possibly small roads but biggest threat may be the treats coming in from 7079

Quality analysis for lakes in the Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Lake name	TNC_ID	Acres	Road density within 500m buffer	Percent natural land cover with 500m buffer	EDU	Rarity within EDU	Rarity in State	Lake class	Airphoto_notes	Airphoto quality	Adjacent natural community	Threats
Pinckney	Losee Lake	6992	12.18	4.29	93.39	16	common	common	2_21_0_1	Not all of lake is in SRA. The northeastern side appears to be private but not heavily developed. The park side is quite natural, only roads are non-natuaral. Only minor development with 100m buffer - There is quite a bit more within 500 m buffer but most of that development is along Silver Lake (TNCID 7490). So that development likley affects that lake and not Lossee.	BC		residential development, roads within 500m buffer
Pinckney	Pickerel Lake	6994	19.31	0.64	97.49	16	common	common	2_21_0_1	Greater than 95% of 500m buffer is natural land cover. Mainly forest around with a small bit of wetland. There appears to be a stream connection between this lake and Crooked Lake (TNCID 10099). So there could be some threats assocated with that lake that may have the potentail to cause issues in this lake.	AB (due to inputs from crooked lake)	Dry-mesic southern forest eoid 9296, num 34; oak barrens eoid 1342, num 19;	potential threats are mainly from the residential from crooked lake and the boat launch on Pickerel. Invasive species spread could be an issue.
Pinckney	Snyder Lake	7015	16.38	0.12	95.22	16	common	common	2_21_0_1	Lake surrounded by wetland and drains into South Lake (7002). Greater than 95% of landscape appears to be natural.	A	upstream there is a southern hardwood swamp - eonum 18, B	minor threat from house/farm within 500m buffer
Pinckney	Sullivan Lake	7007	24.75	3.15	77.22	16	common	common	2_21_0_1	Much of the immedite area around lake is natural. There are 2 roads that are within 100m. Not sure if there is an access point or not - doesn't show one on map but the lake is pretty darn close to the roads.	B?		roads and ag
Waterloo	unnamed	3480	19.19	1.34	97.64	3	common	common	2_21_0_1	100% natural - forested / wetland. There is a small road that runs along the east side of the 500m buffer but it has a forested buffer and doesn't appear to be large. Lake 7043 is within 500m buffer of this lake. When looking at the 1998 and 2005 air photos there appears to be a large difference on what areas appear flooded (aquatic) and more vegetated (wetland). Hence the surrounding wetlands and lakes may vary in size dependent upon modifications in the dam management - this area is impounded - Winewana Impoundment.	B?	na	Road appears to be a mininal threat if any. Impoundment management determines connection with other waterbodies (Winewana Impoundment). Hence this lake may or may not function as natural.

Quality analysis for lakes in the Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Lake name	TNC_ID	Acres	Road density within 500m buffer	Percent natural land cover with 500m buffer	EDU	Rarity within EDU	Rarity in State	Lake class	Airphoto_notes	Airphoto quality	Adjacent natural community	Threats
Waterloo	unnamed	3482	10.63	0.00	64.52	3	common	common	2_21_0_1	This "lake" is sometimes a part of the Winewana Impoundment.	B?	na	Impoundment management determines connection with other waterbodies (Winewana Impoundment). Hence this lake may or may not function as natural.
Waterloo	unnamed	3495	77.82	4.16	78.39	3	common	common	2_21_0_1	30-40% of 500m buffer is non-natural landcover. Appears to have ag and residential, roads. Lake maybe shallow and have large macrophyte beds according to infra-red 2005 photos.	B	na	ag, residential, roads, inputs from other lakes - boat traffic - invasive species, trash, etc.
Waterloo	unnamed	3504	14.73	1.28	72.11	3	common	common	2_21_0_1	about 1/4 of 500m buffer is non-natural landcover. There is some ag, minimal residental, roads, and what looks to be a sand or gravel pit. The sand pit is less than 350m away. Natural landscape is forested and wetland. North lobe of lake may be realtively shallow and have extensive macrophyte beds whereas the southern lobe appears to have more of a pelagic zone. Stream connections, one goes to lake 10036.	B?	na	Road and sand/gravel pit is less than 150m away from wetland adjaecnt to lake. These could be impacting the lake dependent upon the lake catchement.
Waterloo	unnamed	3528	15.05	3.27	95.51	3	common	common	2_21_0_1	Greater than 98% natural within 500m buffer - mainly forested with some lowlying areas and wetlands. There are 2 roads within the buffer but they are far enough away from lake to cause any major inputs. In the 1998 air photos this lake looks to be a lake, but in the 2005 it looks more like a marsh. check?	A	na	roads are the only real threats to this lake/marsh and they are likely mininal impacts.
	unnamed	7029	12.26	2.13	84.93	16	common	common	2_21_0_1				
Pinckney	unnamed	10095	12.27	5.54	81.90	16	common	common	2_21_0_1	Large lake none of which appears to be in park boundary, heavily developed			
Waterloo	Walsh Lake	7066	10.13	1.35	99.28	16	common	common	2_21_0_1	About 5% disturbance in 500m buffer - residential,maybe small ag, and roads. The rest of landcover in buffer is forested and wetlands. Overall it looks to be a well positioned lake	A	na	Road right to lake - this could be a significant threat depending on the level of use it sees. Introdcutions, stocking, fishing pressure, trash, ect.
Pinckney	Clarks Lake	7048	21.26	3.19	85.57	16	common	common	2_21_1_1	Only half of the shoreline is within the park boundaries. Likely not worth a visit.			
Waterloo	Long Lake	7051	52.47	3.37	83.70	16	common	common	2_21_1_1	only about 5% of lakes is within park boundaries.			
Waterloo	unnamed	3527	11.56	2.49	93.22	3	common	common	2_21_1_1	Really just a marsh around a stream.			

Quality analysis for lakes in the Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Lake name	TNC_ID	Acres	Road density within 500m buffer	Percent natural land cover with 500m buffer	EDU	Rarity within EDU	Rarity in State	Lake class	Airphoto_notes	Airphoto quality	Adjacent natural community	Threats
Pinckney	unnamed	6974	46.35	4.21	93.29	16	unique	unique	2_21_1_2	About 90% of 500m buffer appears to be natural landscape. This is more a lobe of highland lake. The main part of Highland Lake is heavily developed with residential development.	C/D		Threats mainly coming from connecting lakes with lots of residential development. Invaisve species also a potentially high threat
Waterloo	unnamed	3464	13.02	0.00	97.87	3	common	common	2_42_0_1	Only ~5% of 500m buffer is ag, the rest is natrual cover (forested and wetland). The ag is along the outside perimeter of the 500m buffer and may not be within the actual catchment. Rick tamarack swamp EO surrounds 3/4 of lake. Lakes appears to have some macrophyte beds along the perimeter and > 1/2 open water.	A	rich tamarack swamp - EOID 15947, num 17 - surrounds 3/4 of lake	none
Waterloo	Crooked Lake	7072	117.14	4.83	88.58	16	common	common	3_11_0_1	Only half of the shoreline is within the SRA the rest mainly has development along it. Mainly residential but some ag. Difficult to say how much the east side of the lake affects the entire lake but it is possible that it is a signficant threat.	C/D?	Dry southern forest - EOID 10880, num 3, quality - A	development on the east side of the lake - possible phosphorus issues, … would be good to drive along to see what the impact looks like
	Joslin Lake	6989	188.81	3.45	76.75	16	common	common	3_11_0_1	80% of lake outside of park boundaries			
Pinckney	South Lake	7002	203.41	1.71	86.41	16	common	common	3_11_0_1	This lake is surrounded by >90% natural landscape. Mainly forested and wetland. Given this lakes is relativley large the natural buffer is surprising. There is an access parking area on Joslin Lake Rd.	A/B	wet mesic praire - eoid 10675, num 6, rank B	access? Fishing? Near by road
	Halfmoon Lake	6976	233.57	5.55	90.96	16	common	common	3_11_1_1	out of park boundaries			
	Portage lake	3509	395.58	3.18	80.76	3	common	common	3_11_1_1	western side may touch park lands but too large to have impact			
	Patterson Lake	6957	223.89	6.01	87.23	16	common	common	3_11_1_2	out of park boundaries			
Waterloo	Clear Lake	10036	129.90	5.08	89.31	3	common	common	3_21_0_1	80% of lake outside of park boundaries and heavily developed	D?		
Pinckney	Island Lake	10098	105.89	2.71	97.23	16	common	common	3_21_0_1	Only a small portion of entire lake is within park. North side of lake is moderately/heavily developed. Whereas the southern half is quite natural (park of park). Doesn't appear to have a public access. Not sure this is worth visiting.	C/D?		residential development in northern half of lake, road
	Sugarloaf Lake	3498	176.03	4.40	87.98	3	common	common	3_21_0_1	outside of park			
	Welch lake	3540	113.13	2.82	93.16	3	common	common	3_21_0_1	not of interest to Parks - outside of park boundaries			
Waterloo	Winewana Impoundment	3484	294.40	2.50	87.11	3	common	common	3_21_0_2	no within park boundaries			
Waterloo	Mill Lake	7070	130.23	2.54	95.92	16				80% of 500m buffer is natural - forested and some wetlands. There is some development (ag? Residential?) but roads are more of a threat. There are some fairly large roads within the buffer. There is also a road that goes straight to the lake.	B?	na	roads and use of the lake are likely the major threats to this lake. Fishing pressure, invasive species, stocking, etc.

Quality analysis for lakes in the Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Lake name	TNC_ID	Acres	Road density within 500m buffer	Percent natural land cover with 500m buffer	EDU	Rarity within EDU	Rarity in State	Lake class	Airphoto_notes	Airphoto quality	Adjacent natural community	Threats
Pinckney	Silver Lake	7490	216.86	4.39	78.21	16				Majority of lake outside of park bounds and it is heavily developed	D?		
Pinckney	unnamed	6982	5.24	4.69	94.80	16				Partially out of park boundaries. Much of surrounding landscape is natural however east shoreline near half moon lake (6976) is developed. May be accessible thru a road between this lake and half moon lake. Connected to Half Moon Lake.	B/C		Shoreline development on east side as well as inputs from stream connection to Half Moon Lake and other surrounding lakes - many of which have developemnt around shorelines.
	unnamed	10103b								Appears to be a marsh in the 2005 air photos			
Pinckney	unnamed	10103c								Surrounding landscape is wetland. Likely very difficult to get to. Natural within 250m buffer - small lake within large marsh complex - likely a sufficient buffer.	A		anything that threatens the marsh
Waterloo	unnamed	3496a								Surrounding landscape is all natural - forested and wetland. Appears very isolated. May be dry/wetland during low water years.	A	na	none
Waterloo	unnamed	3515a								This lake is within a southern wet meadow EO. Ag and roads are within catchment. Stream runs thru this lake.	B/C	southern wet meadow - EOID 13389, num 18, BC quality	roads, ag
Waterloo	unnamed	3515b								This may be more of a marsh? Within 150m there is a road, ag, and residental around this lake.	B/C	na	road, ag, residential
Waterloo	unnamed	3517a								Not sure if this is a lake or not. Check?			
Waterloo	unnamed	3524a								Difficult to determine if lake or marsh/wet - very small			
Waterloo	unnamed	3527a								This pond is a part of a chain of lakes in the grand3517 river system. Less than 1/4 of 500m buffer is non-natural - ag and small bit of residential. Forested and wetland surrounds. There is one relatively big road to the north at the perimeter of the 500m buffer.	A/B	na	road, ag, residential - do pose some threats but they are likely mininal for the lake catchment. Much of the outside influence will come from the connecting streams.
Waterloo	unnamed	3537a								likely a marsh			
Waterloo	unnamed	3537b								likely a marsh			
Waterloo	unnamed	3537c								Surrounding landscape is mainly praire fen and some forest. Wtihin the 500m buffer there is about 25% non-natural - ag mainly and some roads.	B	Prairie fen, EO ID 7086, num 77, rank B	ag, roads,
Pinckney	unnamed	6955a								Almost no development within 100 m buffer. Natural wetland and forested catchement. Small enough pond that 100m buffer is likely sufficient.	A	prairie fen EOID 2260, eonum 33	likely none - except that entire 100m catchement is not within park boundary

