Exploration in classifying ponds and small lakes into natural communities in Michigan

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INTRODUCTION

Protecting aquatic biological diversity in Michigan depends heavily on our ability to protect representative and unique habitats or ecosystems. The state is moving towards preserving ecosystem functions rather than individual threatened or endangered species to preserve biological diversity as seen in the state's Wildlife Action Plan (Eagle et al. 2005). Currently, terrestrial and wetland natural communities are tracked in the Michigan Natural Features Inventory (MNFI) Biotics database, which aids in protecting high quality natural communities or ecosystems through environmental review and other conservation planning efforts. However, Michigan does not yet have fully aquatic natural communities defined or described. To preserve the full breadth of Michigan's biodiversity, representative habitats or ecosystems need to be described and located for aquatic ecosystems.

In Michigan, most of the state's listed as endangered or threatened aquatic species occur in rivers and therefore rivers are considered and protected much more than lakes in the environmental review process and other conservation planning efforts. Inland lakes make up a large portion of Michigan's water bodies and biodiversity and are ecosystems that need to be highlighted as such. There are 5,356 lakes between 4 and 40 acres in Michigan, which accounts for 82% of Michigan lakes; yet, only 0.7% of them are sampled for fish every year by the MDNR (Hayes et al. 2003). Small lakes generally do not provide significant boating opportunities or public boat launches, and can therefore often be entirely privately owned and/or difficult to access. As such, small lakes are often not targeted for stocking, management, or monitoring efforts. However, these characteristics also increase the potential likelihood that small lakes support intact native aquatic communities and may be subject to less human disturbance. In addition, small lakes are an easier, more realistic conservation target since entire watersheds can be preserved. The conservation of small lakes is critical for the preservation of aquatic biodiversity in Michigan.

Small lakes provide a variety of services towards the preservation of biodiversity. They are likely to reflect extremes of certain key environmental variables, such as pH and alkalinity (J. Breck, pers. comm.), providing unique ecosystems and communities. Small lakes have been shown to act as refugia for native species susceptible to declines from human alterations (e.g., Mwanja 2001). Michigan has a variety of species that are at the edge of their range. These "edge of range" populations have the potential to be genetically different than the central populations and are therefore important for maintaining and conserving the genetic diversity of species and providing opportunities for evolutionary processes (Lescia and Allendorf 1995, Nielson, Scott, and Aycrigg 2001).

There is some recent evidence to show that small lakes, especially small isolated lakes, contribute disproportionately to biodiversity (Scheffer et al. 2006) often 'containing specialized flora and fauna which are not represented in other habitats (Bratton 1990, Williams et al. 1998, Williams et al. 2003). Ponds and small lakes are often dominated by vegetation and this can lead to a higher diversity in many animal groups, including use of small lakes by bird species. As mentioned previously, ponds and small lakes are often more subject to winter anoxia and if isolated may be fishless. Fishless lakes support greater diversity of zooplankton, macro-invertebrates, water birds, and amphibians (Hunter et al. 1986, Havas and Rosseland 1995, Hecnar and McLoskey 1997). Fishless lakes also tend to be dominated by vegetation. Hence, the current conservation emphasis on 'preserving large habitat elements and promoting connectivity thru maintenance of habitat corridors' may actually represent a threat to biodiversity in the case of ponds and shallow lakes.

Developing an aquatic community classification will allow us to identify lakes as significant representative elements of biodiversity in Michigan, and will help Michigan's Department of Natural Resources to better manage and protect aquatic organisms and associated habitats as public trusts of Michigan.

This report summarizes other state's lake natural community classifications, provides results of field work conducted in Michigan's ponds, proposes draft EO specifications for ponds and lakes, and proposes a framework for pond and lake natural communities in Michigan.

SUMMARY OF OTHER STATE'S LAKE NATURAL COMMUNITY CLASSIFICATIONS

Florida Natural Areas Inventory (FNAI 1990) describes nine lake natural communities. A couple of the natural communities are described together because of similarities. These natural communities are generally based on landscape context and water source.

1. Clastic upland lakes occur in uplands on clay substrates. These lakes have surface inflows but often do not have significant outflows and may disappear during prolonged droughts through sinks to the aquifer. Lakes are generally densely vegetated. They are typically soft with a low mineral content (particularly sodium, chloride, and sulfate) and have clay and organic substrates.
2. Coastal dune lakes are relatively shallow lakes in coastal communities where the water is derived from lateral groundwater seepage such that they have no significant surface inflows or outflows and water levels may fluctuate substantially. Salinities vary dramatically over time due to coastal storms occasionally contributing salt water into the lakes. These lakes typically have slightly acidic, hard water with high mineral content (predominately sodium and chloride). They are generally oligotrophic with low nutrient levels. These natural communities are very unusual coastal features that are relatively short-lived and are extremely vulnerable to hydrologic changes.
3. Coastal Rockland lakes are rare lakes that are small in size with limestone substrates, variable salinity ranges, alkaline water, with high mineral content.
4. Flatwoods/Prairie/Marsh lakes are typically developed by two geological processes: 1) solution holes form in the underlying limestone, or 2) during higher sea levels, offshore currents, waves, and winds scoured depressions. The water source for these lakes is generally from runoff from surrounding uplands and water levels may fluctuate substantially. Substrates are typically acidic sands with some peat.
5. River floodplain lake and swamp lakes are generally permanent water bodies that can fluctuate substantially and are tied to floodplains or swamps such that during floods they can have some flow. Swamp lakes typically have highly colored, acidic, soft water with moderate mineral content. River floodplain lakes typically have colored, alkaline or slightly acidic, hard or moderately hard water, with high mineral content (sulfate, chloride, calcium, magnesium). Both are typically meso or eutrophic.
6. Sandhill upland lakes are shallow, rounded, solution depressions occurring in sandy upland communities. They typically don't have significant surface inflows or outflows and get much of their water from lateral groundwater seepage. Water levels may fluctuate substantially. They have clear, circum-neutral to slightly acidic, moderately soft water with varying mineral content, relatively low nutrient levels, and sandy substrates.
7. Sinkhole lakes are deep, funnel-shaped and occur in limestone areas. They are typically clear, alkaline, hard water with high mineral content (especially calcium, bicarbonate, and magnesium), and may have significant water level fluctuations.

Illinois Natural Areas Inventory has a single pond community and multiple lake communities. Ponds are defined as eutrophic, small, shallow, still bodies of water that have

rooted aquatic plants across most of it. Lakes have "on its periphery a barren, wave-swept shore (absence of attached aquatic plants or fine organic matter on bottom) normally having thermal stratification." The define four types of lakes: 1) Lake Michigan, 2) reservoir, 3) artificial impoundment (dammed, perched, dug, borrow pit, quarry pit, gravel pit, surface mine), and 4) natural impoundment which is natural formed. The natural impoundments are then further classified as a) glacial (glacial derived origin), b) bottomland (backwater lakes), and sinkholes (karst topography). The community types are based on White (1978) and Iverson (undated).

Massachusetts lacustrine natural communities are based on shorelines and they include: inland acidic pondshore/lakeshore, coastal plain pondshore/lakeshore, and calcareous pondshore/lakeshore (Swain and Kearsley 2001). These communities are based on vegetation along the shoreline.

New Hampshire's aquatic natural communities are at varying scales and are based mainly on the substrates and vegetation, often terrestrial vegetation (Sperduto and Nichols 2004). Generally, the natural communities are describing terrestrial habitats along river banks and pond and lake shores. Described here is the only lake type aquatic community: aquatic beds are broadly defined as floating leaved, submerged, and emergent macrophytes in quick water streams and shallow quiet water areas of ponds, lakes, oxbows, streams, and rivers.

New York defines both riverine and lake natural communities (Edinger et al. 2002). The lacustrine communities in this classification are distinguished primarily by trophic state, alkalinity, annual cycles of thermal stratification, circulation, morphometry (size and shape of lake basin and drainage area; water permanence), and water chemistry (including salinity). They describe natural and cultural lake communities; only the natural types will be described here. They have detailed abstracts about each natural community that includes a description, and associated fish, macrophyte, mollusk, phytoplankton, and zooplankton species.

They describe 13 inland lake natural communities:

1. Bog lakes are dystrophic lakes that typically occur in small, shallow basins (e.g. a kettlehole) that are protected from wind and poorly drained. Water in these communities is typically murky, brown-stained, with low transparency, low nutrients (especially calcium), naturally low pH (<5.4), and may have low oxygen issues. These lakes commonly have a false bottom.
2. Oligotrophic dimictic lakes are nutrient-poor and typically occur in deep, steeply-banked basins. They have a spring and fall mixing and are thermally stratified in summer and winter. Water in these communities is typically blue or green and clear, with high transparency (Secchi depths of 4-8m), low nutrients (especially nitrogen and calcium), low primary productivity, low alkalinities (<12.5mg/l), and have an abundance of oxygen all year.
3. Mesotrophic dimictic lakes are an intermediate between an oligotrophic lake and a eutrophic lake. These lakes have 2 turnovers and are thermally stratified in summer and winter. Water in these lakes is typically moderately clear, with medium transparency (Secchi depths of 2-4m), moderate nutrients, moderate primary productivity, moderate amounts of organic matter in lake sediments, and alkalinity is moderate (slightly greater than 12.5 mg/l).
4. Eutrophic dimictic lakes are nutrient-rich lakes that occur in broad, shallow basins. They too have two mixing periods and stratify. Water in these lakes is typically colored and murky, with low transparency (Secchi depths of <2.5m, but up to 4m), rich in nutrients, high productivity, lake sediments are rich in organic matter, alkalinity is high (>12.5 mg/l), well-oxygenated above the summer thermocline, can be oxygen-depleted below the summer thermocline or under ice, epilimnion is relatively large, and macrophytes are present along shoreline.

5. Summer-stratified monomictic lakes are deep (or large) and have only one period of mixing or turnover each year, are stratified in summer, and typically do no freeze over in winter. They are oligotrophic to mesotrophic and alkaline. The Great Lakes are an example of this type of lake; however NY has separate Great Lakes natural communities.
6. Winter-stratified monomictic lakes are large, shallow lakes that only have one period of mixing each year because they are very shallow and completely exposed to winds. These lakes only stratify in the winter when they freeze over. They can be eutrophic to mesotrophic.
7. Meromictic lakes are relatively deep lakes with small surface areas protected from wind-stirring such that they remain chemically stratified throughout the year. These lakes freeze over in winter and thermally stratify. The lower waters tend to be stagnant, loaded with dissolved salts, and low oxygen.
8. Marl ponds are small, shallow, calcium-rich, spring-fed ponds with marl sediments.
9. Inland salt ponds are small, salty, spring-fed ponds. Salt is from aquifer. Ponds are permanent but water levels may fluctuate seasonally. Substrates are very mucky.
10. Oxbow lakes are small, shallow, usually stagnant lake or pond of fluvial origin that occurs in an old river meander or oxbow that has been cut off from an unconfined river or marsh headwater stream by deposition of a levee. These are usually eutrophic lakes.
11. Coastal plain ponds are shallow, groundwater-fed ponds occurring in kettle-holes or shallow depressions with seasonally and/or annually fluctuating water levels. These ponds are typically hydrologically connected, with substrates of sand and muck. Water is typically acidic, darkly stained, with low transparency.
12. Oligotrophic ponds are small, shallow, nutrient-poor ponds that do not remain stratified in summer but are winter stratified. They typically have blue or green clear water with high transparency (Secchi depths of 4 to 8m), low nutrients (especially nitrogen and calcium), low primary productivity, and low alkalinity (<12.5mg/l).
13. Eutrophic ponds are small, shallow, nutrient-rich ponds with water that is green with algae and mucky substrates. These ponds are too shallow to remain stratified throughout the summer but are stratified in winter. These ponds usually have murky water with low transparency (Secchi depths <4m), nutrient rich (especially phosphorus, nitrogen and calcium), high productivity, high alkalinity (>12.5 mg/l0), and macrophytes around shoreline.

New York also describes nine cultural lake communities, including: lacustrine submerged structure, acidified lake, cultural eutrophic lake, farm pond/artificial pond, reservoir/artificial impoundment, quarry pond, artificial pond, industrial cooling pond, sewage treatment pond.

Rhode Island bases their natural community classification on physiognomy (vegetation), organisms, and ecological processes (Enser and Lundgren 2006). They define lacustrine systems as consisting of "waters situated in topographic depressions or dammed river channels". They lack persistent emergent vegetation, "but areas with submerged or floating-leaved aquatic plants may occur locally". They define lakes by trophic state, thermal stratification, morphometry, and water chemistry. They also describe the fish and macrophyte communities present.

They have three main lacustrine community types: oligotrophic lake, oligotrophic pond, and eutrophic pond.

1) Oligotrophic lakes are defined as relatively nutrient poor, dimictic (2 periods of mixing spring and fall), thermally stratified in summer, moderately clear water with medium transparency (Secchi disk depths of 2-4m), moderately well oxygentated, and low to moderate amounts of organic matter in sediments.

2) Oligotrophic ponds are shallow, nutrient poor, clear, monomictic (stratified in winter but not summer), macrophytes are sparse and diversity is low, with sandy or rocky substrates.
3) Eutrophic ponds are shallow, nutrient rich, monomictic (stratified in winter but not summer), water clarity is reduced, and substrates are generally mucky.

Wisconsin's Natural Heritage unit does not appear to track lake natural communities. However, they are defined by Wagner (undated). They define lakes as larger than 10 acres of standing water. Their lake natural communities are defined by the water source, thermal stratification, and chemical attributes. They define three types of water sources: 1) seepage – primary water sources are groundwater infiltration, overland flow, and precipitation with no stream connections; 2) drainage – the primary water sources are the same sources as seepage plus stream connections, but these lakes have a outlet stream; 3) spring – substantial inputs into the lake come from spring runs, spring ponds, or from beneath the lakes surface, they typically have an outlet stream. They define three types of thermal stratification: 1) deep – lakes are stratified during the summer and winter; 2) shallow – lakes does not thermally stratify and can become oxygen depleted in summer and winter; 3) meromictic – these lakes are very deep (often >20m) with an exposed surface area of no more than a few hectares, and thermal or chemical stratification is permanent or mixing of surface and deep waters are very limited. Chemical attributes are generally based on alkalinity: 1) hard – total alkalinity equals or exceeds 50ppm and 2) total alkalinity is less than 50ppm.

Wisconsin proposed 17 lake types: 1) deep, hard, drainage; 2) deep, hard, seepage; 3) deep, soft, drainage; 4) deep, soft, seepage; 5) deep, very soft, seepage; 6) hard bog; 7) meromictic; 8) oxbow; 9) shallow, hard, drainage; 10) shallow, hard, seepage; 11) shallow, soft, drainage; 12) shallow, soft, seepage; 13) shallow, very hard, drainage (marl); 14) soft bog; 15) unique; 16) spring lake; 17) spring pond (<10 acres). Wisconsin does not have detailed abstracts written.

Lake classifications proposed in Michigan

An early lake classification for Michigan was proposed by *Humphrys and Veatch (undated)*. This classification describes a variety of ways of classifying lakes including based on origin, by lake basins, in relation to runoff and water tables, shoreline configuration, shore-borderland environment, shore modifications, stability of water level, kind of water, vegetation, size, depth, life stage, productivity, ownership, shore types, and substrate types. Very generalized and includes pictures and classifying groups.

Schneider (Schneider 1975) suggested that there were six lake characteristics that were related to fish productivity: relative abundance of panfish, climate, Secchi depth, and relative abundance of macrophytes. Mean depth and area were less important.

Pringle (1983) suggested a classification for Michigan's lakes based on: alkalinity, drainage type, stratification, and trophic status. Other lake classes included: stained bog lakes, fen lakes, Michigan finger lakes, inland water route lakes, and sink lakes. Finger lakes are characterized by cold, clear, alkaline waters with long-steep sided basins. Inland water route lakes describe approximately 50 miles of lakes that extend from Cheboygan to close to Traverse Bay; these are generally large lakes connected by large and relatively fast flowing rivers. Sink-hole lakes were also designated separately because they are believed to be unique. They are located in the karst regions and are likely subject to drying up.

METHODS

Approach

The main objective of this study is to begin to define lake natural communities, as assemblages of co-existing, interacting species, and the physical environment and associated ecological processes in combination, using small lakes as a starting point, defined. Field data will be used to explore which within-lake environmental variables best define lakes and species assemblages within those lakes. The results will

provide a methodology that can be used across lake types and sizes to describe natural communities of lakes. Ultimately, this work will incorporate aquatic natural communities into Biotics to help manage and protect the biodiversity of Michigan.

Using existing landscape-level classifications (e.g. Higgins et al. 1998) as a first step to determine if these frameworks are sufficient for capturing representative ponds and lakes, communities, and significant species of greatest conservation need. Using in-lake habitat and species data, ponds and small lakes were defined as natural communities as well as determining criteria for defining natural quality and condition.

Selection of Lakes

Using the Higgins et al. (1998) lake classification, ponds were chosen based on proximate geology (based on surficial geology), connectivity, size, and shoreline complexity. Efforts were focused in the small category, and as such most of these water bodies have a round-type shoreline complexity. Lakes were stratified based on proximate geology and connectivity. Ponds were generally targeted in state lands, however to include more types or add more sampled ponds to a lake type private lands were targeted.

Field Methods

At each lake, a pelagic point and 15 littoral points were sampled for habitat. The pelagic point was sampled in the deepest area of the lake, the following parameters were measured: maximum depth, dominant and subdominant substrate type, Secchi depth, pH, specific conductivity, alkalinity, hardness, and a water temperature / oxygen profile was taken. A water sampled was collected for total nitrogen and phosphorus. Additionally, zooplankton and macroinvertebrate samples were taken to identify species.

In the littoral zone, three sampling points were sampled along each of 5 relatively evenly spaced transects around the lake for habitat and biological measures. The first sampling point was 1 m from the lake bank. Parameters measured here include: depth, dominant and subdominant substrate, dominant and subdominant macrophytes, percent woody structure, type of riparian and shoreline vegetation. The second sampling point was in the mid-depth of the littoral zone and the third sampling point was at the maximum depth of the littoral zone or edge of macrophyte beds. Parameters measured at these two sampling points include: depth, dominant and subdominant substrate, dominant and subdominant macrophytes, percent woody structure. Macroinvertebrates were collected at 5 points from each lake so that a sampled was collected from each type of sampling point (pelagic, shoreline, mid-littoral, maximum-depth littoral, targeted).

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.

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.

Field Methods

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.

RESULTS

Fifty-four lakes have been sampled (Figure 1, Table 1). An additional 46 lakes were visited but not sampled due to inaccessibility, unable to obtain private landowner permission, or macrophytes were covering the entire surface of the water body. Those lakes with macrophytes covering the entire lake were deemed wetlands.

Lakes ranged in depth from 1.1m to 29 m and all were dominated by mud/muck substrates. Lakes ranged in pH from 4.5 to 9.28 and alkalinity from 4 to 320 (for full descriptions see Appendix C-E). Macrophyte communities varied within a lake type. More analysis is needed for this data. Zooplankton and macrophyte communities were sampled at all lakes and will be processed over the next year. Water samples will also be processed over the next year in cooperation with researchers at Michigan State University.

Table 1. Summary of water quality data collected at lakes. Connectivity denotes how the lake is connected to a stream network: connected has inflow and/or outflow streams, and unconnected doesn't have any stream connections.

Location (facility)	County	Lake	Area (Acres)	Connectivity	Max Depth	Secchi Depth	pH	Sp Cond	Alk	Hard-ness
Allegan State Game Area	Allegan	Ely Lake	14.6	connected	3.9	2.3	6.02	30.7	12	40
Allegan State Game Area	Allegan	Little Tom Lake	17.2	unconnected	3	1.6	5.85	24.1	15	
Allegan State Game Area	Allegan	Little Tom Lake	17.2	unconnected	3.3	1.4	5.46	31.1	12	20
Allegan State Game Area	Allegan	Mud Lake	4.1	unconnected	4.5	2.6	7.62	140.7	72	
Allegan State Game Area	Allegan	Mud Lake	4.1	unconnected	4.3	1.3	7.38	188.8	56	100
Au Sable State Forest	Midland	Unnamed Lake	10.1	unconnected	1.2	1.2	8.91	152.4	108	100
Bald Mountain State Game Area	Oakland	Shoe Lake	6.08	connected	5.8	1.9	7.7	628	0	260
Barry State Game Area	Barry	Dagget Lake	17.7	unconnected	4.1	2.85	0	0	20	40
Barry State Game Area	Barry	Shaw Lake	4.7	connected	5.1	4.1	8.4	335	185	
Barry State Game Area	Barry	Shaw Lake	4.7	connected	5.1	3.4	0	0	136	240
Brighton State Game Area	Brighton	Little Appleton Lake	5.17	connected	5.8	2.9	8.27	488	200	200
Cooper Country State Forest	Baraga	Coon Lake	67.97	unconnected	13.5	4	6.9	29.2		
Cooper Country State Forest	Dickinson	Parlemee Lake	21.56	unconnected	8	5	8.72	140.5		
Cooper Country State Forest	Iron	Spring Lake	12.34	unconnected	10	4.3	7.8	233		
Cooper Country State Forest	Iron	Square Lake	9.15	connected	4.3	1.2	6.12	84.1		
Craig Lake State Park	Baraga	Nelligan Lake	30.94	connected	0	0	0	0		
Craig Lake State Park	Baraga	Teddy Lake	60.1	connected	4	1	6	0		
Escanaba River State Forest	Marquette	Charley Lake	7.9	connected	5.5	4	8.31	442		
Escanaba River State Forest	Marquette	Haywire Lake	10.07	connected	5	3	8.11	359		
Escanaba River State Forest	Marquette	Johnson Lake	12.25	unconnected	3	1.1	5	0		
Escanaba River State Forest	Marquette	Martells Lake	7.5	unconnected	2	1.7	7	105		
Escanaba River State Forest	Marquette	Porterfield Lake	33.47	unconnected	8.5	3.7	8.4	275		
Escanaba River State Forest	Marquette	Round Lake	8.6	unconnected	2.5	2	7.99	238		
Escanaba River State Forest	Marquette	Twin Lakes (N)	17.17	unconnected	29	5.3	7	0		
Escanaba River State Forest	Marquette	Unnamed Lake	7	unconnected	13.5	4.5	4.5	16.9		
Flat River State Game Area	Montcalm	Clear Lake	16.3	unconnected	8.1	5.2	8.39	172.4	88	140
Flat River State Game Area	Montcalm	Race Lake	8.7	unconnected	7	3.3	8.4	316	164	220
Flat State Game Area	Montcalm	Unnamed Lake - 2958	2.97	unconnected	6.7	3.4	8.46	0	116	220