Quality analysis for lakes in the Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Lake name	TNC_ID	Acres	Road density within 500m buffer	Percent natural land cover with 500m buffer	EDU	Rarity within EDU	Rarity in State	Lake class	Airphoto_notes	Airphoto quality	Adjacent natural community	Threats
Pinckney	unnamed	6971a								Very small lake - maybe more of a marsh than lake. Within 100m of lake all natural forested and some marsh. Not sure this lake is accessible. Likely has a small catchment not much bigger than a 100m buffer.	B		near by roads
Pinckney	unnamed	6971b								Surrounding landscape is natural - forested with some wetlands. Does not look accessible	A		none
Pinckney	unnamed	6995a								same as 6995	A	Dry-mesic southern forest eoid 9296, num 34	same as 6995
Pinckney	unnamed	6995b								same as 6995	A	Dry-mesic southern forest eoid 9296, num 34	same as 6995
Pinckney	unnamed	6995c								same as 6995	A	Dry-mesic southern forest eoid 9296, num 34	same as 6995
Pinckney	unnamed	7015a								Small pond that drains southern hardwood swamp. Set in a marsh.	A	upstream there is a southern hardwood swamp - eonum 18, B	minor threat from embury road
Waterloo	Unnamed Pond	3528a								at least 80 natural cover. There is some ag, residential, and roads with in 500m buffer. But some of this may be outside of the actual catment. Natural cover is mainly forested with some wetland. Difficult to tell if this is more of a marsh or a lake - the different air photos portary it differently.	B	na	roads, ag, residential. Immediate threats may be minimal.
Waterloo	Unnamed Pond	3528b								looks to be a marsh			
Waterloo	Unnamed Pond	3528c								Landcover is 100% natural - however there is at least one road within the 500m buffer. There may also be small roads or trails or powerlines within buffer. Mainly forested with some wetland.	A	na	roads are the only real threat and they are likely mininal impacts.
Pinckney	Woodburn Lake	6957a								Attahced to Patterson Lake. Only western side of lake is within park boundaries. Lake is about 75% natural land cover within riparian zone. Likely little the parks can do to protect this waterbody without getting involved with the public side of things	B/C?		residential development around the lake proper and Patterson Lake. Roads

Appendix A2

Summary of stream quality in the Waterloo and Pinckney Recreation Areas based on aerial photo interpretation

Quality analysis for streams in Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Stream name	PUGAP CODE*	Reach code from NHD	River class	EDU	Drainage areas (km^2)	Stream order	Stress code^	Air photo notes	Air photo Quality	Adjacent natural community	Reach length	Threats
Pinckney		huron324	4090005000304	1_Cool_1	16	19.8558	2	NOIMPACT	Only about 256 m are in park. Connection to Trask Lake outside of park boundary (likely drains the lake). Lots of ag, roads, and some development upstreams (assuming this is the drain to Trask Lake).	C		256m	ag, road crossings, some development
Pinckney	Honey Creek	huron327	4090005000781	1_Cool_2	16	28.2861	2	REF	Portion in SRA is surrounded by all natural - forested. Section of stream outside of SRA seems to have a forested buffer but quite a bit of ag around within watershed and quite a few roads. quality may increase- if looking only within SRA but due to the reach outside it down grades it - may also depend on direction of flow.	B		>1250 m	Roads, and ag
Pinckney		huron386	4090005000323	1_Cool_2	16	20.6514	1	REF	This reach of river is completely surround by natural land cover. The headwaters of this reach drain an agricultaural landscape, but riparian buffers do look to be relatively common in the headwater areas. This reach drains into Woodburn Lake.	A?		~2km	within park the stream does cross Doyle Rd. There are two sections of the stream reach that is outside of the park boundary - acquisition might be good where possible. Threats associated with Woodburn Lake (TNCID 6957) may influence this stream as well.
Pinckney	Portage Creek	huron415	4090005000325	2_Warm_1	16	147.7332	3	NOIMPACT	~1.5km of stream is within park boundary. 100% natural landscape surrounding. Half of landscape is forested and half is wetland. Drains(?) into Woodburn Lake. Much of upstream area, outside of park boundary, is a mixture of natural and residential and some ag. But there appears to be a pretty contiguous forested riparian buffer following much of the upstream tribs and main stem. Likely difficult to get to reach.	A/B?		1.5km	Woodburn Lake could introduce threats - invasive species, other boating issues. Upstream landscpae - road crossings, residential housing, ag. But no threats within park boundaries.
Pinckney		huron427	4090005000315	2_Warm_1	16	183.9105	3	NOIMPACT	Reach is less than 1Km between Highland Lake and Half Moon Lake. Much of surrounding landscape is forested and natural. However, the threats from the two somewhat developed lakes and fishing/boat access suggests that this stream has so high threats.Road crosses street.	C		~1km	residential deveolpment issues related to Hi-Land Lake and Half Moon Lake. Road crossing also a threat.
Pinckney		huron441	4090005004938	2_Cool_1	16	205.6914	3	NOIMPACT	Reach is surrounded by forest and is in a very natural setting. Drains or feeds tncid_6955.	A/B?		~1km	All threats outside of park - roads, development, ag

Recreation Area	Stream name	PUGAP CODE*	Reach code from NHD	River class	EDU	Drainage areas (km^2)	Stream order	Stress code^	Air photo notes	Air photo Quality	Adjacent natural community	Reach length	Threats
Pinckney		huron461	4090005004794	1_Cool_2	16	11.664	1	NOIMPACT	Section of river with SRA is forested and pretty natural, however outside of the park it is impacted by quite a bit of residential development, roads, and agriculture. This reach is likely pretty high quality relatively but it is difficult to assess given the context of the river outside of the SRA. Access is likley difficult except at the Toma Rd crossing.	B/C?		~1km	None within park, outside of park - roads, residential development, ag
Pinckney		huron536	4090005000248, 4090005000248	1_Cool_2	16	10.6083	1	REF	The stream reach within the park is natural, surrounded by forest and prairie fen. However, outside of park the stream crosses roads and there is some residential development around it.	B?	prairie fen, eonum 135, rank A/B	1.2km	Outside of park - road crossings, and residential development
Pinckney		huron90135	4090005000777	-	16	183.2256	3		connection between Half Moon Lake and Watson Lake - very small reach. Natural surrounding area, but threats likely due to large lakes (Half Moon and Patterson Lakes)	C?		100m	residentiall development on connecting lakes
Pinckney	connection between Bruin Lake an d10103		4090005004779	-	16				Much of surrounding riparian buffer is natural and forested, some ag but this maybe managed fields in the park. Crosses road in 4 places. Check road crossings	B		1.5km within park, 2km to Bruin Lake	road crossings, Bruin Lake development
Pinckney	draining 10103c and 7010		4090005000211	-	16				Not sure if this is a true stream or not. May only flow when surrounding landscape is saturated. Drains large marsh and 10103c and 7010 and 7010a lakes.	A			road crossing of trib
Pinckney	draining 10103c		4090005000741	-	16				Not sure if this is a true stream or not. May only flow when surrounding landscape is saturated. Drains large marsh and 10103c lake.	A			crosses road (Hadley Rd) -check culvert for issues
Pinckney	drains southern hardwood swamp (eonum 8)		4090005004947	-	16				Drains southern hardwood swamp and flows thru a marsh and into 7015a and 7015 and finally into South Lak e (7002). May not have a full distinct channel, may have a true stream channel spotily.	A	southern hardwood swamp (eonum 8) - rank B	~1.2	adjacent road minor threat
Pinckney	drains? South Lake		4090005000768	-	16				Likely drains South Lake (7002). Riparian buffer within park. Crosses road as leaves park. Most of ripiaran close to stream is wetland.	A?		~1km	road crossing, ag practice within larger riparian buffer may be problem - but likely not (may just be mowing and that shouldn't cause much of an issue for the stream.
Waterloo		grand3444		1_Cool_1	3	67.4892	1	REF	Forested headwater stream, drains into grand3459.	A		1.2km	none

Quality analysis for streams in Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Stream name	PUGAP CODE*	Reach code from NHD	River class	EDU	Drainage areas (km^2)	Stream order	Stress code^	Air photo notes	Air photo Quality	Adjacent natural community	Reach length	Threats
Waterloo		grand3459		1_Cool_1	3	73.7685	2	REF	There is some confusion as to whether the headwater of this stream comes from on state rec property or from outside - different layers show different sources. The majority of stream reach is forested. If it's source comes from the park it is entirely forested. If from outside there is minor development (houses, ag) upstream. grand3444 drains into this stream. Stream drains into Little Portage Lake.	A	rich tamarack swamp, EOID 15946, nearby	3.7km	small bit of ag but not within 100m
Waterloo		grand3500		1_Warm_1	3	48.9474	2	NOIMPACT	There is a road that follows the river for about 1.5km and is within 100m. There are 2 roads that cross the stream. Much of the river corridor is forested and wetland. Upstream end (?) comes from a pond or a marsh.	A/B?		3.5km	road crossing, adjacent road
Waterloo		grand3504		1_Tran_2	3	0.4554	1		About 300m of stream reach are within southern wet meadow community. The upstream section of stream (headwater) is about 900m outside of SRA. 2 road crossings upstream of reach. Ag development upstream as well. Wtihin SRA surrounding landscape is mostly forested, however stream does follow stream with 60m for entire reach within SRA. This reach becomes grand3517 downstream after input of grand3532.	B	southern wet meadow - EOID 13389	300m	road crossing, ag development
Waterloo		grand3505		1_Tran_1	3	1.458	1	REF	Headwater of stream is from a small lake which is surrounded by pasture/grass and a house nearby. 1 small road crosses stream on non-SRA land. Most of stream is surrounded by forest and lowlands. Drains into pond/flooding/marsh (TNCID 3517).	A/B?		860m, whole stream	road crossing, depending on use of headwater pond this could provide a threat as well as surrounding landscape upstream of SRA
Waterloo		grand3517		1_Tran_2	3	5.5251	2	NOIMPACT	About 500m of stream is within 100m of road. Road crosses stream once. Downstream of reach is the same moderate sized development mentioned in grand3571. At the upstream end of the reach within the park boundaries there is a small pond that is not in the TNC database. Most of reach is in forested landscape a small bit looks to be in wetlands. Upstream of reach is pretty natural , with a large portion in SRA. In upstream portion there is a southern wet meadow natural community (~400m of stream reach).	A/B?	southern wet meadow - EOID 13389	1.5 km	

Recreation Area	Stream name	PUGAP CODE*	Reach code from NHD	River class	EDU	Drainage areas (km^2)	Stream order	Stress code^	Air photo notes	Air photo Quality	Adjacent natural community	Reach length	Threats
Waterloo		grand3523		1_Tran_2	3	9.9243	2	DETECTAB	connecting channel between Portage Lake and unnamed lake (3527). Fairly large road crosses stream twice. House within 150m, medium development within 400m of stream. Non-forested wetland surrounding most of stream within 100m or more.	B	praire fen- EOID 16131		development, road crossing
Waterloo		grand3532		1_Tran_2	3	3.3039	1	REF	About half of stream is within natural community. Much of land surrounding river is forested or lowland/wetland. There is a road that crosses at the upper end near the start of the stream. Stream inputs into grand3517. There is a house within 150 m of stream at the upper end but it doesn't appear to be a significant threat. Again, much of upper portion of stream is forested.	A	southern wet meadow - EOID 13389	1.3km	road crossing
Waterloo		grand3540		1_Cool_2	3	42.129	2	NOIMPACT	There is a road crossing at the border of the park. (can't really tell if it's upstream on down stream). The stream runs along the border of the park. There is agricultural activity near the stream (within 150 m) for about a third to a quarter of the stream.	B		!1.5km	road crossing, ag
Waterloo		grand3549		1_Tran_2	3	4.0518	1	DETECTAB	About 50% of riparian zone (even within 30m) is ag fields. Downstream portion is more forested and natural. Stream essentially starts in a prairie fen. Small portion in middle of reach is privately owned.	B	prairie fen - EOID 7086	2.7km	ag
Waterloo		grand3556		1_Tran_2	3	2.1051	1	NOIMPACT	One road crossing at about the middle of the reach. ~50m swath around stream that seems to be non-forested wetland or lowland. Much of surrounding landscape is wetland or forest but there is a large tract of land to the west with a house/farm (270x500m)	B	prairie fen - EOID 9954 (most of which is outside of park boundaries		
Waterloo		grand3561		1_Cool_2	3	36.8712	2	NOIMPACT	Relatively natural landscape setting. There is ag near by but it is over 300 m away. There is one road crossing. Forested all around.	A/B?	praire fen- EOID 8490	~560m	road crossing
Waterloo		grand3568		1_Cool_2	3	14.508	1	NOIMPACT	Entire stretch is forested and natural. About 1.5km upstream is outside of park - this is the headwaters of the stream. Outside of the park the stream crosses a major highway and on/off ramps 5 times. Outside of this distrubance the stream is forested.	A/B?		1.2km	road crossings upstream

Quality analysis for streams in Waterloo and Pinckney Recreation Areas based on 1998 and 2005 air photos

Recreation Area	Stream name	PUGAP CODE*	Reach code from NHD	River class	EDU	Drainage areas (km^2)	Stream order	Stress code^	Air photo notes	Air photo Quality	Adjacent natural community	Reach length	Threats
Waterloo		grand3571		1_Tran_2	3	11.8062	1	NOIMPACT	upstream section: A small road (dirt?) crosses the stream about 100 m after it starts, there is a highway about 650m away and a developed area (parking and buildings) also within a 650 m buffer of the upstream most section of stream. Downstream section: No roads cross the downstream section until the stream leaves the park. There is a wide natural buffer around this stretch of stream.	A			road crossing
Waterloo		grand3577		1_Cool_2	3	21.0897	2	NOIMPACT	Only 365 m in park boundary. Forested around. Ag within 250 m but only a small bit.	A/B		~365	road crossings upstream and down potentail to influence. Ag?
Waterloo	North Fork Mill Creek	huron537		1_Cool_2	16	21.2265	1	NOIMPACT	The reach of rivers is surrounded by forest, but one road does bisect it. It drains/or inputs into Mill Lake. Outside of park up/down stream is developed with ag and other? if draining from lake - hi? If inputing into lake mod-lo	B?		800m	road crossing, possbily development/ag
Waterloo	North Fork Mill Creek	huron560		1_Tran_2	16	9.6462	1	REF	Forested headwater stream. Inputs into Mill Lake.	A		700m (all?)	Development around Cavanaugh Lake within 250m
		huron342	4090005000303	1_Warm_1	16	52.1163	3	NOIMPACT	Mainly forested or wetland riparian along stretch within SRA. Reach does cross road twice. Depending on which direction the stream flows may determine quality. To the east of the park there is quite a bit of agriculture and residential development, including roads	B (A - if looking only within SRA but due to the reach outside it down grades it - may also depend on direction of flow.		>1650 m	roads, ag and residential outside of park
		huron386a		-	16				This stream doesn't show up on the epastar or new nhd shapefiles - not sure if it is a true stream or just a part of the wetland. Surrounding landscae is 100% natural and encompasses entire reach that was delineated in the parks shapefile.	A (although not sure if true stream or not)			
		huron436		2_Warm_2	16	177.9066	3	NOIMPACT	Connecting channel between 6976 and 6983. too small - not worth visiting				
		huron487		1_Tran_2	16	3.3147	1	NOIMPACT	Very little (~300m) of stream is in park - not worth visiting.				
		huron502		1_Tran_2	16	1.3365	1	NOIMPACT	Stream connecting 7057 and 7051 lakes. 100% natural riparian - one road crossing.				

*PUGAP CODE is from aquatic GAP analysis conducted for the Great Lakes

^ Stress code is from analysis conducted by Wang et al. 2006

Appendix A3

Detailed descriptions of surveyed lakes and rivers in Waterloo Recreation Area

Appendix A3
Waterloo Recreation Area

Streams 2
Grand3500 2
Grand3523 5
Grand3556 7
Grand3571 9
Lakes 10
Lakes 11
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Doyle Lake, 7080 13
Little Cedar Lake, 7077 15
Walsh Lake, 7066 16

Streams

Grand3500

Type: warm, low gradient, small stream
Order: 2nd   Drainage area: 48.95 km^2
Sub-watershed: 14 13 (Portage River at gage #04103500)








Quality
GIS analysis: no impact
Air photo analysis: AB
Field survey: B

General characteristics of stream

Parameter	Value	Parmeter	Value	Parameter	Value
Water temp	23.4 ºC	pH	7.97	% riffle	30
DO	7.44	Alkalinity	470	% run	40
spCond	7.44	Hardness	320	% pool	30

This warm, second order stream meanders through forested, shrub, and prairie fen-like habitats. The riparian land forms range from low wetlands to more hilly upland forests. The surrounding landscape, especially within the riparian buffer is natural and much of it is undisturbed. It has a variety of different in-stream habitats that include shallow riffles, under cut banks, overhanging vegetation, woody structure, and slow-moving run areas with macrophytes such as spadderdock (*Nuphar spp.*) and water celery *(Vallensinaria Americana*). This low-base flow stream appears to be quite high-energy during high flows, likely during spring run off. The stream banks throughout the surveyed reach are scoured and have bare dirt and roots exposed. Stream bank height ranges from less than a foot to over a 1.5 m. The stream channel is relatively stable and does have some sand and gravel bars throughout the reach. Substrates are varied, but are dominated by sandy/mucky and gravel/cobble. Much of the substrate is covered by silt and algae in rocky areas. The riparian canopy over the stream ranges from totally enclosed to quite open in prairie fen-like areas. Adding to the variety of habitats, water flows vary between very slow in deeper lake-like sections to quite fast across riffles.

The biotic community within the reach surveyed is as varied as the habitat. Native mussel shell were common and included: fat mucket (*Lampsilis siliquoidea*), giant floater (*Pyganodon grandis*), creeper (*Strophitus undulates*), Wabash pigtoe (*Fusconaia flava*), rainbow (*Villosa iris*, special concern), round pigtoe (*Pleurobema sintoxia*, special concern), cylindrical papershell (*Anodontoides ferussacianus*, species of greatest conservation need). Native crayfish, snail, and dragonfly were present. Frogs were common along the stream banks, jumping into the stream when disturbed. Fish were abundant and included: largemouth bass (*Mircopterus salmodies*), bluegill (*Lepomis macrolatus*), pickerel or pike (*Esox spp*.), northern hog sucker (*Hypentelium nigricans*), Carp (*Cyprinus carpio*), northern logperch (*Percina caprodes semifasciata*), as well as minnows and likely darters. Largemouth bass were abundant and there were quite a few individuals of significant size. Of special note, a colony of freshwater sponge was found (see bottom left picture). It was relatively small (~5x5inches) and found on a ~7 inch diameter cobble and a couple pieces of gravel. A small patch was also found on a spent mussel shell and a large boulder.

Management recommendations
There is a horse crossing just upstream of Seymour Road that has the potential for becoming a significant threat to the stream and the biota within the stream. There is a small hand-made dam using rocks to create a pool for horses to water. However, at the crossing, about 20 m of one stream bank and 10 m of the other stream bank have been bulldozed and all vegetation has been removed (see pictures below). With the potential energy that this stream appears to get during high flows, this crossing is going to become an issue for the stream and the horse crossing area. With the un-stabilized bank and high energy flow, much of the stream bank will be eroded away and swept downstream.

It is recommended that the stream crossing be a small as possible. The small hand-made dam to create a pool for the horses to water is a natural way to accommodate different uses. However, for the stream banks and crossing to remain stable, management actions to stabilize the banks are needed. Stream side vegetation should be maintained or re-planted.




Grand3523

Type: cool, moderate gradient, small stream
Order: 2^{nd} Drainage area: 9.92 km^2
Sub-watershed: 14 14 (Portage River above Orchard Creek)
Nearby natural community: Prairie fen (EOID 16131)






Quality
GIS analysis: detectable
Air photo analysis: B/C
Field survey: B

General characteristics of stream

Parameter	Value	Parmeter	Value	Parameter	Value
Water temp	14.5 ºC	pH	8.09	% riffle	10
DO	10.07	Alkalinity	320	% run	70
spCond	758	Hardness	440	% pool	20

This cool, clear, second order stream gently meanders through prairie fen and shrubby wetland and drains into Portage Lake. This narrow stream (average stream width of 3 m) is relatively straight due to the low gradient wetland that it runs through. The GIS data layer suggests that this is moderate gradient, but it is really quite low. The stream reach mainly consists of sand, with some gravel and a bit of muck. Silt was minimal in this stretch. Overall cover in the reach was extensive and consists of overhanging vegetation, undercut banks, shallows, woody structure, and some sparse macrophytes [water celery (*Vallinsenaria Americana)*, watercress (*Nasturtium officinale*), grass-leaved pondweed (*Potamogeton gramineus*) and Illinois pondweed (*Potamogeton illinoensis*). Overhanging grasses and shrubs [e.g., silky dogwood (*Cornus amomum*) and gray dogwood (*Cornus foemina*)] were the main in-stream cover. Stream banks are stable and are fully vegetated with grasses and shrubs. There was some natural undercutting of stream banks. Stream likely gets much of its water through groundwater and infiltration from the fen. There are a few iron seeps scattered in the reach.

The biotic community noted during the survey included frogs, spent native mussel shells from cylindrical papershell (*Anodontoides ferussacianus)*, fat mucket (*Lampsilis siliquoidea)*, creek heelsplitter (*Lasmigona compressa, SGCN*), and a great blue heron (*Ardea herodias*). No fish were seen.

Management recommendations
The main threats to this stream are the inadequate stream and road crossings and the adjacent roads. The Seymour Road crossing is a concrete box bridge that is generally adequate. However, the Willis Road crossing is a small round culvert that is not big enough for the channel. This culvert is restricting flows and altering sediment movements.

The walking bridge across the stream off of Willis Road has a dam constructed of 2 or 3 boards. This dam doesn't appear to be really holding back water. There is some undercutting of the concrete platform at the upstream end, which may become an issue for the dam and bridge by undermining it's integrity. It is recommended that when it comes time to upgrade this bridge that the dam and concrete platform is removed and the bridge is constructed to allow for the stream channel to shift.





Grand3556

Type: transitional, moderate gradient, headwater stream
Order: 1st Drainage area: 2.1 km^2
Sub-watershed: 14 14 (Portage River above Orchard Creek)



Quality
GIS analysis: no impact
Air photo analysis: B
Field survey: A/B

General characteristics of stream

Parameter	Value	Parmeter	Value	Parameter	Value
Water temp	15.0 ºC	pH	7.91	% riffle	0
DO	8.89	Alkalinity	288	% run	90
spCond	752	Hardness	240	% pool	10

This small, sandy, stable stream flows through a prairie fen-like wetland in a tangle of shrubs. The surrounding fen is quite wet and there are small seeps inputting quite a bit of water when it rains and may throughout the summer. This silt-free stream has an average width of 2 m and is about 0.2 m in depth. There are some undercut banks providing some cover and habitat, although much of the in-stream cover is dominated by overhanging vegetation and shrub branches. There is some residential housing nearby and managed grasslands but much of the surrounding landscape is forested.

Management recommendations
The major threats to this stream are the culvert (see below photos) and road that runs along the stream for a short distance. The existing culvert restricts water and sediment flows; water is pooling up behind the upstream side of the culvert. This culvert should be replaced with a more adequate road crossing. Additionally, the dirt

road may pose a threat if the road is oiled often. It is recommended that the road section near the road crossing and where the road follows the stream not be oiled down. This type of pollution can have significant negative impacts of stream biota.