Location (facility)	County	Lake	Area (Acres)	Connectivity	Max Depth	Secchi Depth	pH	Sp Cond	Alk	Hard-ness
Hiawatha National Forest	Chippewa	Salt Lake	10.3	unconnected	0.7	0.7	4.75	30.2	4	
Lake Superior State Forest	Luce	Brush Lake	8.4	connected	7.4	4.7	6.94	16.86	4	20
Langston State Game Area	Langston	Tacoma Lake	18.45	connected	10	4.4	8.52	274	0	220
Lapeer State Game Area	Lapeer	Fish Lake	16	connected	6	2.6	7.75	209	68	140
Lapeer State Game Area	Lapeer	Twin Lake	15.1	unconnected	8.1	2.1	8.29	303	152	240
Lapeer State Game Area	Lapeer	Watz Lake		unconnected	8	2.3	7.66	357	184	260
Mackinaw State Forest	Montmorency	Jackson Lake	29.8	unconnected	6.7	4.7	8.66	198.7	110	140
Mackinaw State Forest	Montmorency	Twin Tomahawk Lake	19.07	connected	5.6	2	8.58	242	168	280
Michigamme State Forest	Marquette	Chain of Lakes (E)	10.4	unconnected	7	2.6	8.2	0		
Michigamme State Forest	Marquette	Chain of Lakes (M)	5.4	connected	3.5	2.3	8.2	0		
Ortonville State Recreation Area	Lapeer	Algoe Lake	7.76	connected	12	2	8.02	462	0	320
Pere Marquette State Forest	Kalkaska	Papoose Lake	24.7	unconnected	4.3	4.1	7.81	45.4	25	40
Pinckney State Recreation Area	Washtenaw	Losee Lake	12.2	unconnected	10	4.3	8.22	4.06	160	240
Pinckney State Recreation Area	Washtenaw	Pickerel Lake	19.3	connected	17	3.9	8.23	367	184	300
Pinckney State Recreation Area	Washtenaw	Sullivan Lake	24.7	unconnected	6.1	3.4	8.4	374	156	260
Private - Rifle River Rec Area	Ogemaw	Unnamed Lake			9.7	3.1	7.75	282	160	160
Rifle River Recreation Area	Ogemaw	Lodge Lake	8.4		5	3	8.18	212	160	160
Rogue River State Game Area	Kent	Spring Lake	10.04	connected	5.5	1	8.75	444	196	320
Rose Lake State Game Area	Ingham	Fox Knoll Lake	7.7	connected	6.3	3.1	8.28	891	200	260
Rose Lake State Game Area	Clinton	Potter Lake	20.76	connected	1.5	1	7.54	613	320	380
Stanton State Game Area	Montcalm	Colby Lake	19.042	connected	9	2.3	0	0	165	260
Stanton State Game Area	Montcalm	Grass Lake	34	unconnected	9.2	3.9	8.78	223	155	
Stanton State Game Area	Montcalm	Grass Lake	34	unconnected	9.2	3.8	0	0	125	180
Stanton State Game Area	Montcalm	Twin Lake	12.8	connected	5.7	2.7	8.16	354	210	
Stanton State Game Area	Montcalm	Twin Lake	12.8	connected	7.6	2.5	8.45	354	180	280
Stanton State Game Area	Montcalm	Unnamed Lake - 3206	3.523	unconnected	5	1.6	8.04	104.1	58	100
Superior State Forest	Luce	Pratt Lake	17.2	unconnected	7.1	6.6	7.91	15.33	8	20
Superior State Forest	Luce	Rainy Lake	11.7	unconnected	4	2.5	6.24	10.24	4	20
Superior State Forest	Luce	Ready Lake	20.1	unconnected	1.1	1.1	9.28	68.4	32	40
Tahquamenon Falls State Park	Chippewa	Cabin Lake	11.5	unconnected	1.6	1.6	4.79	19.1	4	20

Location (facility)	County	Lake	Area (Acres)	Connectivity	Max Depth	Secchi Depth	pH	Sp Cond	Alk	Hard-ness
Tobico Marsh State Game Area	Bay	Tobico Lake	16.6	connected	2.1	2	8.08	525	170	240

Water quality and physical habitat data
A variety of variables were used to conduct a multivariate analysis. For a list of variables see Appendix A.

A principal component analysis (PCA) using varimax rotation was performed on 22 chemical and physical variables. Six rotated principal components explained 82% of the variance. The first principal component was based on water chemistry (alkalinity, hardness, SpCond, pH) and explained 30% of the variance. The next 3 principal components explained between 18% and 10% each: depth (depth to low oxygen, Secchi depth, depth of greatest temperature change, max depth), littoral depth (average mid-depth of littoral zone, average max depth of littoral zone), and substrate (% muck, -%algae, color wheel). The last 2 principal components explained 6% and 5% of the variation respectively: littoral distance (average maximum littoral width, maximum littoral distance) and proximate geology.

A PCA using varimax rotation was also preformed on 21 macrophyte variables. Nine resultant principal components were identified that explained ~76% of the variation. Each principal component explained between 12% and 6% of the variation. Principal components were based on: 1) Potamogeton sp., 2) Grass and Scirpus, 3) Bressina and Utricularia, 4) Equisetum and Lemna, 5) Nuphar, 6) Typha and Nymphaea, 7) Justicia, 8) Sagittaria, and 9) Vallisneria. More analysis is needed with this data. The water quality and physical habitat data was analyzed separately from the macrophyte data because the correlation matrix for the combined data was "not positive definite", which means that there are very high correlation values in the matrix; however a review of the matrix did not show this. This issue still needs to be resolved.

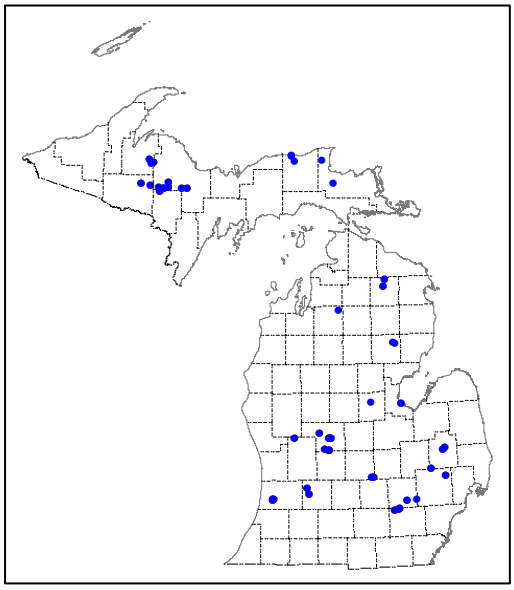

Figure 1: Location of small lakes sampled.

Connectivity did not arise as a major factor in the multivariate analysis. Although given the close tie between connectivity and alkalinity (Figure 2), connectivity is partially represented.

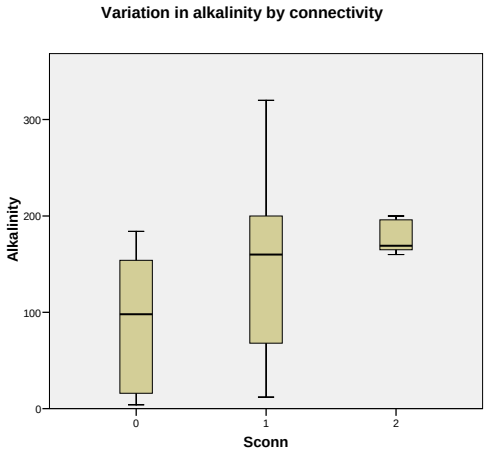

Figure 2: Variation in alkalinity by connectivity. Sconn is lake connectivy; 0 = no connections, 1 = headwater lake, 2=riverine lake.

DISCUSSION

A suite of water chemistry variables (alkalinity, hardness, specific conductivity, and pH; somewhat related variables) were shown to explain 30% of the variation in the data. Yet, proximate geology explained only 5% of the variation in the data.

The depth variables, included depth to low oxygen. Dissolved oxygen is a key factor in determining community composition for ponds and small lakes (Zalawski and Naiman 1984, Jackson et al. 2001). Large predatory species typically have higher oxygen requirements than smaller species (Magnuson et al. 1985). Because ponds and small lakes are more likely to have oxygen depletion issues over the winter with no refuge areas there communities can often be determined by small differences in winter anoxia (Jackson et al. 2001). Therefore, complexes of ponds and small lakes in the same area can have very different communities.

Future work needed:
Much of the macro-invertebrate data collected has not been processed for all the small lakes sampled. This effort can be quite time consuming. However, the variation in some taxa groups may be good indicators for the biodiversity of the whole macro-invertebrate community for that lake. Species richness in the families Coenagriidae and Limnephildae have been shown in other places to represent the overall richness in other taxa groups. Effort might be best spent processing data on these taxa groups first. This data combined with the results of the multivariate analysis would better elucidate relationships between lakes and would further the pond and small lake classification efforts.

PROPOSED DRAFT FRAMEWORK FOR EO SPECIFICATIONS

Element Occurrences are essential for Natural Heritage methodology and are used as a basis for conservation planning. Eos are added to the Biotics database to track and gather information on important species and natural communities in each state. “EO specifications are used to delineate and differentiate Eos” (NatureServe 2002). Essentially, EO specifications for natural communities define where the boundaries are for a specific ecosystem. Criteria of what constitutes an EO are often based on the minimum size needed for an ecosystem to function, the processes or quality needed for a functioning ecosystem, and the distance or factors that separate one EO from another. EO specifications provide the standard for how a natural community is defined.

Lentic natural communities are defined and delineated by their lake basin and are described as polygons; inflows and outflows are not included. Lentic ecosystems are defined here as greater than 2 acres; water bodies less than 2 acres are likely wetland natural communities, which may include vernal pools. Separation barriers include dams, other water level devices, concrete channels, below ground channels, or stretches of stream or river greater than 500 m. Some lakes are lobed and have small connecting channels between the lobes. But the connecting channels are typically quite short. If connecting channels or streams are greater than 500 m the lakes likely function as separate ecosystems. Lake chains, lakes separated by connecting channels or streams greater than 500 m, likely heavily affect each other.

PROPOSED DRAFT EO RANK SPECIFICATIONS

Element Occurrence ranks and rank specifications provide an evaluation of estimated viability or probability of persistence of a given EO often based on condition, size, and landscape context (NatureServe 2002). Ranks, typically A through D, provide a succinct measure of whether an EO has excellent estimated viability (i.e. A or high quality) or poor estimated viability (i.e. D or degraded). EO rank specifications provide replicable criteria to determine rank based on knowledge of historical evidence, current status, and threshold values, all variables that suggest ecological processes are functioning within an ecosystem.