Grand3571

Type: cool, moderate gradient, headwater stream
Order: 1st Drainage area: 11.81 km^2
Sub-watershed: 14 20 (Portage River at Wooster Road



Quality
GIS analysis: no impact
Air photo analysis: A
Field survey: A/B (with well designed culvert could be an A)

General characteristics of stream

Parameter	Value	Parmeter	Value	Parameter	Value
Water temp	14.9ºC	pH	7.69	% riffle	0
DO	8.25	Alkalinity	424	% run	95
spCond	1124 ?	Hardness	480	% pool	5

This small iron seep stream drains a prairie-shrub wetland. This iron seep is narrow, with an average width of 2 m and an average depth of about 2 inches, and has little habitat for fish. However, frogs along the stream bank were abundant and included wood frog (*Rana sylvatica*) and bull frog (*Rana catesbeiana*). The complexity of the stream channel is driven by the woody structure in and crossing the stream. No riffles are present in the reach surveyed and pools were shallow and generally a result of water flowing over woody structure. Most of the downed woody structure in this stream are between 1-2 inches. Substrates in this stream are mainly muck (50%), sand (20%), detritus (20%), and coarse detritus (10%). Substrates were moderately covered by fines. Overall cover is moderate and included overhanging vegetation, shallows, woody structure, and sparse undercut banks. Stream banks are stable and flows are likely always low. There is evidence of water levels getting 1 ft higher than base flow. Other species of note: adult *Chaborus sp*., Gerridae, and evidence of crayfish (holes along bank).

Management recommendations

The only threat to this stream reach is the culvert crossing Upton Road (see below photos). The ~2 ft round culvert is not adequate for this stream. The culvert has created a pool upstream of the road crossing. Additionally, the stream bed has been undercut and now the bottom of the round culvert is within only a couple of inches of the water surface, yet the stream bed is much deeper. On the downstream side of the road, the culvert is perched and there is at least a 4 inch drop to the water surface. When possible, replacing this stream crossing with an adequate culvert or bridge would allow for natural exchange of water flows and sediment between the stream and its headwater wetland.

Lakes

Cedar Lake, 7079

Type: Seepage, round small lake in ice-contact outwash sand and gravel geology (2_21_0_1)
Size: 62.51 acres
Common type
Sub-watershed: 15 24 (North Fork at mouth)






Quality
Air photo analysis: B?
Overall field ranking: B/C?

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	20 ft	pH	8.22	Sp. Cond.	233
Secchi depth (m)	3.1	Alkalinity	116	Stratified	No
Water color	10	Hardness	108	Avg. littoral width (m)	40

This clear, sandy lake has a wide littoral zone (average ~40 m width) and a diverse macrophyte community that is sparse to moderate. About 10% of the shoreline is lined by houses. Most houses have docks and boats. The rest of the shoreline is forested and natural. The lake bottom gently slopes. Oxygen levels drop off quickly; between 3 and 4 m dissolved oxygen drops to below 5 mg/l, which is where fish begin having trouble. *Chara* is the dominant plant but white water-lily (*Nymphaea spp*.), pickerelweed (*Pontederia cordata*), waterwillow (*Justicia americana*), Spatterdock (*Nuphar spp*.), soft-stem bulrush (*Schoenoplectus tabernaemontani*), and unknown grass (*Scirpus*) are also common. The following macrophytes were less common: Eurasian milfoil (*Myriophylllum spicatum*), eelgrass pondweed (*Potamogeton zosteriformis*), watershield (*Brasenia schreberi*), common pondweed (*Potamogeton natans*), grass-leaved pondweed (*Potamogeton gramineus*), water celery (*Vallisneria americana*), big leaf pondweed (*Potamogeton amplifolius*), and *Najas*. Although Eurasian milfoil is present, it is only occasionally seen. Given the relative diverse macrophyte community it is difficult to say if Eurasian milfoil has significantly disrupted the ecosystem. Boat traffic, fishing pressure, invasive species, and residential housing are all threats to this lake. Boat traffic can stir up sediments and release nutrients back into the water column, as well as introduce exotic species. The residential housing may increase nutrient inputs via lawn fertilizers or malfunctioning septic systems. These things need to be considered when determining the quality of this lake. Because of these ever present threats this lake was ranked as a B/C? quality.

Other species seen include: mute swans (*Cygnus olor*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and giant floater (*Pyganodon grandis*).

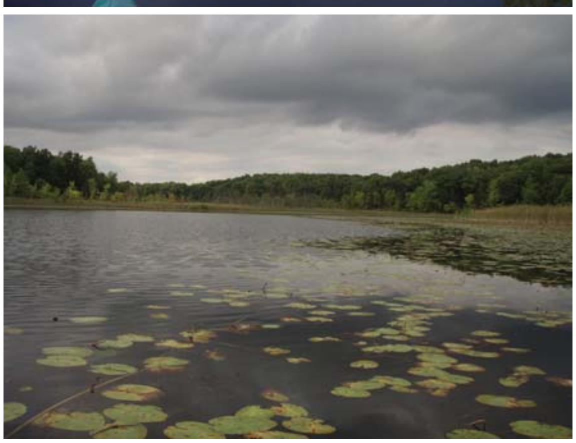
Management recommendations
Eurasian milfoil and other aquatic invasive species introduced by boat traffic is a major threat to all water bodies. It is critical to educate the public boat launch users of this threat. It is recommended that educational signs be installed at the Cedar Lake boat launch reminding boaters to wash their boats and remove vegetation.

Doyle Lake, 7080

Type: Seepage, round small lake in ice-contact outwash sand and gravel geology (2_21_0_1)
Size: 15.97 acres
Common type
Sub-watershed: 15 24 (North Fork at mouth)








Quality
Air photo analysis: A
Overall field ranking: B?

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	12 ft	pH	7.80	Sp. Cond.	632
Secchi depth (m)	2.6	Alkalinity	264	Stratified	No
Water color	5	Hardness	192	Avg. littoral width (m)	20

This pretty little lake is not very deep and has quite low oxygen levels. The lake basin is gently sloping and has mucky organic substrates. Throughout the water column oxygen levels only reach to 5.65 mg/l; 5 mg/l is where fish begin to have trouble surviving. The surrounding landscape is forested with some wetlands adjacent. There are quite a few tamarcks surrounding the lake. The macrophyte community is fairly diverse; common species include Spatterdock (*Nuphar spp*.), white water-lily (*Nymphaea spp*.), bladderwort (*Utricularia spp*.), coontail (*Ceratophyllum demersum*), big leaf pondweed (*Potamogeton amplifolius*), sago pondweed (*Stuckenia pectinata*), waterwillow (*Justicia americana*), Cat-tail (*Typha spp*.), and *Chara*. Colonies of coontail is localized around the lake. Other macrophytes seen include: common milfoil (*Myriophyllum spp*.), common pondweed (*Potamogeton natans*), *Najas*, and Eurasian milfoil (*Myriophylllum spicatum*). Although Eurasian milfoil is present, it is still a minor component of the macrophyte community. Bluegill (*Lepomis macrochirus*) were commonly seen in the lake, as well as frogs.

Management recommendations
Eurasian milfoil and other aquatic invasive species introduced by boat traffic is a major threat to all water bodies. It is critical to educate the public boat launch users of this threat. It is recommended that educational signs be installed at the Cedar Lake boat launch reminding boaters to wash their boats and remove vegetation.

Additionally, it is recommended that a more permanent dock structure be installed. Currently, the hand launch at the lake has disturbed the shore due to the hap-hazard nature of the existing structures (see photo below). It is recommended that the launch continue to be only a hand launch and by installing a more permanent structure shoreline disturbance can be abated.

Little Cedar Lake, 7077

Type: Seepage, round small lake in ice-contact outwash sand and gravel geology (2_21_0_1)
Size: 10.07 acres
Common type
Sub-watershed: 15 24 (North Fork at mouth)






Quality
Air photo analysis: A
Overall field ranking: B/C

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	12 ft	pH	7.53	Sp. Cond.	253
Secchi depth (m)	2.2	Alkalinity	130	Stratified	No
Water color	5	Hardness	96	Avg. littoral width (m)	25

This small, sheltered lake has mucky, organic substrate and relatively dense macrophytes. The littoral zone is quite large, with an average width of 25 m. The north shoreline is a bit boggy, where as the rest of the shoreline appears dryer. There is small bay on the west side of the lake that is thick with Spatterdock *(Nuphar spp.)* and white water-lily *(Nymphaea spp.)* and very shallow. The surrounding landscape is 100% natural. The shoreline is dominated by shrubs, whereas the riparian area has forest, shrub, and wetland. There is a connecting channel to Cedar Lake (where the launch is located) and it appears to get quite a bit of boat traffic. Oxygen levels are quite low in the lake and is only above 5 mg/l within the first 2 m of water. The outside of the lake is rimmed by cat-tail *(Typha spp.)*, three-sided sedge (*Dulichium arundinaceum*), waterwillow (*Justicia americana*), and pickerelweed (*Pontederia cordata*). Other common macrophytes in the lake include: white water-lily, Spatterdock, Eurasian milfoil (*Myriophylllum spicatum*), bladderwort (*Utricularia spp*.), big leaf pondweed (*Potamogeton amplifolius*). Other macrophytes seen in lake include: common milfoil (*Myriophyllum spp*.), common pondweed (*Potamogeton natans*), watersheild (*Brasenia schreberi*), and eelgrass pondweed (*Potamogeton zosteriformis*). Eurasian milfoil was more dominant in this lake than the connecting Cedar Lake. There were mats of uprooted Eurasian milfoil on the water surface. This exotic may be more common in this lake due to its sheltered nature and the rich organic substrates, as well as the absence of *Chara*.

Eurasian milfoil is dominant in this lake, but overall macrophyte diversity is still quite high. It is difficult to determine the overall impact of the introduction of Eurasian milfoil has had on this lake. As a note, the connection between this lake and Cedar Lake is relatively large and well traveled by boaters. Hence, any threat to this lake is a threat to Cedar Lake and vise versa.

Two mute swans (*Cygnus olor*) were seen at the lake as well as muskrat (*Ondatra zibethicus*). Mute swans are not native to Michigan and may pose significant threats to common loon (*Gavia immer*), trumpeter swan (*Cygnus buccinator*), and other waterfowl and waterbirds. Mute swans are quite aggressive and have been known to drive off other birds from nesting and feeding areas.

Management recommendations

Eurasian milfoil and other aquatic invasive species introduced by boat traffic is a major threat to all water bodies. It is critical to educate the public boat launch users of this threat. It is recommended that educational signs be installed at the Cedar Lake boat launch reminding boaters to wash their boats and remove vegetation.

Walsh Lake, 7066

Type: Connected, round small lake in ice-contact outwash sand and gravel geology (2_21_1_1)
Size: 10.13 acres
Common type
Sub-watershed: 15 24 (North Fork at mouth)






Quality
Air photo analysis: A
Field survey: A/B

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	--	pH	8.29	Sp. Cond.	343
Secchi depth (m)	--	Alkalinity	188	Stratified	--
Water color	--	Hardness	120	Avg. littoral width (m)	15

This small lake has a relatively narrow littoral zone and a diverse macrophyte community. The surrounding landscape within a 500 m buffer is ~95% natural with forests and wetlands. There is only a small bit of residential land use, potentially some agriculture, and roads. Cat-tail (*Typha spp*.), waterwillow (*Justicia americana*), Spatterdock (*Nuphar spp*.), white water-lily (*Nymphaea spp*.), pickerelweed (*Pontederia cordata*), and coontail (*Ceratophyllum demersum*) were common macrophytes in the lake. Other macrophytes seen include: eelgrass pondweed (*Potamogeton zosteriformis*), common milfoil (*Myriophyllum spp*.), bladderwort (*Utricularia spp*.), *Najas*, arum, crowfoot (*Rununculus spp*.) and big leaf pondweed (*Potamogeton amplifolius*).

Management recommendations

The only threat to this lake is the boat launch. It is recommended that more prominent signs be displayed to highlight the threat of invasive species to lakes, including zebra mussels and invasive macrophytes.