The National Research Council (1992) described six major types of stresses or threats to lakes ecosystems: excessive nutrient inputs, hydrologic and physical alterations, siltation, introduction of non-native species, acidification, and contamination. These threats can change simplify lake food webs by the loss of sensitive species and the addition of invasive non-native species that dominant. Additionally, nuisance algal blooms can become common. The deliberate or unintentional stocking of fish can completely alter a food web, especially in lake ecosystems that have low natural species diversity, and are low in productivity and physio-chemically undisturbed (Li and Moyle 1981, Bain 1992).

To determine an EO rank for a pond or lake community, it is proposed that condition and landscape context be weighted equally. Size is not an appropriate ranking factor for aquatic ecosystems. Condition id defined as "an integrated measure of the quality of biotic and abiotic factors, structures, and processes *within* the occurrence, and the degree to which they affect the continued existence of the EO" (NatureServe 2002). Components of this ranking factor include ecological processes, species composition, abiotic physical and chemical parameters. Where as landscape context is "an integrated measure of the quality of biotic and abiotic factors, structures, and processes *surrounding* the occurrence, and the degree to which they affect the continued existence of the EO" (NatureServe 2002). Components of this ranking factor include landscape structure and extent, and condition of the surrounding landscape. Taken together they reflect the local as well as the watershed influence on a particular natural community. For more information on EO rank specifications see Appendix B.

For condition, six main factors are proposed to rank a lentic EO. (1) Shoreline cover is an important component for determining stability of lake banks, nutrient inputs, and shoreline in-lake structure. Natural shoreline and riparian cover stabilizes lake shoreline and provides natural in-lake cover. Shoreline development or modifications, such as grass lawns, docks or bulkheads, can significantly alter nutrient inputs, sediment movements, and amount and types of in-lake cover. (2) It is important that the water quality parameters, such as dissolved oxygen and phosphorus, are within natural variability. (3) Hydrologic alterations, such as dams or other water control structures can significantly alter the natural water cycles, including natural residence time variability. This can significantly change nutrient inputs and outputs. (4) Lentic ecosystems rely on nitrogen and phosphorus cycles; these are key abiotic factors that help determine the community composition of lakes. Any nutrient alterations can significantly change the community composition, for example increased frequency and amount of toxic algae blooms. (5) Invasive species are one of the most significant threats to lentic ecosystems. They are easily transported on boats and fishing gear between lakes and significantly alter the natural community composition of a lake. (6) Boat traffic is also included in the ranking factors of condition, since they can not only introduce invasive species, but they can also create increase turbidity which can significantly alter the macrophyte community present in the lake which can cascade to the whole community. In lake quality relies on external influences.

For landscape context, three main ranking factors are proposed: (1) land cover composition within 500 m buffer of lake; (2) composition and size of riparian buffer; (3) amount of impervious surfaces in watershed. Recent work (Soranno CITE) has shown that composition within a 500 m buffer of a lake can provide a lot of insight into the quality of that lake. The more natural the land cover within that buffer the higher quality and less disturbed that lake is likely to be. The composition and size of the riparian buffer is also important. A more natural buffer provides a lot of services to the lake, such as slowing down water inputs, decreasing nutrient inputs, and providing quality in-lake cover (e.g., downed woody structure). And the larger the buffer the better. There are many studies (cite) that suggest that when a watershed has greater than 10% impervious surface, the water bodies in that watershed are fairly degraded. As impervious surfaces increase in a watershed, less water in absorbed into the soils and groundwater and more is pushed right into the lake with the

chemical component is has picked up from the road surfaces. Intact watersheds are important to lakes, but intact and natural riparian buffers may be critical to keeping lakes of higher quality.

Future Directions

A more in-depth literature review is needed to support or refute these proposed factors. The following are additional factors that should be examined for inclusion or modification into the EO rank specifications for lentic natural communities:

Rank factor – Condition

- Amount of time since last herbicide treatment?
- More specifics on hydrologic and nutrient alterations?
- Include more biological components, like macro-invertebrate community data?

Rank factor – Landscape context

- Are the thresholds listed here appropriate?
- Should road density and specific land use be included?
- Number of point-source facilities, mining operations, or farming operations in watershed?

PROPOSED DRAFT POND AND SMALL LAKE NATURAL COMMUNITY TYPES

Ponds and lakes should be viewed in a nested framework. Ecological Drainage Units (EDUs) are similar in concept to terrestrial ecoregions, except that they are defined by how water moves across the landscape (Higgins et al. 2005). They are aggregates of watersheds based on hydrologic units that share similar ecological characteristics such as climate, hyrologic regime, physiography, and zoogeographic history. Michigan has nine EDUs (Figure 2). This is the broadest scale framework described here. Ponds and lakes can be classified in a variety of ways using landscape-level or GIS data. This allows for a full inventory of the types of ponds and lakes in Michigan. Currently, there are efforts in Michigan (DNR Fisheries Division, Institute for Fisheries Research; Michigan State University, Fisheries and Wildlife Department) to characterize and classify lakes at the landscape level. These efforts are on-going and are focused on lakes greater than 25 acres. At the finest scale of classifying, field data should be the driving factors. Field data is the only way to determine chemical composition of ponds and lakes as well as determining turbidity, basin shape, stratification, and community composition. It is proposed that Michigan's lentic natural communities have a three-level hierarchical framework: 1) EDUs, 2) Landscape-level types, and 3) natural communities based on field data.

Ecological Drainage Units

There are nine Ecological Drainage Units in Michigan, we combined them into 7 EDUs. The following paragraphs briefly describe each one in terms of climate, within ecoregion sections and subsections, major landforms, water features, and zoogeography.

(16) Southeast Michigan Interlobate and Lake Plain (SEMILP) contains most of the Lake Erie drainage in Michigan. Mean annual temperature is 48.6˚F (sd 1.1) and 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 flow to the Ohio River via the Teays River but today they all flow into western Lake Erie and Lake St. Clair.

(2) Only a small portion of the Western Lake Erie (WLE) EDU is in Michigan, most of the EDU is in Ohio. The mean annual temperature in this EDU is 48.6-50.1˚F (sd 1.0-1.2) and the mean annual precipitation is between 30.5-34.3 (sd 4.6-4.8) inches. This EDU mainly has low gradient, surface water-fed streams except in the interlobate area (along the glacial boundary) where moderate gradient streams occur.

Historically, all streams drained to the Ohio River via Teays River but today they all flow into western Lake Erie. Because only a small area of this EDU is in Michigan, it will be combined with the SEMILP EDU for this analysis.

(4) The Saginaw Bay (SB) EDU if found in the lower half of the Huron River Basin. The mean annual temperature is 48.5 to 43.3 (sd 1.08) ˚F and the mean annual precipitation is 29.2 (sd 3.8) to 31.7 (sd 4.56) inches from south to north respectively. Many of the streams in this EDU are intermittent. Those that are perennial are part of the Saginaw River system and are generally low gradient streams. Historically, all streams drained west out to the Grand River into Lake Chicago but today they drain to Saginaw Bay and Lake St. Clair.

(3) The Southeast Lake Michigan (SELM) 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.

(5) The Northern Lake Michigan, Lake Huron, and Straits of Mackinac (NLMLHSM) EDU encompasses the northern half of the lower peninsula of Michigan. Mean annual air temperatures range from 46.1 (sd 1.16) to 43.3 (sd 1.08) ˚F from west to east and mean annual precipitation ranges from 33.1 (sd 4.38) to 29.5 (sd 3.29) inches from west to each with a rain shadow from southwest to northwest. There are kettle lakes in the outwash plains areas. In the lake plain area there are some large lakes, lakes of many geneses, and intermittent streams. Groundwater streams can be found in the outwash surrounded by coarse moraines and ice contact. Historically, this area likely drained to the St. Lawrence River via the Ottowa River and Champlain Sea but today, rivers drain west to Lake Michigan, east to Lake Huron, and north to the straits. The Lake Michigan and Lake Huron drainage divide roughly bisects this EDU.

(7) In the Eastern Upper Peninsula (EUP) EDU the mean annual temperature is 41.1 (sd 1.06) ˚F and the mean annual precipitation is 32.5 (sd 4.07) inches. This EDU has many small and medium sized low-gradient streams which are underlain by deep sandy outwash deposits or sedimentary rock. They are also often connected to wetlands. Historically, the streams in this area likely drained to the St. Lawrence River via the Ottowa River and Champlain Sea, but today waters drain to the north to Lake Superior and to the south to Lakes Michigan and Huron and to the St. Mary's River.

(8) In the Central Upper Peninsula (CUP) EDU the mean annual temperature is 40.4 (sd 1.22) ˚F and the mean annual precipitation is 32.5 (sd 4.39) inches. Half of this EDU is within the Menominee River drainage. There are many lakes, spring ponds, springs, wetlands, and streams in this EDU. Kettle lakes are common. Streams tend to be low in density and have dendritic drainages and high spring and fall water flows with relatively low flows in the summer. These low gradient streams are underlain by sandy outwash, limestone, or shale. Historically, the waters in this EDU drained south to the Mississippi River via a connection through Green Bay (Wolf/Fox Rivers), but today it drains north to Lake Superior and south to northern Lake Michigan / Green Bay.

(6) The Western Upper Peninsula and Keweenaw Peninsula (WUPKP) EDU has mean annual air temperatures of 40.42 (sd 1.22) ˚F and a mean annual precipitation of 32.5 (sd 4.39) inches. This EDU has many kettle lakes in the outwash plains. Historically, the waters in this EDU drained to the upper Mississippi River via St. Croix River drainage of glacial Lake Duluth with a possible connection to Hudson Bay and Lake Agassiz. Today the waters drain to the southwest into Lake Superior.

(12) A very small portion of Michigan is in the Bayfield Peninsula and Uplands (BPU) EDU. The mean annual temperature in this EDU is

41.41 (sd 1.16) ˚F and the mean annual precipitation is 31.29 (sd 5.39) inches, this precipitation. There are few lakes in this EDU and the streams are low gradient and flow from west to east into Lake Michigan. Historically, this EDU drained to the Mississippi River via the Fox River, but today it drains to western Lake Michigan. Only a very small portion of this EDU is in Michigan, hence we will combine it with the WUPKP EDU during our analysis because it is in the same ecoregion.

Landscape-level types

It is proposed here that efforts are not duplicated, and that the broad landscape-level framework for Michigan's natural communities be those defined by the on-going efforts.

Natural Communities (field-based)

Given the data and analysis, alkalinity, depth variables, littoral depth, and substrate should be used to classify ponds and small lakes. Additional analysis to include macroinvertebrate communities will provide a more refined look at important variables for small lake classification.

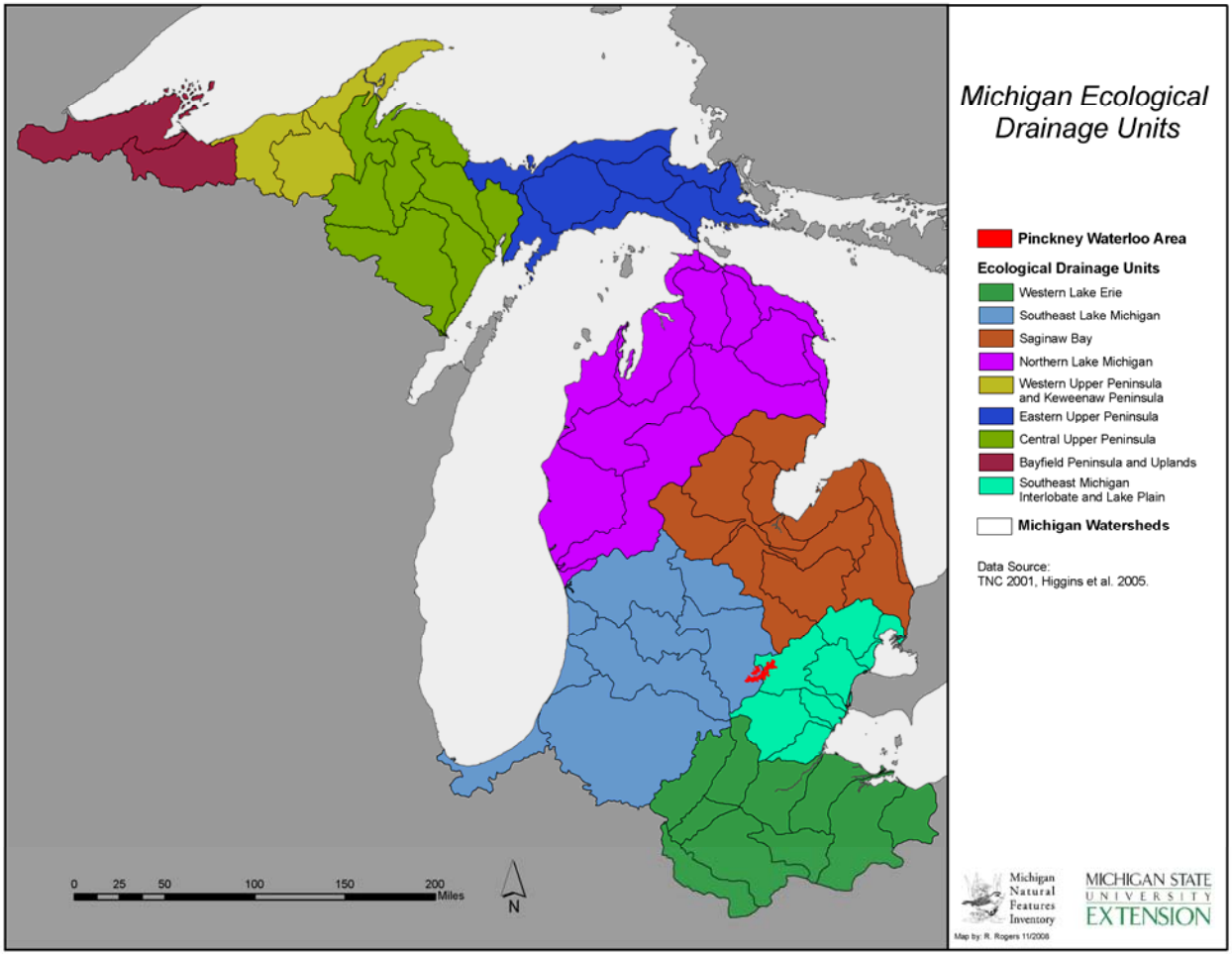

Figure 3: Ecological Drainage Units and Major Watersheds of Michigan.

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: (SpCond) 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 A

Variables to use for multivariate analysis:

Water quality

1. Secchi depth
2. pH
3. conductivity
4. alkalinity
5. hardness
6. color wheel
7. stratification (Y/N)
8. D>TC [depth at which the greatest water temperature change occurred (Hutchinson 1957)]
9. DLO [depth at low oxygen levels – depth at which oxygen levels are below 5mg/l (minimum oxygen level required by fish)

Landscape level

10. connectivity
11. proximate geology
12. coarse/fine geology

Morphology

13. max depth
14. average mid littoral depth
15. average max littoral depth
16. average max littoral distance
17. maximum littoral distance

Substrates

18. average percent OM
19. average percent marl
20. average percent sand
21. average percent gravel
22. average percent pebble
23. average percent cobble
24. average percent boulder

Structure

25. average percent woody structure

Shoreline/ Riparian

26. relative composition of shoreline stabilities
27. relative composition of shoreline types
28. relative composition of shoreline cover types
29. relative composition of riparian cover types

Appendix B

Draft EO and Rank Specifications for Lakes

SPECS GROUP

Lentic ecosystesm – ponds and lakes

NATURAL COMMUNITY MAPPING UNIT

Pond or lake polygon.

NATURAL COMMUNITY MAPPING UNIT JUSTIFICATION

Ponds and lakes have distinct boundaries. Inflows and outflows are not included.

MINIMUM SIZE

We consider ponds and lakes to be greater than 2 acres. Those water bodies less than 2 acres are likely wetland natural communities, which may include vernal pools.

EO Separation

SEPARATION BARRIER

Barriers that would separate pond or lake communities include dams, concrete channels, below ground channels, or stretches of stream or river greater than 500m.

Edition

SPECS AUTHOR

Derosier, A.L.

SPECS EDITION DATE

2008-06-04

SPEC NOTES

This is a proposed draft EO Specification for ponds and lakes. This draft still needs to go through a review process.

EO Rank Specs

RANK SPECS GROUP

RANK PROCEDURE

Condition and landscape context are weighted equally for this type because aquatic ecosystems are strongly affected by the surrounding watershed as well as the local conditions.

EO RANK FACTOR *[1st]*

Condition – is an integrated measure of the quality of biotic and abiotic factors, structures, and processes *within* the occurrence, and the degree to which they affect the continued existence of the EO. Components of this factor are: ecological processes, species composition

and biological structure, abiotic physical and chemical factors (taken from pg. 45, NatureServe 2002).

A SPECS

a) Shoreline and riparian vegetation/cover is natural. No shoreline development or modifications.
b) Water quality parameters fall within natural variability of regimes of natural community type.
c) No evidence of hydrologic alterations.
d) No evidence of nutrient alterations.
e) No evidence of invasive species.

B SPECS

a) Shoreline and riparian vegetation/cover is mostly natural. Shoreline development or modifications occupy <10% of shoreline.
b) Water quality parameters fall within natural variability of regimes of natural community type.
c) Minimal evidence of hydrologic alterations.
d) Minimal evidence of nutrient alterations.
e) Exotic fish, clams, or macrophytes may be present at low densities.
f) Minimal boat traffic.

C SPECS

a) Shoreline development or modifications occupy between 30 and 60% of shoreline.
b) Water quality parameters fall within natural variability of regimes of natural community type.
c) Minimal to moderate evidence of hydrologic alterations.
d) Minimal to moderate evidence of nutrient alterations.
e) Exotic fish, clams, or macrophytes are present.
f) Minimal to moderate boat traffic.
g) Moderate algal blooms occur.

D DPECS

a) Shoreline development or modifications occupy > 60% of shoreline.
b) Moderate to extensive evidence of hydrologic alterations.
c) Moderate to extensive evidence of nutrient alterations.
d) Exotic species are common.
e) Invasive macrophytes are dominant and are a nuisance.
f) Moderate to heavy boat traffic.
g) Moderate to heavy algal blooms occur.

RANK SPEC JUSTIFICATION

FACTORS TO EXAMINE FOR INCLUSION OR MODIFICATION

- More in depth literature search is needed to back or refute proposed factors.
- Amount of time since last herbicide treatment?
- More specifics on hydro and nutrient alterations?

- How can we tell between nuisance and natural macrophyte growth?
- Include more biological components? Macroinvertebrate community data?
- Water quality parameters within normal variation? More details needed.
- Others?

EO RANK FACTOR *[2nd]*

Landscape context – is an integrated measure of the quality of biotic and abiotic factors, structures, and processes *surrounding* the occurrence, and the degree to which they affect the continued existence of the EO. Components of this factor are: landscape structure and extent, including genetic connectivity, condition of the surrounding landscape (taken from pg. 46, NatureServe 2002).

A SPECS

a) Natural riparian buffer is wide (>50 m).
b) Amount of impervious surfaces in watershed is low.
c) No development within 500m buffer of pond or lake.

B SPECS

a) Natural riparian buffer is wide (>25 m).
b) Amount of impervious surfaces in watershed is low to moderate.
c) Minimal development within 500m buffer of pond or lake.

C SPECS

a) Natural riparian buffer is moderate (>10 m).
b) Amount of impervious surfaces in watershed is moderate.
c) Minimal to moderate development within 500m buffer of pond or lake.

D DPECS

a) Riparian buffer is small or non-existent (<10 m).
b) Amount of impervious surfaces is moderate to high.
c) Moderate development within 500m buffer of pond or lake.

RANK SPEC JUSTIFICATION

FACTORS TO EXAMINE FOR INCLUSION OR MODIFICATION

- More in depth literature search is needed to back or refute proposed factors.
- Thresholds for the amount of development in watershed is needed.
- Thresholds for percent impervious surface in watershed or riparian buffer or critical watershed area is needed.
- Use of disturbance gradient analysis (500m buffer – land use and road density) as a factor
- Number of point-source facilities in watershed
- Number of active mining operations or farming operations in watershed
- Others?

RANK SPECS AUTHOR

A.L. Derosier

RANK SPECS EDITION DATE

2008-06-04

RANK SPEC NOTES

This is a proposed draft EO Rank Specification for ponds and lakes. This draft still needs to go through a review process.

Appendix C

State Game Areas

Allegan State Game Area

Ely Lake (4244)

Location: Allegan, Allegan State Game Area
Lake Type: lake sand and gravel, fine, headwater, round

Photo:

Site Description:
Ely Lake is a relatively shallow, uniform pond. There is some human use around the lake via the campground. There are quite a few access points to the lake. There is an arm of the lake that is covered in vegetation.

Dominant macrophytes include: *Brasenia, Nymphaea, Utricularia,* and sedges.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	26.51	pH	**6.02**	hardness	40
Max depth (m)	3.9	conductivity	30.7	water color	
Secchi depth (m)	**2.3**	alkalinity	**12**	color wheel	15

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.5	**30**	22	45
mid-depth	1.31	**16.2**	13	24

Little Tom Lake (4246)

Location: Allegan, Allegan State Game Area
Lake Type: lake sand and gravel, fine, unconnected, round
Photo:

Site Description:
This small, round pond is shallow, turbid, with darkly-stained water. Substrates were quite smelly. There were large areas of "mud flats".

Fish collected in this lake include: warmouth, yellow bullhead, and largemouth bass.

Dominant macrophytes include: *Brasenia*, *Nymphaea*, and *Utricularia*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	17.25	pH	**5.46**	Hardness	20
Max depth (m)	3.3	conductivity	31.1	water color	Dark tannin
Secchi depth (m)	**1.4**	alkalinity	**12**	color wheel	40

Parameter	Value	Parameter	Value	Parameter	Value
Acres	17.248	pH	5.85	Hardness	
Max Depth	3	Conductivity	24.1	water color	Tannic
Secchi Depth	1.6	Alkalinity	15	color wheel	35

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.34	**52.4**	38	70
mid-depth	1.77	**43.8**	35	68

Mud Lake (4243)

Location: Allegan, Allegan State Game Area
Lake Type: lake sand and gravel, fine, unconnected, round

Photo:

Site Description:
This is a small, undeveloped lake with tannic-stained water with a narrow littoral zone. The littoral area has a quick drop off. There was quite a lot of blue-green algae / green balls of algae on surface. This lake had a difficult hand launch that was about 100m from the road with no parking area nearby, hence this lake likely has little human use.