Appendix A4

Detailed descriptions of surveyed lakes and rivers in Pinckney Recreation Area

Appendix A4
Pinckney Recreation Area

Streams 2
Honey Creek, Huron342 3
Livermore Creek, Huron386 5
Portage Creek, Huron441 7
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Lakes 11
Eagle Lake, 7012 11
Gosling Lake, 6953 13
Losee Lake, 6992 15
Pickerel Lake, 6994 17
Snyder Lake, 7015 19
South Lake, 7002 21
Sullivan Lake, 7007 22
Unnamed Lake, 6995 25

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Streams

Honey Creek, Huron342

Type: warm, low gradient, small stream
Order: 3rd Drainage area: 52.12 km^2
Sub-watershed: 15 17 (Honey Creek at mouth)




Quality
GIS analysis: no impact
Air photo analysis: AB
Field survey: C

General characteristics of stream

Parameter	Value	Parmeter	Value	Parameter	Value
Water temp	16.9 ºC	pH	7.91	% riffle	0
DO	8.44	Alkalinity	248	% run	100
spCond	560	Hardness	204	% pool	0

This slow moving stream is quite wide (average 8 m) and has silty, mucky substrates. In places the water appears stagnant. Stream banks are either grass hummocks or somewhat unstable, eroded mud. The surrounding landscape is mixed; north of the river there is some residential, other development, roads, and possibly agriculture, whereas the southern part of the watershed has wetland and forested land cover. Much of the residential houses are sparse with large mowed lawns. Habitat in the stream includes overhanging vegetation, roots, woody structure, and some shallows and macrophytes. The dominant macrophyte is *Nuphar spp*, *Sparganium spp*. (bur-reed) is also present.

Management recommendations

Due to the varied land cover within the watershed of this reach, there are many inputs that the Parks and Recreation Division can not manage. However, by keeping the riparian area natural, this aids in providing habitat for fish and macroinvertebrates, as well as other animals. The Lakeland Trail bridges appear to be adequate and allow the stream room to swell and move. However, the culvert on the main road is too small for the stream channel and is causing water to pool up. The right culvert design for road and stream crossings is important to streams to ensure natural exchange of flow, sediment, and animal movement.

Livermore Creek, Huron386

Type: cold, moderate gradient, headwater stream
Order: 1st   Drainage area: 20.65 km^2
Sub-watershed: 15 20 (Portage Creek at gage #04172500)




Quality
GIS analysis: ref
Air photo analysis: A?
Field survey: B/C?

General characteristics of stream

Parameter	Value	Parmeter	Value	Parameter	Value
Water temp	15.5 ºC	pH	7.33	% riffle	0
DO	4.61	Alkalinity	270	% run	100
spCond	712	Hardness	228	% pool	0

This is a deep (average 0.5 m), fairly wide (average 4 m), cold stream that runs through a grassy marsh. The GIS data suggests this as a cool water stream but it appears to be cold water according to the field data. The stream banks are grassy hummocks that are quite stable. The water flows in this stream in late summer are quite slow and oxygen levels are very low. Typically fish need oxygen levels over 5 mg/l to effectively survive. Overhanging vegetation from stream banks are the dominant cover in the stream, and macrophytes and woody structure are occasionally present. Substrates consist of a mixture of sand, gravel, clay, and mud/muck and the substrate is covered with moderate silt. This stream must get quite a bit of groundwater input given the cold water even with the very slow flows. Duckweed (*Lemna spp.*), coontail (*Ceratophyllum demersum*), and a sedge were abundant in this stream reach, further demonstrating the slow flows. The landscape context of this stream is quite natural.

In both the GIS analysis and the air photo analysis this stream was ranked as likely high quality. The field quality ranking is based on the very slow flows and on the low oxygen levels. Because a full natural community classification has not been described it is difficult to determine if this is the streams natural state or if there is some external influence creating the low oxygen.

Management recommendations
The only real visible threat to the stream is the road; but this is a relatively minor threat since the bridge is adequate and allows for natural flows of water and sediment. It is important to continue to keep the surrounding landscape natural.

Portage Creek, Huron441

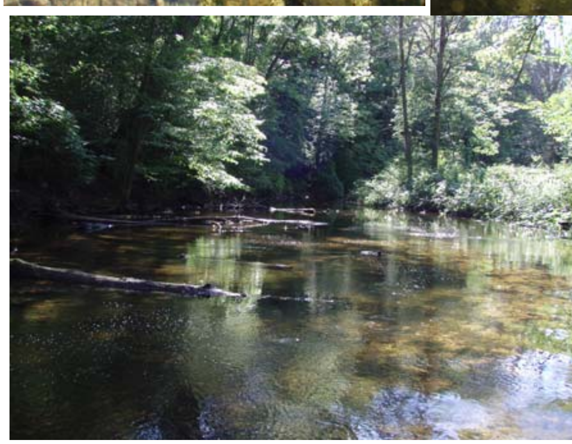
Type: cool, low gradient, medium stream
Order: 3rd   Drainage area: 205.69 km^2
Sub-watershed: 15 20 (Portage Creek at gage #04172500)









General characteristics of stream

Parameter	Value	Parmeter	Value	Parameter	Value
Water temp	22.7 ºC	pH	8.18	% riffle	0
DO	9.88	Alkalinity	196	% run	80
spCond	487	Hardness	156	% pool	20

This wide (average 10 m), sand/ gravel stream has lots of varied habitats and good flow. Water depth is also varied; on average water depth is about 0.3 m but there are areas of the stream where it is ankle deep, as well as over 0.5 m. Substrates consist mainly of sand with gravel, cobble, and clay mixed in. Structural habitat is abundant and includes overhanging vegetation and shrubs, macrophytes, and woody structure. *Vallisneria spp*. and *Cladophora spp.* are common and sago pondweed (Stuckenia pectinata) (*Stuckenia pectinata*) and arum (*Peltandra virginicum*) are found occasionally. This stream appears to have a lot of energy moving through it during high flows given the heavily scoured stream banks. Roots are often exposed along the banks. But these flows are likely natural given there is a small lake (TNCID 6955) upstream of the reach which should help buffer the stream from extreme flows due to upstream impervious surfaces. The landscape surrounding this reach is natural and mainly forested with deciduous trees and pine plantations. This is a beautiful stream reach.

Lots of animals were observed during the survey. Bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), northern hog suckers (*Hypentelium nigricans*), and a small black striped minnow were seen. A fairly large (~10" in diameter) spiny soft shell turtle (*Apalone spinifera spinifera*) was observed, as well as many frogs. Tricoptera caddisfly were abundant on all rocks and mussel shell; waterpenny (Psephenidae) were also observed. Native mussels were fairly abundant. Live mussels found include: spike (*Elliptio dilatata*), pocketbook (*Lampsilis ventricosa*), kidneyshell (*Ptychobranchus fasciolaris*, SGCN), Fatmucket (*Lampsilis siliquidea*). Unfortunately, zebra mussel (*Dreissena polymorpha*) and Asiatic clams (*Corbicula fluminea*) are also common in the stream. There were at least 3 zebra mussels on each live native mussel found. At this point, zebra mussels are not so abundant that they are killing native mussels but this is always a concern when the two co-exist. Typically Asiatic clam have a minor affect on native mussels.

Management recommendations

The horse/ foot bridge crossing the stream seems adequate. Large rocks have been used to stabilize the stream banks under the bridge, and they have been relatively successful. But due to the high energy flows of this stream, it is a good idea to monitor the bridge to ensure that it stays intact and adequate. There is an area on the north side of the stream next to the bridge where horses are watered. So far, this hasn't created too much of an erosional issue. However, it is recommended that the impact be kept contained to ensure that the stream bank isn't damaged to badly. Because this can not only cause issues for the stream but also for the bridge since the impact is just upstream of the bridge.

Because of the diverse native mussel community in this stream it is important to monitor the infestation of zebra mussels. Zebra mussels are a huge threat to native mussels. They compete for food but zebra mussels also use the native mussels as substrate and can colonize native mussels to such an extent that the native mussels are suffocated. Monitoring is needed here. This may also be a good site to conduct some experiments to look at how well zebra mussel removal from native mussels can be used as a management technique to help the native mussel persist until a more long term control method is developed.

Tributary to Snyder Creek

Type: cold, low gradient, headwater stream
Order: 1st Drainage area:
Sub-watershed: 15 20 (Portage Creek at gage #04172500)




Quality
GIS analysis: na
Air photo analysis: A
Field survey: A

General characteristics of stream

Parameter	Value	Parmeter	Value	Parameter	Value
Water temp	15.8 ºC	pH	7.74	% riffle	0
DO	7.39	Alkalinity	252	% run	90
spCond	591	Hardness	216	% pool	10

This small, marsh stream is surrounded by a very saturated southern hardwood swamp (B-ranked). In many areas along the stream banks the ground was floating on water. The narrow-channel (average width 1 m) stream strongly meanders through the swamp and has quite a bit of water flowing through it. There are quite a few small inlet streams running throughout the swamp to the stream, although no water was present in them at the time of the survey. These channels may only have water running through them at very high flows given that the surrounding land was water logged. The stream has organic, mucky substrates and cover types are dominated by overhanging vegetation, shallows, but macrophytes and woody structure are also present. Bur-reed (*Sparganium spp*.) were present. Stream banks are quite stable.

Management recommendations
The only management issue at this stream reach is the stream / road crossing. The culvert is too small and is currently restricting flows, both water and sediment. At the upstream end of the culvert water is pooled up, yet only about 4 in of water is going through the culvert when the water is at least 10 in deep. Water is eroding under the culvert. It is suggested that when possible the culvert be replaced by a more adequate stream / road crossing. Inadequate stream / road crossings can alter hydrology, sediment movements, and species movements.


Lakes

Eagle Lake, 7012

Type: Connected, round, pond in ice-contact outwash sand and gravel geology (1_21_1_1)
Size: 6.6 acres
Common type
Sub-watershed: 15 20 (Portage Creek at gage #04172500)




Quality
Air photo analysis: A
Field survey: A/B

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	6.7	pH	7.82	Sp. Cond.	365
Secchi depth (m)	~3*	Alkalinity	180	Stratified	No
Water color	5	Hardness	120	Avg. littoral width (m)	12

*lost Secchi disk

This oblong lake has a relatively narrow and dense littoral zone. The bottom of the lake drops off quickly; within 10 m from shore the lake depth drops to over 3.5 m. Surrounding landscape is forested and wetland. There is a very narrow and shallow channel that connects this lake with South Lake (TNCID

7002), which limits boat traffic. Only very small boats and canoe/kayaks can pass through the channel. Macrophytes are the main cover in this lake. *Chara* and hardstem bulrush (*Schoenoplectus acutus*) are the dominant macrophytes in this lake, other common species include common milfoil (*Myriophyllum spp.*), bladderwort (*Utricularia spp.*), big leaf pondweed (*Potamogeton amplifolius*), White water-lily *(Nymphaea spp.)*, pickerelweed (*Pontederia cordata*), and waterwillow (*Justicia Americana*). Other macrophytes observed include Eurasian milfoil (*Myriophyllum spicatum*), *Najas spp.*, coontail (*Ceratophyllum demersum*), sago pondweed (*Stuckenia pectinata*), common pondweed (*Potamogeton natans*), eelgrass pondweed (*Potamogeton zosteriformis*), *Spatterdock (Nuphar spp.)*, and cat-tail (*Typha spp*.). Eurasian milfoil is rare in this lake. Hence the extent of disruption from this exotic, invasive plant is unknown. There is still quite a bit of diversity of macrophytes within the lake. *Chara* may be limiting Eurasian milfoil. Other species seen in this lake are bluegill (*Lepomis macrochirus*), pickerel/pike (*Esox sp.*), and minnows.