Fish collected in this lake include: largemouth bass, warmouth, yellow bullhead, white crappie, black crappie.

Dominant macrophytes included: *Potamogeton* sp., *Nuphar*, *Nymphaea*, and *Utricularia*. Water willow was present along shoreline.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	4.15	pH	**7.62**	Hardness	100
Max Depth	4.5	Conductivity	140.7	Water Color	tannic
Secchi Depth	**2.6**	Alkalinity	**56**	Color Wheel	60

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.13	**9**	7	11
mid-depth	1.27	**4.6**	3	7

Bald Mountain State Game Area

Shoe Lake (6444)

Location: Oakland, Bald Mountain State Game Area
Lake Type: outwash sand and gravel, coarse, riverine, round

Photo:

Site description:
Shoe Lake has a narrow littoral zone with two basins and is surrounded by forest. Shoreline macrophytes include cattails, rush, and arrowweed (scattered patches).

Dominant vegetation includes: coontail, *Nuphar*, *Nymphaea*, *Utricularia*, *Potamogeton*, *Typha*, and milfoil (?).

Parameter	Value	Parameter	Value	Parameter	Value
Acres	6.1	pH	**7.7**	Hardness	260
Max Depth	5.8	Conductivity	628	Water Color	
Secchi Depth	**1.9**	Alkalinity	0	Color Wheel	25

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.23	**5.8**	4	9

mid-depth	1.375	**2.875**	2	4

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.43	**46.6**	26	72
mid-depth	1.1	**20**	12	30

Barry State Game Area

Dagget Lake (2624)

Location: Barry, Barry State Game Area
Lake Type: coarse till - end moraine, coarse, unconnected, round

Photo:

Site Description:
Dagget Lake is very shallow but has seemingly little vegetation. There is a small beach area and a separate launch, but no houses on the lake. The dominant macrophyte is watershield and cattails surround about a quarter of the lake. There are no dead trees around lake.

Dominant macrophytes include: *Brasenia, Potamogeton sp*., and *Sagittaria sp*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	17.74	pH	-	Hardness	40
Max Depth	4.1	Conductivity	-	Water Color	-
Secchi Depth	**2.85**	Alkalinity	**20**	Color Wheel	30

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2	**42.8**	18	76
mid-depth	1.14	**22.2**	14	39

Shaw Lake (2563)

Location: Barry, Barry State Game Area
Lake Type: outwash sand and gravel, coarse, unconnected, round

Photo:

Site Description:
This small lake is associated with a fen. The lake generally has very little macrophytes and the substrates smell and have a cottage cheese consistency. Substrates are marl. Lots of spawning beds were noted.

Fish collected in this lake include: bluegill, pumpkinseed, blackstripe topminnow, green sunfish, yellow bullhead, white sucker, largemouth bass, black crappie.

The dominant macrophyte was Chara. Other macrophytes relatively common were *Nymphaea* and *Nuphar*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	4.654	pH	-	Hardness	240
Max Depth	5.1	Conductivity	-	Water Color	clear/green
Secchi Depth	**3.4**	Alkalinity	**136**	Color Wheel	15

Parameter	Value	Parameter	Value	Parameter	Value
Acres	4.654	pH	**8.4**	Hardness	
Max Depth	5.1	Conductivity	335	Water Color	clear
Secchi Depth	**4.1**	Alkalinity	**185**	Color Wheel	15

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.12	**4.5**	1.5	7
mid-depth	0.5	**2.6**	1	3

Brighton State Game Area

Little Appleton Lake (6849)

Location: Brighton, Brighton State Game Area
Lake Type: coarse till - end moraine, coarse, riverine, round

Photo:

Site Description:
Little Appleton is a nice little pond with 3 basins and a narrow littoral zone that is steep and drops off quickly. There is a stream connection.

Chara was the dominant macrophyte. Other macrophytes present include Nymphaea and coontail. (milfoil?)

Parameter	Value	Parameter	Value	Parameter	Value
Acres	5.168	pH	**8.27**	Hardness	200
Max Depth	5.8	Conductivity	488	Water Color	
Secchi Depth	**2.9**	Alkalinity	**200**	Color Wheel	20

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.93	**4.6**	3	5
mid-depth	1.03	**2.1**	1.5	3

Flat River State Game Area

Clear Lake (2957)

Location: Montcalm, Flat River State Game Area
Lake Type: outwash sand and gravel, coarse, unconnected, round

Photo:

Site Description:
Clear Lake is surrounded by cattails and the water is extremely clear. There are 2 houses and a cabin on this lake. The launch area is sandy. Largemouth bass and sunfish were seen in lake.

Dominant vegetation includes: *Nuphar, Nymphaea, Potamogeton amplifolius, P. natans, Typha*, scouring rush, and grass.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	16.3	pH	**8.39**	Hardness	140
Max Depth	8.1	Conductivity	172.4	Water Color	clear
Secchi Depth	**5.2**	Alkalinity	**88**	Color Wheel	15

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.72	**21**	0	40
mid-depth	1.7	**15.2**	9	26

Langston State Game Area

Tacoma Lake (2753)

Location: Langston, Langston State Game Area
Lake Type: outwash sand and gravel, coarse, headwater, round

Photo:

Site Description:
Tacoma Lake is large, with residential land use on ~20-30% of the shoreline. The lake is used by pontoon boats and skidoos. This lake is clear and deep with a relatively large littoral zone with *Chara* and rush. There is an area of fallen logs and trees along the shoreline.

Chara and rush dominate the vegetation in the lake. Other vegetation present: *Carex, Potamogeton*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	18.4	pH	**8.52**	Hardness	220
Max Depth	10	Conductivity	274	Water Color	clear
Secchi Depth	**4.4**	Alkalinity	**0**	Color Wheel	7

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.82	**28**	13	42
mid-depth	0.8	**15.8**	7	26

Lapeer State Game Area

Fish Lake (5923)

Location: Lapeer, Lapeer State Game Area
Lake Type: coarse till - end moraine, coarse, headwater, round

Photo:

Site Description:
Fish Lake is a long pond with most of the shore covered by overhanging vegetation and cattails. There is no development on the lake, but there is a house across the road from the launch. This lake appears to be heavily used judging by the amount of beer cans noted and large, easy-access launch. No fish were seen.

Dominant macrophytes include: *Brasenia schreberi, Nympheae, Nuphar, Potamogeton, Typha,* and milfoil. Unsure if milfoil is the invasive species.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	16.0	pH	**7.75**	Hardness	140
Max Depth	6	Conductivity	209	Water Color	-
Secchi Depth	**2.6**	Alkalinity	**68**	Color Wheel	35

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.91	**19**	7	32
mid-depth	0.96	**8.8**	3	14

Race Lake (2954)

Location: Montcalm, Flat River State Game Area
Lake Type: outwash sand and gravel, coarse, unconnected, round

Photo:

Site Description:
Race Lake is a small two basin lake, one basin is completely covered in *Nymphaea* and the other larger basin has a pelagic habitat. There is a band of *Chara* between the two basins. There is one dock in the larger basin, but not boat is associated. The lake is surrounded by forest and there are dead standing trees all around the large basin.

Nymphaea and milfoil (unsure if this is the invasive sp.) are the dominant macrophytes in the lake. Other vegetation common: *Potamogeton, Utricularia, Sagittaria,* and scouring rush.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	8.739	pH	**8.4**	Hardness	220
Max Depth	7	Conductivity	316	Water Color	
Secchi Depth	**3.3**	Alkalinity	**164**	Color Wheel	20

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.15	**20.2**	6	49
mid-depth	1.73	**8.8**	2	21

Twin Lake (5906)

Location: Lapeer, Lapeer State Game Area
Lake Type: coarse till - end moraine, coarse, unconnected, round

Photos:

Site Description:
Twin Lake is surrounded by Typha and shrubs and trees with overhanging vegetation. There is a small island of Potamogeton in the center of the lake. There is also a large beaver dam in the lake and there was lots of signs of beaver activity. Due to this, there is a significant large woody structure in the lake.

Dominant macrophytes seen include: *Chara, Nympheae, Najas, Nuphar, Potamogeton, Utricularia*, coontail, and milfoil. *Typha* surrounds lake. Unsure if milfoil is the invasive.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	15.1	pH	**8.29**	Hardness	240
Max Depth	8.1	Conductivity	303	Water Color	-
Secchi Depth	**2.1**	Alkalinity	**152**	Color Wheel	15

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.99	**25.8**	13	72
mid-depth	0.78	**9.8**	3	31

Watz Lake (4)

Location: Lapeer, Lapeer State Game Area
Lake Type: ?,Coarse, ?, round

Photo:

Site Description:
Watz Lake had a variety of habitats and had a significant amount of woody structure. Marsh (*Typha*) and dead trees surround pond. There was a beaver lodge on the lake. The lake is easily accessible and likely fished frequently.

Dominant macrophytes included: *Chara, Nuphar, Nympheae, Utricularia,* and coontail.

Parameter	Value	Parameter	Value	Parameter	Value
Acres		pH	**7.66**	Hardness	260
Max Depth	8	Conductivity	357	Water Color	
Secchi Depth	**2.3**	Alkalinity	**184**	Color Wheel	30

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.43	**43.2**	26	59
mid-depth	1.04	**29.2**	15	35

Unnamed Lake (2958)

Location: Montcalm, Flat State Game Area
Lake Type: outwash sand and gravel, coarse, unconnected, round

Photo:

Site Description:
The small, clear, unnamed lake has a narrow littoral zone and is surrounded by shrubby forest. The shoreline habitat varies and includes *Typha* and water willow. There are a few large dead pine trees along the shore. The launch seems to be well used.

Dominant macrophytes include: *Nymphaea, Potamogeton, Chara, Typha,* and *Sagittaria*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	3.0	pH	**8.46**	Hardness	220
Max Depth	6.7	Conductivity	-	Water Color	-
Secchi Depth	**3.4**	Alkalinity	**116**	Color Wheel	15

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.85	**9.4**	7	13
mid-depth	1.16	**4.8**	3	8

Ortonville State Recreation Area

Algoe Lake (6084)

Location: Lapeer, Ortonville State Recreation Area
Lake Type: outwash sand and gravel, coarse, headwater, round

Photo:

Site Description:
Algoe Lake is deep and has two basins. The entire lake is surrounded by *Nympheae* lily, except for one area near the launch that is a large *Nuphar* bed.