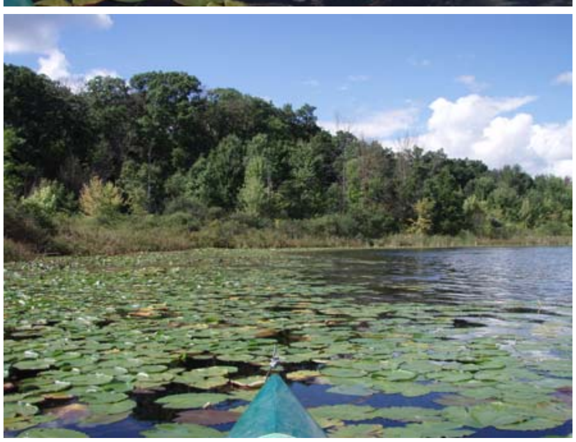
Management recommendations
Invasive species introductions through boat traffic from South Lake are the major threat to this pond. More prominent signs on the threats of invasive species via boat traffic is needed at the South Lake launch. Invasive species (macrophytes, zebra mussels, zooplankton, and others) are the major threats to aquatic ecosystems today. And education is one of the few ways to help limit this threat.

Gosling Lake, 6953

Type: Seepage, round small lake in outwash sand and gravel geology (2_11_0_1)
Size: 13.8 acres
Common type
Sub-watershed: 15 20 (Portage Creek at gage #04172500)








Quality
Air photo analysis: A
Field survey: A/B

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	17 ft	pH	7.87	Sp. Cond.	375
Secchi depth (m)	2.5	Alkalinity	180	Stratified	no
Water color	5	Hardness	156	Avg. littoral width (m)	18

This small lake is surrounded by shrub and forest and has a relatively diverse macrophyte community with a littoral zone average width of 18m. White water-lily *(Nymphaea spp.)* is the dominate macrophyte around the lake and common macrophytes include: *Chara*, common milfoil (*Myriophyllum spp*.), sago pondweed (*Stuckenia pectinata*), bladderwort (*Utricularia spp*.), coontail (*Ceratophyllum demersum*), *Najas*, cat-tail (*Typha spp*.), waterwillow (*Justicia americana*). Other macrophytes present in the lake include eelgrass pondweed (*Potamogeton zosteriformis*), big leaf pondweed (*Potamogeton amplifolius*), Spatterdock *(Nuphar spp.)*, pickerelweed (*Pontederia cordata*), and the exotic Eurasian milfoil (*Myriophyllum spicatum*). Although Eurasian milfoil is present in the lake it is uncommon and does not appear to have changed the macrophyte community dramatically. Other species seen include: blackstripe topminnow (*Fundulus notatus*), bluegill (*Lepomis macrochirus*), and Great blue heron (*Ardea herodias*).

Management recommendations
The biggest threat to any small lake, especially ones that have boating and fishing activity, is invasive species. Measures should be taken to help keep more invasive plants and other animals out of this lake. Currently there are no signs at the boat launch warning about cleaning off boats and making people aware of the threat. Signs are important reminders that everyone has a role in stopping invasive species.

Losee Lake, 6992

Type: Seepage, round, small lake in ice-contact outwash sand and gravel geology (2_21_0_1)
Size: 12.2 acres
Common type
Sub-watershed: 15 21 (Huron River at gage #04173000)





Quality
Air photo analysis: B/C
Field survey: ?

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	10	pH	8.22	Sp. Cond.	--
Secchi depth (m)	34.3	Alkalinity	160	Stratified	Yes
Water color	20	Hardness	240	Avg. littoral width (m)	15

This small lake is surrounded by forest and shrub and has a relatively diverse macrophyte community with an average littoral zone of 15 m. There is a road adjacent to the lake in the southeast and a single residence on the northeastern shore. Common macrophytes in the lake include: *Chara*, White water-lily *(Nymphaea spp.)*, Eurasian milfoil (*Myriophyllum spicatum*), Spatterdock *(Nuphar spp.)*, hard-stem bulrush (*Schoenoplectus acutus*), cat-tail (*Typha spp*.), arrowhead (*Sagittaria spp*.), watershield (*Brasenia schreberi*). Other species seen include: blackstripe topminnow (*Fundulus notatus*) and longear sunfish (*Lepomis peltastes*).

Management recommendations

The biggest threat to any small lake, especially ones that have boating and fishing activity, is invasive species. Measures should be taken to help keep more invasive plants and other animals out of this lake. Adequate signs are important reminders that everyone has a role in stopping invasive species.

Pickerel Lake, 6994

Type: Connected, round, small lake in ice-contact outwash sand and gravel geology (2_21_1_1)
Size: 19.3 acres
Common type
Sub-watershed: 15 20 (Portage Creek at gage #04172500)





Quality
Air photo analysis: A/B
Field survey: ?

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	17	pH	8.23	Sp. Cond.	367
Secchi depth (m)	3.9	Alkalinity	184	Stratified	Yes
Water color	5	Hardness	300	Avg. littoral width (m)	13

This small lake is a pretty little lake surrounded by shrub and forest. There is a great little sandy, swimming sand beach at the launch. This would be a good area to monitor for the introduction of invasive macrophytes. The substrates are marly and muck with some sand. Dominant macrophytes observed in the lake include: *Chara*, Spatterdock *(Nuphar spp.)*, White water-lily *(Nymphaea spp.)*, common milfoil (*Myriophyllum spp*.), hard-stem bulrush (*Schoenoplectus acutus*), coontail (*Ceratophyllum demersum*). Other common macrophytes observed include: bladderwort (*Utricularia spp*.), common pondweed (*Potamogeton natans*), big leaf pondweed (*Potamogeton amplifolius*), sago pondweed (*Stuckenia pectinata*), Eurasian milfoil (*Myriophyllum spicatum*), and pickerelweed (*Pontederia cordata*). Fish species collected or seen in 2006 include: warmouth (*Lepomis gulosus*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), largemouth bass (*Micropterus salmoides*), blackstripe topminnow (*Fundulus notatus*) and yellow bullhead (*Ameiurus natalis*).

Management recommendations

The major threat to this lake is the currently small Eurasian milfoil population and the introduction of new invasive species through boat traffic. More prominent educational signs on the threats of invasive species via boat traffic are needed at the Pickerel Lake launch. Invasive species (macrophytes, zebra mussels, zooplankton, and others) are the major threats to aquatic ecosystems today. Currently, the launch is a hand launch and it is recommended that this continues. Hand launches are less of a threat to water bodies than drive in launches where invasive species can get caught in trailers. Additionally, the sandy launch may also help limit macrophyte introductions because many species do not attach well to sand.

It may be advisable to consider management actions in Pickerel Lake to remove Eurasian milfoil since it is currently rare. If it could be eradicated from Pickerel Lake, this management action not only protects Pickerel Lake but also the attached Unnamed Lake.

Snyder Lake, 7015

Type: Connected, round, small lake in ice-contact outwash sand and gravel geology (2_21_1_1)
Size: 16.4 acres
Common type
Sub-watershed: 15 20 (Portage Creek at gage #04172500)




Quality
Air photo analysis: A
Field survey: A/B

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	9.2	pH	7.77	Sp. Cond.	508
Secchi depth (m)	4	Alkalinity	240	Stratified	No*
Water color	5	Hardness	180	Avg. littoral width (m)	7

* may be stratified earlier in the season

This lobed, two-basin lake drains an intact marsh and has quite a bit of shoreline complexity for such a small lake. Snyder Lake is relatively deep and clear with a narrow littoral zone. This lake has a small lobe attached to it that is almost it's own lake with just a narrow open water connection; the rest of the connection is dense macrophytes. This small lobe is also deep (9.2 m) and drops off quickly. The littoral zone has dense macrophytes. Common macrophytes include pickerelweed (*Pontederia cordata*), hard-stem bulrush (*Schoenoplectus acutus*), waterwillow (*Justicia americana*), Spatterdock *(Nuphar spp.)*, White water-lily *(Nymphaea spp.)*, coontail (*Ceratophyllum demersum*), common milfoil (*Myriophyllum* *spp*.), bladderwort (*Utricularia spp*.), big leaf pondweed (*Potamogeton amplifolius*), and *Chara* is dominant. Less common macrophytes include: cat-tail (*Typha spp*.), *Najas*, eelgrass pondweed (*Potamogeton zosteriformis*), waterweed (*Elodea canadensis*), sago pondweed (Stuckenia pectinata), common pondweed (*Potamogeton natans*), spikerush (*Eleocharis spp*.), Eurasian milfoil (*Myriophyllum spicatum*), and water smartweed (*Polygonum amphibium*). This lake has a diverse macrophyte community and although Eurasian milfoil is present, it is rare, and does not appear to have had a major impact on this lake yet. This lake is connected to South Lake by a stream channel that is easily accessible by boats. Although boat traffic doesn't appear to have a major impact on the lake since it is so deep. Motor boats can sometime stir up sediments in small lakes and make them more turbid. Bluegill (*Lepomis macrochirus*) and yellow perch (*Perca flavescens*) were common fish seen. Freshwater sponge was occasionally seen in the lake.

Management recommendations

Aquatic invasive species introductions through boat traffic from South Lake is the main threat to this lake. More prominent signs on the threats of invasive species via boat traffic is needed at the South Lake launch. Invasive species (macrophytes, zebra mussels, zooplankton, and others) are the major threats to aquatic ecosystems today and education is one of the few ways to help control this threat.

South Lake, 7002

Type: Connected, round small lake in outwash sand and gravel geology (3_11_1_1)
Size: 203.4 acres
Common type
Sub-watershed: 15 20 (Portage Creek at gage #04172500)






Quality
Air photo analysis: A/B
Field survey: B

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	--	pH	8.33	Sp. Cond.	76
Secchi depth (m)	--	Alkalinity	156	Stratified	--
Water color	5	Hardness	132	Avg. littoral width (m)	80

This large lake has a wide littoral zone mainly consisting of shallow (<0.5 m), marly-sand flats. The surrounding land cover is about 95% natural (forested and wetland) but the lake does have about 10-15 houses along the south western edge of the lake. The average width of the littoral zone is 80 m. Macrophytes, woody structure, and shallow flat areas make up the majority of the in-lake cover. Common macrophytes include spikerush (*Eleocharis spp*.), *Chara*, bladderwort (*Utricularia spp*.), big leaf pondweed (*Potamogeton amplifolius*), sago pondweed (*Stuckenia pectinata*), common milfoil (*Myriophyllum spp*.), *Nymphyaea spp*., pickerelweed (*Pontederia cordata*), hard-stem bulrush (*Schoenoplectus acutus*), soft-stem bulrush (*Schoenoplectus tabernaemontani*), waterwillow (*Justicia americana*), and cat-tail (*Typha spp.*). Other less common macrophytes include *Najas*, waterweed (*Elodea canadensis*), watersheild (*Brasenia schreberi*), Eurasian milfoil (*Myriophyllum spicatum*), common pondweed (*Potamogeton natans*), and Spatterdock (*Nuphar spp*.). Eurasian milfoil is uncommon and so far does not seem to have impacted the native macrophyte community heavily. The native mussel, giant floater (*Pyganodon grandis*), were common in the marly-sand flats. Bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), and minnows were observed. A small bit of freshwater sponge was also observed at the north end of the lake.

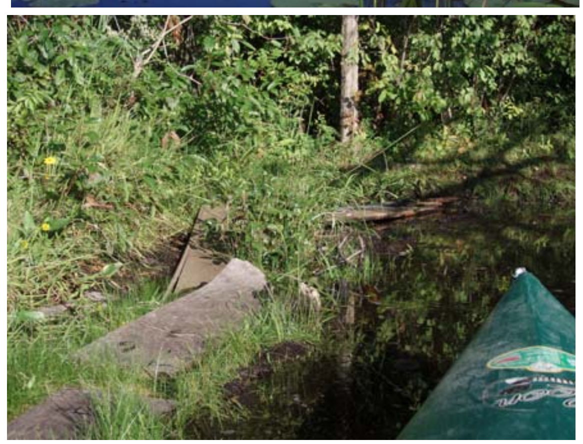
Management recommendations
Invasive species introductions through boat traffic are the major threat to this lake. More prominent educational signs on the threats of invasive species via boat traffic are needed at the launch. Invasive species (macrophytes, zebra mussels, zooplankton, and others) are the major threats to aquatic ecosystems today. And education is one of the few ways to help limit this threat.

Sullivan Lake, 7007

Type: Seepage, round small lake in ice-contact outwash sand and gravel geology (2_21_0_1)
Size: 24.7 acres
Common type
Sub-watershed: 15 20 (Portage Creek at gage #04172500)





Quality
Air photo analysis: B?
Field survey: A/B

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	6	pH	8.00	Sp. Cond.	389
Secchi depth (m)	2.8	Alkalinity	200	Stratified	No
Water color	5	Hardness	144	Avg. littoral width (m)	8

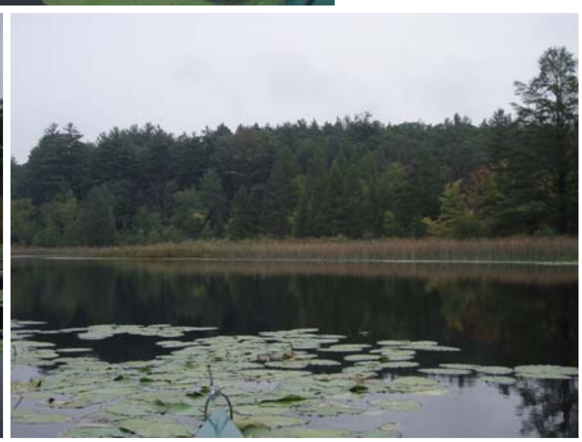
This small lake has a narrow littoral zone on the west and east shores and drops off quickly, to 3.5 m within 5-10 m of the shoreline. The north and south ends of the lake are more gradually sloping and have a wide littoral zone. This lake has some woody structure. Much of the surrounding landscape is natural and forested, however to the east of the lake there is a farm with cows. The density of the cows appears low and they are free ranging. There is about 50 m of forested buffer between the pasture and the lake, so this is likely not a high threat. There are no stream connections but there is a relatively dry connection to the wetland at the south western side of the lake. White water-lily (*Nymphyaea spp*.) and *Chara* are dominant in this lake; pickerelweed (*Pontederia cordata*), hard-stem bulrush (*Schoenoplectus acutus*), sago pondweed (*Stuckenia pectinata*), big leaf pondweed (*Potamogeton amplifolius*), bladderwort (*Utricularia spp*.), coontail (*Ceratophyllum demersum*), waterwillow (*Justicia americana*), and cat-tail (*Typha spp*.) are common. Other macrophytes occurring in lake are: common pondweed (*Potamogeton natans*), Spatterdock (*Nuphar spp*.), curly pondweed (*Potamogeton crispus*), and common milfoil (*Myriphyllum spp*.). Only one plant of the invasive curly pondweed was found. Currently, there is no evidence that this invasive species has impacted the macrophyte community. Other species seen include: bluegill (*Lepomis macrochirus*), blackstriped topminnow (*Fundulus notatus*). Sandhill cranes (*Grus canadensis*) were heard from nearby.

Management recommendations
A sign explaining to boaters the threats to lakes from invasive species and the importance of washing boats between lakes is critical at this launch. Additionally, the hand boat launch at this lake is relatively disturbed. Because of the wet nature of the shoreline, the launch impact area has become larger than needed. Currently, there are boards laid down to allow people to get out to the lake. A more permanent, small structure would help limit the impact and destruction around the shoreline of the lake.

Unnamed Lake, 6995

Type: Connected, round pond in ice-contact outwash sand and gravel geology (1_21_1_1)
Size: 3.0 acres
Common type
Sub-watershed: 15 20 (Portage Creek at gage #04172500)



Quality
Air photo analysis: A
Field survey: A

General characteristics of lake

Parameter	Value	Parmeter	Value	Parameter	Value
Max. depth (m)	4.5	pH	7.69	Sp. Cond.	435
Secchi depth (m)	2.5	Alkalinity	228	Stratified	No
Water color	5	Hardness	168	Avg. littoral width (m)	12

This tannic-colored pond is connected through a narrow and shallow stream to Pickerel Lake (TNCID 6994). The surrounding landscape is natural and has forest and wetlands. The lake drops off fairly quickly and the littoral zone is narrow (average width 12 m). Within the first meter of water the oxygen level drops down to below 5 mg/l, which is often cited as the lower limit for fish populations. Spatterdock (*Nuphar spp*.), white water-lily (*Nymphyaea spp*.), pickerelweed (*Pontederia cordata*), hard-stem bulrush (*Schoenoplectus acutus*), *Chara*, and bladderwort (*Utricularia spp*.) are common. Cat-tail (*Typha spp*.), waterwillow (*Justicia americana*), common milfoil (*Myriophyllum spp*.), big leaf pondweed (*Potamogeton amplifolius*), coontail (*Ceratophyllum demersum*), sago pondweed (*Stuckenia pectinata*), common pondweed (*Potamogeton natans*), and eelgrass pondweed (*Potamogeton zosteriformis*) were less common. No exotic invasive species were seen in this lake. Fish were seen surfacing. Of special note, this lake had the largest population of freshwater sponge in all the water bodies sampled in Waterloo and Pinckney Recreation Areas. Sponge colonies (see above picture) were found throughout lake, not just in one area. Boat traffic from Pickerel Lake is the only current threat to this small, natural lake.

Management recommendations
The only current threat to this lake is the introduction of invasive species through boat traffic. Pickerel Lake does have a small population of Eurasian milfoil, and hence this is a threat to this attached unnamed lake. More prominent educational signs on the threats of invasive species via boat traffic are needed at the Pickerel Lake launch. Currently, the launch is a hand launch and it is recommended that it continues to have this restriction. Hand launched boats are less of a threat to water bodies than trailer boats. Additionally, the sandy launch may also help limit introductions because many species do not attach well to sand.

It may be advisable to consider management actions on Pickerel Lake to remove Eurasian milfoil since it is currently rare. If it could be eradicated from Pickerel Lake, this management action not only protects Pickerel Lake but also the Unnamed Lake.

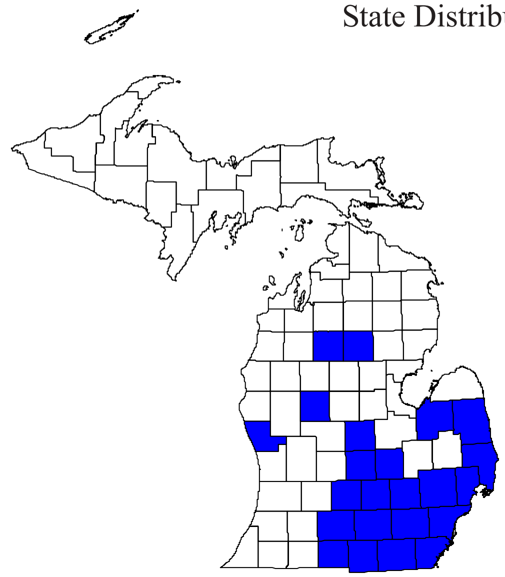
Appendix A5

Special animal abstracts for rainbow and round pigtoe

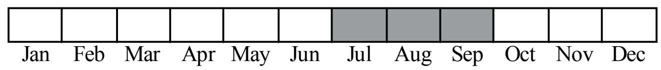
Villosa iris Lea — Rainbow

Photo by Kurt Stepnitz, MSU University Relations

State Distribution



Best Survey Period



Status: State listed as Special Concern

Global and state ranks: G5/S2S3

Family: Unionidae (Pearly mussels)

Synonyms: *Micromya iris* (Lea). Another common name is rainbow shell.

Total range: The global range of the rainbow is restricted to eastern North America, from Ontario, Canada south to Alabama, west to Oklahoma, and east to New York. It is present in the St. Lawrence River system in the Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario drainages, and in the Ohio, Tennessee, and upper Mississippi River systems. (Burch 1975, Clarke 1981, NatureServe 2006)

State distribution: In Michigan the rainbow has been documented in the St. Joseph (Lake Michigan drainage), St. Joseph (Maumee drainage, Hillsdale Co.), Kalamazoo, Grand, Muskegon, Saginaw, St. Clair, Clinton, Detroit, Huron, and Raisin watersheds. Though this species is fairly wide ranging in Michigan, it was found infrequently and in relatively low abundance in recent surveys. (Badra and Goforth 2003, Carman and Goforth 2003, Badra 2004, Badra 2005)

Recognition: The rainbow has an oval outline that can be slightly pinched at the posterior end of the shell. It is moderately compressed, as opposed to highly inflated or highly compressed. The outside of the shell is smooth, without bumps or ridges, and is yellow to dark tan in color. The posterior ridge often has a slight convex shape. Green rays are almost always present, becoming wider and more pronounced toward the posterior end of the shell. Maximum length of the rainbow is approximately 3 inches (75mm). The beaks (also known as umbos) are low, only slightly raised above the hinge line. Beak sculpture consists of irregular double looped ridges. The shells are of moderate thickness relative to most species in Michigan. Pseudocardinal and lateral teeth are somewhat fine but well developed. The lateral teeth and hinge line are relatively long. The beak cavity is shallow. The nacre is white or bluish-white, and iridescent posteriorly. Shells of males and females are morphologically similar.

Similar species in Michigan are the ellipse (*Venustaconcha ellipsiformis*), slippershell (*Alasmidonta viridis*), and spike (*Elliptio dilatata*). Rainbow can be difficult to separate from the ellipse, which has a shorter hinge line and is usually more pinched at the posterior end than the rainbow. The ellipse's rays tend to be more wavy and more uniformly distributed from the anterior to posterior end of the shell. The ellipse often has wrinkles near the posterior end of the shell running from the edge of the shell toward the beak. The slippershell is more inflated than the rainbow and is smaller, although large old slippershells can be equal in size to small young rainbows. The slippershell also has a roughly rectangular outline. The spike is a larger species than the rainbow, brown to black in color, and lacks rays. (Clark 1981, Oesch 1984, Cummings and Mayer 1992, Watters 1995, pers. observation of Michigan shells)

Best survey time: Surveys for the rainbow, as with most freshwater mussels, are best performed in the summer when water levels are low and water clarity is high. Low water levels make it easier to spot mussels and can expose muskrat middens containing empty freshwater mussel shells. During the winter months unionid mussels tend to burrow deeper into the stream bottom making them difficult to detect. In water that is less than two to three feet deep, a glass-bottomed bucket is an efficient tool for finding live mussels. In deeper habitats, SCUBA is often needed to perform surveys.

Habitat: The rainbow is found in small to medium sized streams with sand and gravel substrates. Suitable habitat for fish host species must be present for rainbow reproduction to be successful (see Biology).

Biology: Like most freshwater mussels of the family Unionidae, the rainbow requires a fish host to complete its life cycle. Eggs are fertilized and develop into larvae within the female. These larvae, called glochidia, are released into the water and must attach to a suitable fish host to survive. The females of some unionids have structures resembling small fish or other prey that are displayed when the larvae are ready to be released. Other unionids display conglutinates, packets of glochidia that are trailed out in the stream current, attached to the unionid by a clear strand. These lures entice fish into coming into contact with glochidia, increasing the chances that glochidia will attach to a suitable host. The rainbow attracts potential host fish with an elaborate lure and behavior. The rainbow's lure is a specialized structure extending from the mantle flap (edge of the mussels body near the siphons) that resembles a crayfish, complete with eyespots, antennae, legs, and tail. What makes the lure even more convincing is that the mussel flaps the "tail" and moves the "legs", mimicking the swimming motion of a crayfish. Some unionids are winter breeders that carry eggs, embryos, or glochidia through the winter and into the spring (bradytictic), while others are summer breeders whose eggs are fertilized and glochidia released during one summer (tachytictic). The rainbow is reported to be a summer breeder (Oesch 1984).

Glochidia remain on the fish host for a couple weeks to several months depending on the unionid species and other factors. During this time the glochidia transforms into the adult form then drops off its host (Kat 1984). Although the advantages of having fish hosts are not fully understood, two factors are known to provide benefits. Similar to animal facilitated seed dispersal in plants, fish hosts allow mussels that are relatively sessile as adults to be transported to new habitat and allow gene flow to occur among populations. The fish host also provides a suitable environment for glochidia to transform in. Some unionid species are able to utilize many different fish species as hosts while others have only one or two known hosts. In laboratory experiments (O'Dee and Watters 2000), the rainbow has been found to utilize striped shiner (*Luxilus chrysocephalus*), streamline chub (*Hybopsis dissimilis*), smallmouth bass (*Micropterus dolomieui*), largemouth bass (*Micropterus salmoides*), green sunfish (*Lepomis cyanellus*), bluebreast darter (*Etheostoma camurum*), greenside darter (*Etheostoma blennioides*), rainbow darter (*Percina shumardi*), and yellow perch (*Perca flavescens*) as hosts. Other fish species may act as hosts in Michigan. Maximum life-span for some unionids is over 50 years. Rainbow likely live to over 15 years of age.