The lake is dominated by *Chara* and *Nympheae*. Other vegetation present includes coontail and *Typha*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	13.1	pH	**8.02**	Hardness	320
Max Depth	12	Conductivity	462	Water Color	
Secchi Depth	**2**	Alkalinity	**0**	Color Wheel	15

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.13	**32.6**	25	53
mid-depth	0.91	**17.6**	13	30

Rogue River State Game Area

Spring Lake (2832)

Location: Kent, Rogue River State Game Area
Lake Type: medium-textured glacial till, fine, riverine, round

Photo:

Site Description:
Spring Lake is a small lake with a narrow littoral zone and very little lilly present. There appear to be multiple stream connections to the lake including an inlet and outlet. There were thick algal blooms present. Purple loosestrife was seen around lake. Lake is surrounded by cattail marsh. Largemouth bass and minnows were seen in lake.

Macrophytes include: *Chara*, *Potamogeton sp.*, *Elodea*, coontail, and *Typha*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	10.4	pH	**8.75**	Hardness	320
Max Depth	5.5	Conductivity	444	Water Color	-
Secchi Depth	**1**	Alkalinity	**196**	Color Wheel	15

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.69	**11.4**	3	20
mid-depth	1.66	**5.3**	1.5	10

Rose Lake State Game Area

Fox Knoll Lake (3341)

Location: Ingham, Rose Lake State Game Area
Lake Type: coarse till– ground moraine, coarse, riverine, round

Photo:

Site Description:
Fox Knoll Lake is approximately 500m from the parking area and the boat launch is a hand launch consisting of old pallets. Substrate is mucky and deep and smells like sulpur. Water in this lake is tannic in color with a short littoral zone. Human use is likely infrequent due to the poor launch and distance from parking area.

Macrophytes include: *Chara*, *Nuphar variegata*, *Typha sp*., and *Potamogeton sp*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	7.727	pH	**8.28**	Hardness	260
Max Depth	6.3	Conductivity	891	Water Color	tannic
Secchi Depth	**3.1**	Alkalinity	**200**	Color Wheel	40

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.55	**9.2**	7	14
mid-depth	0.83	**4.6**	3	7

Potter Lake (3331)

Location: Clinton, Rose Lake State Game Area
Lake Type: Coarse, round

Photo:
pict#293-295

Site Description:
Potter Lake is a c-shaped lake that is relatively narrow and shallow with tannic water. Boat launch consists of old pallets and a hand launch only. Substrates are mucky and deep. The littoral zone is approximately 10-15m in width with lots of lilly. Chara occurs to surface in littoral and in the pelagic zone. The riparian area is marsh.

Dominant macrophytes are *Chara, Nymphaea, Nuphar,* other macrophytes include: coontail, sago pondweed, *Utricularia*, duckweed.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	20.76	pH	**7.54**	Hardness	380
Max Depth	1.5	Conductivity	613	Water Color	tannic
Secchi Depth	**1**	Alkalinity	**320**	Color Wheel	15

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.42	**19.6**	5	38
mid-depth	1.1	**9.8**	3	17

Stanton State Game Area

Colby Lake (3203)

Location: Montcalm, Stanton State Game Area
Lake Type: coarse till - end moraine, coarse, riverine, round

Photo:

Site Description:
Colby Lake is a lobed pond with turbid water and a short littoral zone. The boat launch drops off fast. Sediment was thick black pudding.

Chara dominated the macrophytes, other macrophytes included *Nymphaea, Potamogeton epihydrus*, coontail, broad leaf pondweed, and duckweed.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	19.042	pH	-	Hardness	260
Max Depth	9	Conductivity	-	Water Color	turbid / brown
Secchi Depth	**2.3**	Alkalinity	**165**	Color Wheel	0

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.87	**9.2**	3	22
mid-depth	0.845	**5**	1.5	16

Grass Lake (3205)

Location: Montcalm, Stanton State Game Area
Lake Type: coarse till - ground moraine, coarse, unconnected, round

Photo:

Site Description:
Grass Lake is a clear lake dominated by chara. The surrounding landscape is marshy with lots of dead standing trees. This lake is likely heavily used by anglers.

Fish collected in this lake included: largemouth bass, warmouth, bluegill, yellow perch, spottail shiner, pumpkinseed, spotfin shiner, and green sunfish.

Chara is the dominant macrophyte. Other macrophytes present in the lake include *Nuphar*, *Nymphaea*, *Potamogeton*, coontail, and rush.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	34.1	pH	-	Hardness	180
Max Depth	9.2	Conductivity	-	Water Color	-
Secchi Depth	**3.8**	Alkalinity	**125**	Color Wheel	0

Parameter	Value	Parameter	Value	Parameter	Value
Acres	34.1	pH	**8.78**	Hardness	-
Max Depth	9.2	Conductivity	223	Water Color	clear
Secchi Depth	**3.9**	Alkalinity	**155**	Color Wheel	20

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.71	**18.6**	10	30
mid-depth	0.725	**10**	5	15

Twin Lake (2786)

Location: Montcalm, Stanton State Game Area
Lake Type: coarse till - ground moraine, coarse, unconnected, round

Photo:

Site Description:
Twin Lake is a large open lake, that is relatively deep with relatively narrow littoral zone. This lake seems to be used regularly by anglers.

Fish collected in this lake include: bluegill, largemouth bass, spottail shiner, pumpkinseed, white sucker, and brown bullhead.

Dominant macrophytes include: coontail, *Potamogeton, Nuphar, Nymphaea, Sagittaria, Typha,* duckweed, and scouring rush.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	12.9	pH	**8.16**	Hardness	-
Max Depth	5.7	Conductivity	354	Water Color	tannic
Secchi Depth	**2.7**	Alkalinity	**210**	Color Wheel	40

Parameter	Value	Parameter	Value	Parameter	Value
Acres	12.9	pH	**8.45**	Hardness	280
Max Depth	7.6	Conductivity	354	Water Color	-
Secchi Depth	**2.5**	Alkalinity	**180**	Color Wheel	0

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.565	**14.2**	4	40
mid-depth	1.195	**7.95**	1.5	27

Unnamed Lake (3206)

Location: Montcalm, Stanton State Game Area
Lake Type: coarse till - ground moraine, coarse, unconnected, round

Photo:

Site Description:
This small lake has a uniform complex of Typha, water willow, and shrubs around it. The lake is surrounded by forest.

Dominant macrophytes include: coontail, *Nymphaea*, *Utricularia*, and *Typha*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	3.5	pH	**8.04**	Hardness	100
Max Depth	5	Conductivity	104.1	Water Color	
Secchi Depth	**1.6**	Alkalinity	**58**	Color Wheel	0

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.85	**17.4**	10	26
mid-depth	2.22	**9.8**	3	18

Tobico Marsh State Game Area

Tobico Lake (5130)

Location: Bay, Tobico Marsh State Game Area
Lake Type: Sand, riverine, round

Photo:

Site Description:
Tobico Lake has some human influence. There is a floating dock, a bridge (with possible dam), and a natrure trail along the shore. The littoral zone in this pond is typically cattails closest to shore, lilly, and coontail towards the center. Around the entire pond watermeal occurs. Coontail and algae is thick throughout the lake. Along one shore there is a seasonally exposed “false shore”.

Dominant macrophytes include coontail, *Nymphaea*, duckweed, watermeal, curly leaf pondweed.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	16.605	pH	**8.08**	Hardness	240
Max Depth	2.1	Conductivity	525	Water Color	
Secchi Depth	**2**	Alkalinity	**170**	Color Wheel	10

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.79	**30.4**	17	59
mid-depth	0.79	**15.6**	8	32

Appendix D
State Parks and Recreation Division Lands

Craig Lake State Park

Nelligan Lake (16700)

Location: Baraga, Craig Lake State Park
Lake Type: Bedrock, bedrock, riverine, round, limestone/dolomite

Photo: none

Site Description:
Nelligan Lake has darkly tannin-stained water. The northwest corner of Nelligan is shallow (0.5m) with substrates composed on organic matter over sandy-gravel. In the northeast part of the lake there is exposed bedrock with cobbly-sandy substrates. There was little woody structure in lake. This lake has some shallow bays (1m). Animals seen include: yellow perch, sponge, and P. grandis (lots).

The dominant macrophyte is *Scripus subterminalis*. Other macrophytes present in lake include: *Bressinia schreberi, Potamogeton pusillus, Utricularia vulgaris, Nymphaea odonrta, Sparganium fluctuans, Nuphar variegatum, Eleocharis smallii, Glyceria borcalis, Potamogeton epihydrus. Callitrige verna* was present along channel from road.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	30.94	pH	-	Hardness	-
Max Depth	13.5	Conductivity	-	Water Color	-
Secchi Depth	0.5	Alkalinity	-	Color Wheel	-

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	-	**50**		

Teddy Lake (16671)

Location: Baraga, Craig Lake State Park
Lake Type: Bedrock, bedrock, headwater, round, limestone/dolomite

Photo: none

Site Description:
The water levels in Teddy Lake had recently risen by about 30-50 cm due to beaver flooding. There is a beaver dam in the northeast part of the lake. The lake is surrounded by swamp forest which are inundated and most of the trees are dead but their bark is intact and there are a few inundated spruce trees that are still alive. The lake is outlined by a zone of inundated Myrica and Chamaedaphne except where bedrock is present at the edge of the lake and where there is a steep slope adjacent to the lake. Macrophytes are generally sparse to heavy. Substrates in the lake are composed of organic matter over sand, sand and gravel, and occasionally boulders. Animals seen include: sponge (large ones) and bluegill.

Dominant macrophytes are *Nymphaea odorata* and *Bressina schreberi*. Other macrophytes include: *Utricularia vulgaris, Potamogeton vulgaris, P. natans, P. epihydrus, Sparganium fluctuans, Nuphar variegata, Equisetum fluviatile, and Potamogeton sp*. Vegetation from the shore to 5m includes: *Myrica gale, Chamaedaphne calyculata, Carex lasiocarpa, Dulichium arundinaceum, Triadenum fraseri, Scirpus atrovirens, and Lycopus uniforus.*

Parameter	Value	Parameter	Value	Parameter	Value
Acres	60.105	pH	**6**	Hardness	-
Max Depth	4	Conductivity	-	Water Color	tanic
Secchi Depth	**1**	Alkalinity	-	Color Wheel	-

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	-	**7?**	3	12

Tahquamenon Falls State Park

Cabin Lake (13992)

Location: Chippewa, Tahquamenon Falls State Park
Lake Type: Fine, unconnected, round

Photo:

Site Description:
Cabin Lake is lobed and has 3 basins with small islands throughout lake. The lake is surrounded by marsh and further back a pine forest. The water is shallow and fairly tannic. There are areas of thick grasses and a lot of beaver activity; there is a beaver lodge in the lake. The shoreline is undercut in areas. This lake is very

different lake than other lakes sampled in 2007.

Macrophytes include three-square rush, *Utricularia*, spikerush, *Nuphar*, and *Equisetum*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	11.51	pH	**4.79**	Hardness	20
Max Depth	1.6	Conductivity	19.1	Water Color	tannic
Secchi Depth	**1.6**	Alkalinity	**4**	Color Wheel	12

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	0.4	**7.5**	3	10
mid-depth	0.3	**4.7**	4	5

Ortonville State Recreation Area

Algoe Lake (6084)

Location: Lapeer, Ortonville State Recreation Area
Lake Type: outwash sand and gravel, coarse, headwater, round

Photo:

Site Description:
Algoe Lake is deep and has two basins. The entire lake is surrounded by *Nympheae* lily, except for one area near the launch that is a large *Nuphar* bed.