Conservation/Management: Eastern North America is the global center of diversity for freshwater mussels with over 290 species. In a review of the status of U.S. and Canadian unionids by the American Fisheries Society, one third (97) of these were considered endangered (Williams et al. 1993). Thirty-five unionids are thought to have gone extinct in recent times (Turgeon et al. 1998). There are 45 species native to Michigan and nineteen of these are state-listed as endangered, threatened, or special concern.

The decline of this group over the last couple hundred years has been attributed mainly to direct and indirect impacts to aquatic ecosystems. Threats include habitat and water quality degradation from changes in water temperature and flow regime; the introduction of heavy metals; organic pollution such as excessive nutrients from fertilizers, pesticides and herbicides; dredging; and increased sedimentation due to excessive erosion (Fuller 1974, Bogan 1993, Box and Mossa 1999). High proportions of fine particles (sand and silt) were found to be a limiting factor for unionid density and species richness across several watersheds in lower Michigan (Badra and Goforth 2003). Using certain agricultural practices such as conservation tillage, grass filter strips between fields and streams, and reforestation in the floodplain can help reduce the input of silt and other pollutants. Forested riparian zones help maintain a balanced energy input to the aquatic system, provide habitat for fish hosts in the form of large woody debris, reduce the input of fine particles by stabilizing the stream banks with roots, and provide shade which regulates water temperature. Due to the unique life cycle of unionids, fish hosts must be present in order for reproduction to occur. The loss of habitat for these hosts can cause the extirpation of unionid populations. Barriers to the movement of fish hosts such as dams and impoundments also prevent unionid migration and exchange of genetic material among populations, which helps maintain genetic diversity within populations.

The zebra mussel (*Dreissena polymorpha*) and the Asian clam (*Corbicula fluminea*) are exotics from Eurasia that have spread quickly throughout the Great Lakes region. Zebra mussels are known to have severe negative impacts on native unionids. Zebra mussels require stable, hard substrates for attachment and often use unionid mussels as substrate. Unionids can get covered with enough zebra mussels that they cannot reproduce or feed, eventually killing the unionid. This exotic has had a dramatic effect on native unionid communities in habitats where it has been introduced. The continued range expansion of the zebra mussel into streams and lakes remains a serious threat. Boaters can reduce the spread of zebra mussels by making sure they do not transport water (which can contain zebra mussel larvae) from one water body to another. Washing boat and trailer or letting both dry overnight reduces the potential for spreading zebra mussels. Zebra mussels are present throughout the rainbow's range in Michigan. Laboratory experiments have demonstrated that, at high densities, Asian clams can affect the survival and growth of juvenile rainbow (Yeager et al. 2000)

Because unionid conservation involves a wide range of issues they are useful umbrella taxa for the conservation of aquatic ecosystems as a whole. By working towards solutions to threats to freshwater mussels we ameliorate threats to the stream and lake ecosystems they inhabit.

Research needs: Unionid mussels are found in rivers that are subject to cumulative impacts from upstream. Creative solutions are needed to promote the reduction of impacts that occur throughout entire watersheds while allowing for agricultural, development, and other landuses. Cultural, economic, and ecological perspectives need to be integrated into management plans for each watershed. Rainbow populations that are threatened by zebra mussels should be monitored. Methods for minimizing the spread of zebra mussels and preventing future invasive species from being introduced need to be developed and applied. Additional studies are needed to determine which fish species act as hosts for the rainbow in Michigan.

Related abstracts: Ellipse (*Venustaconcha* ellipsiformis), Slippershell (*Alasmidonta viridis*), Wavy-rayed lampmussel (*Lampsilis fasciola*)

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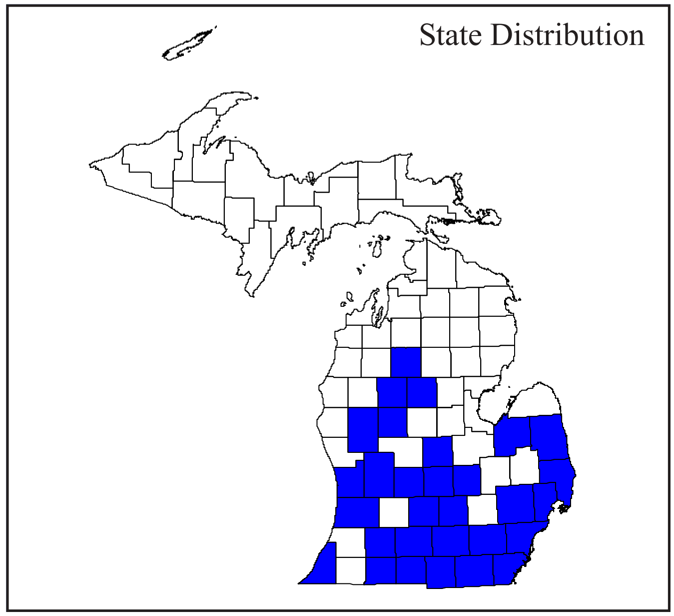
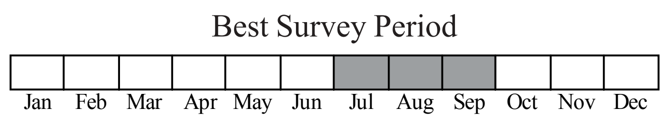
Pleurobema sintoxia Rafinesque — Round pigtoe

Photo by Kurt Stepnitz, MSU University Relations





Status: State listed as Special Concern

Global and state ranks: G4/S2S3

Family: Unionidae (Pearly mussels)

Synonyms: *Pleurobema coccineum* (Conrad). Other common names include false pig-toe, solid pigtoe, flat pigtoe, and bullnose

Total range: The global range of the round pigtoe is restricted to eastern North America, from Ontario, Canada south to Alabama, west to South Dakota and east to New York. It is present in the Mississippi and Ohio River drainages, and Lake Michigan, Lake Huron, Lake St. Clair, and Lake Erie drainages. (Burch 1975, NatureServe 2006)

State distribution: In Michigan the round pigtoe has been documented in most of the major drainages in the southern half of the Lower Peninsula, including the St. Joseph (Lake Michigan drainage), Kalamazoo, Grand, Muskegon, Saginaw, St. Clair, Clinton, Detroit, Huron, and Raisin watersheds. Though this species is fairly wide ranging in Michigan it was found infrequently and in relatively low abundance in recent surveys (Badra and Goforth 2003, Carman and Goforth 2003, Badra 2004, Badra 2005)

Recognition: The round pigtoe has a roughly circular outline. It is relatively compressed, as opposed to inflated or spherical. The outside of the shell is smooth, without bumps or ridges, and is usually brown or dark brown in color. Rays are absent. Maximum length of the round pigtoe is approximately 4 inches (102mm). The beaks (also known as umbos) are low, only slightly elevated above the hinge line. Beak sculpture consists of 2 or 3 ridges. The shells are thick and heavy relative to most species in Michigan. Pseudocardinal and lateral teeth are well developed. The beak cavity ranges from shallow to moderately deep. The nacre is most often white but can be pink or salmon colored. Shells of males and females are morphologically similar. Round pigtoe shell morphology can vary widely between rivers of different sizes. Those in smaller rivers tend to be more compressed, round in outline, and have low beaks, while those in large rivers tend to be the opposite.

Similar species in Michigan are wabash pigtoe (*Fusconaia flava*), northern clubshell (*Pleurobema clava*), hickorynut (*Obovaria olivaria*), and round hickorynut (*Obovaria subrotunda*). Round pigtoe can be very difficult to separate from wabash pigtoe, which usually has a more rectangular outline and deeper beak cavity. The northern clubshell is more elongate in shape than round pigtoe and usually have broad green rays and a lighter yellow colored shell. The hickorynut is

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less compressed and has proportionately larger beaks. The round hickorynut is smaller, has a more centrally placed beak, and less developed pseudocardinal and lateral teeth. Hickorynut and round hickorynut are usually lighter colored than round pigtoe. (Clark 1981, Oesch 1984, Cummings and Mayer 1992, Watters 1995, pers. observation of Michigan shells)

Best survey time: Surveys for the round pigtoe, as with most freshwater mussels, are best performed in the summer when water levels are low and water clarity is high. Low water levels make it easier to spot mussels and can expose muskrat middens containing empty freshwater mussel shells. During the winter months unionid mussels tend to burrow deeper into the stream bottom making them difficult to detect. In water that is less than two to three feet deep, a glass-bottomed bucket is an efficient tool for finding live mussels. In deeper habitats, SCUBA is often needed to perform surveys.

Habitat: The round pigtoe is found in medium to large rivers with sand and gravel or sand and mud substrates. Suitable habitat for fish host species must be present for round pigtoe reproduction to be successful (see Biology).

Biology: Like most freshwater mussels of the family Unionidae, the round pigtoe requires a fish host to complete its life cycle. Eggs are fertilized and develop into larvae within the female. These larvae, called glochidia, are released into the water and must attach to a suitable fish host to survive. The females of some unionids have structures resembling small fish, crayfish, or other prey that are displayed when the larvae are ready to be released. Other unionids display conglutinates, packets of glochidia that are trailed out in the stream current, attached to the unionid by a clear strand. These lures entice fish into coming into contact with glochidia, increasing the chances that glochidia will attach to a suitable host. The round pigtoe is not known to have a lure. Some unionids are winter breeders that carry eggs, embryos, or glochidia through the winter and into the spring (bradytictic), while others are summer breeders whose eggs are fertilized and glochidia released during one summer (tachytictic). The round pigtoe is a summer breeder (Oesch 1984).

Glochidia remain on the fish host for a couple weeks to several months depending on the unionid species and other factors. During this time the glochidia transforms into the adult form then drops off its host (Kat 1984). Although the advantages of having fish hosts are not fully understood, two factors are known to provide benefits. Similar to animal facilitated seed dispersal in plants, fish hosts allow mussels that are relatively sessile as adults to be transported to new habitat and allow gene flow to occur among populations. The fish host also provides a suitable environment for glochidia to transform in. Some unionid species are able to utilize many different fish species as hosts while others have only one or two known hosts. Bluegill (*Lepomis macrochirus*) are known to be suitable hosts for the round pigtoe (Watters 1995). This species was identified as a host in laboratory experiments. It is likely that additional species are utilized as hosts in natural systems. Maximum life-span for some unionids is over 50 years. Round pigtoes likely live to over 20 years of age.

Conservation/Management: Eastern North America is the global center of diversity for freshwater mussels with over 290 species. In a review of the status of U.S. and Canadian unionids by the American Fisheries Society, one third (97) of these were considered endangered (Williams et al. 1993). Thirty-five unionids are thought to have gone extinct in recent times (Turgeon et al. 1998). There are 45 species native to Michigan, and nineteen of these are state-listed as endangered, threatened, or special concern.

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Research needs: Unionid mussels are found in rivers that are subject to cumulative impacts from upstream. Creative solutions are needed to promote the reduction of impacts that occur throughout entire watersheds while allowing for agricultural, development, and other landuses. Cultural, economic, and ecological perspectives need to be integrated into management plans for each watershed. Round pigtoe populations that are threatened by zebra mussels should be monitored. Methods for minimizing the spread of zebra mussels and preventing future invasive species from being introduced need to be developed and applied. Additional studies are needed to determine which fish species act as hosts for the round pigtoe.

Related abstracts: Northern clubshell (*Pleurobema clava*), Hickorynut (*Obovaria olivaria*), Round hickorynut (*Obovaria subrotunda*), Purple wartyback (*Cyclonaias tuberculata*)

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