The lake is dominated by *Chara* and *Nympheae*. Other vegetation present includes coontail and *Typha*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	13.1	pH	**8.02**	Hardness	320
Max Depth	12	Conductivity	462	Water Color	
Secchi Depth	**2**	Alkalinity	**0**	Color Wheel	15

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.13	**32.6**	25	53
mid-depth	0.91	**17.6**	13	30

Riffle River Recreation Area

Lodge Lake (9748)

Location: Ogemaw, Rifle River Recreation Area
Lake Type:?, fine, ?, round

Photo:

Site Description:
Lodge Lake has mucky substrates and some woody structure. Beaver activity was noticed.
The shoreline is dominated by cattail and water willow, with a few sparse areas of pickerel weed. The east side of the lake shoreline is quite steep and has a smaller littoral zone covered mostly by Nymphaea. The south and west sides have a larger littoral zone. No motors are allowed on the lake but there is a cement boat launch (with a drop off). There is an observation platform on the road overlooking the lake. The lake is surrounded by forest.

Dominant shoreline vegetation includes: three-square bulrush, Typha (broad), water willow, pickerel weed, sedges

Dominant macrophytes include: *Utricularia*, coontail, *Nymphaea*, eelgrass pondweed, variable leaf pondweed, *Nuphar*, *Chara*, floating leaf pondweed, common water milfoil, sago pondweed , *Vallisneria*, and *Elodea*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	8.4	pH	**8.18**	Hardness	160
Max Depth	5	Conductivity	212	Water Color	-
Secchi Depth	**3**	Alkalinity	**160**	Color Wheel	0

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.34	**23**	16	32

mid-depth	1.92	**11.2**	8	16

Unnamed Lake (9740)

Location: Ogemaw, Private - Rifle River Rec Area
Lake Type:?, fine, ?, round

Photo:

Site Description:
This unnamed lake is deep, stratified lake has a large littoral zone and false shoreline. The shoreline vegetation is relatively complex. Access is difficult and the lake does not appear to be heavily used by the public. Although there is a dock near the farm house with a boat (motor?).

Dominant shoreline vegetation includes: *Sagittaria*, spike rush, *Typha*, softstem bulrush, sedge, and three-square bulrush.

Dominant vegetation includes: *Nuphar*, floating leaf pondweed, *Utricularia, Elodea, Brasenia*, *Nymphaea*, common milfoil, duckweed, big leaf pondweed, coontail, eelgrass pondweed, and *Najas*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	16.3	pH	**7.75**	Hardness	160
Max Depth	9.7	Conductivity	282	Water Color	0
Secchi Depth	**3.1**	Alkalinity	**160**	Color Wheel	0

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	2.43	**46.6**	26	72
mid-depth	1.1	**20**	12	30

Pinckney State Recreation Area

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

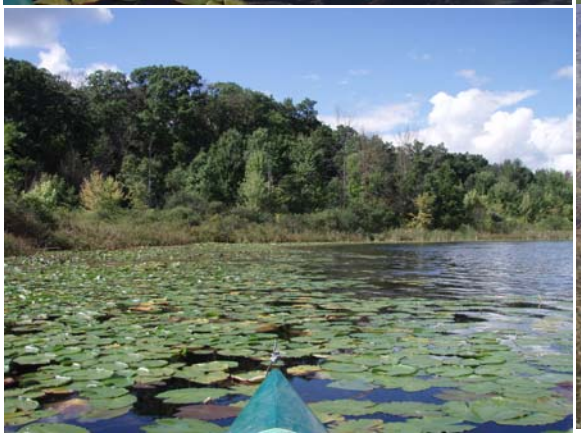
Invasive species introductions through boat traffic from South Lake are the major threat to this pond. More prominent signs on the threats of invasive species via boat traffic is needed at the South Lake launch. Invasive species (macrophytes, zebra mussels, zooplankton, and others) are the major threats 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

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.95	**15**	5	25
mid-depth	0.64	**8.6**	3	16

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

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.62	**13**	7	21
mid-depth	0.6	**5.8**	3	12

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*).

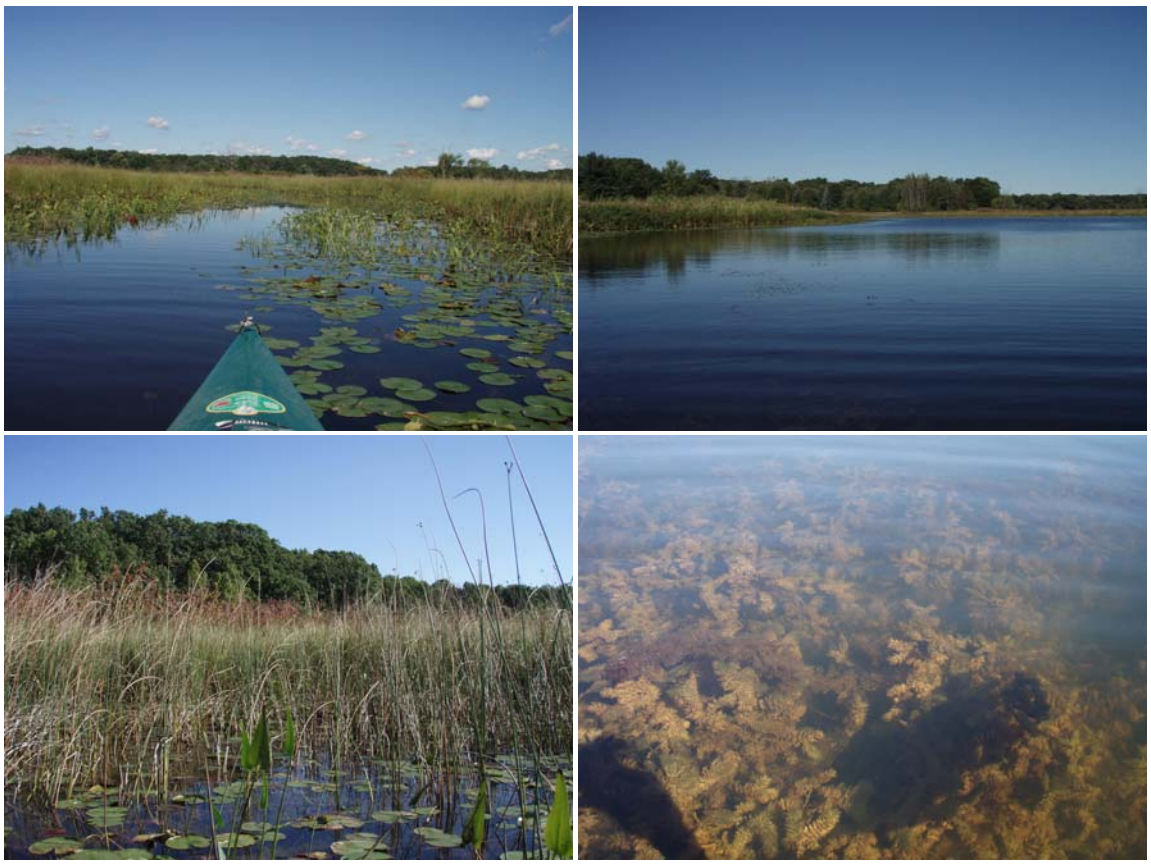
Management recommendations

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

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.97	**14**	5	30
mid-depth	0.5	**8.2**	3	21

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.

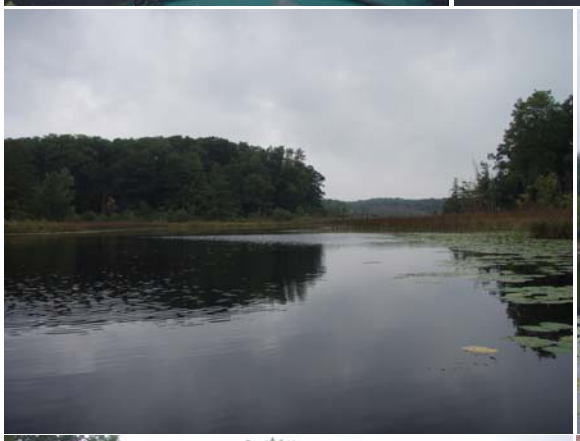
Management recommendations

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.

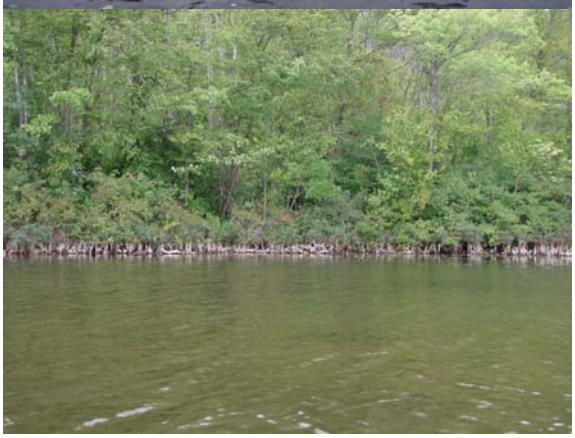
Waterloo State Recreation Area

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 (*Runnunculus 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 E
State Forest Lands

Au Sable State Forest

Unnamed Lake (5419)

Location: Midland, Au Sable State Forest
Lake Type: ?, fine, unconnected, round

Photo:

Site Description:
This unnamed lake is very shallow with 80% of it less than 1 m deep with macrophytes throughout. The lake is uniform with sandy substrates. There are exposed sand bars in the lake. The riparian zone is forested.

Macrophytes present include: *Potamogeton illinoiensis*, Eurasian milfoil, variable leaf pondweed, *Typha* (narrow-leaf), foating leaf pondweed, and a small amount of *Brasenia schreberi*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	10.131	pH	**8.91**	Hardness	100
Max Depth	1.2	Conductivity	152.4	Water Color	
Secchi Depth	**1.2**	Alkalinity	**108**	Color Wheel	0

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	0.84	**18.4**	5	44
mid-depth	0.77	**9**	3	22

Cooper Country State Forest

Coon Lake (16718)

Location: Baraga, Cooper Country State Forest
Lake Type: bedrock: limestone/dolomite, bedrock, headwater, round

Photo: none

Site Description:
Coon lakes is a long oval lake, oriented west to east. There is a steep slope on the south side of the lakes and a much more gradual slope on the north side. Generally, there is a zone of floating-leaved macrophytes <10m wide on the south and east sides of the lake; this zone is generally 10 to 20m wide but can be as wide as 40m on the north and west sides. Beyond the floating-leaved macrophytes there is a zone dominated by *Potomageton amplifolius* with a carpet of *Potamogeton robbinsii* on the bottom. Where *P. robbinsii* is absent there is a carpet of *Najas flexilis* to a depth of ~ 5m. Substrates are organic matter over sand and occasionally cobbles and boulders. Animals seen include: kingfisher, loon, bluegill, pumpkinseed, largemouth bass, northern pike, sponge (rare).

Dominant macrophytes in water less than 1.5m include: *Nymphaea odorata* and *Brassenia schrebeli*. Other species seen here include: *Nuphar variegata, P. natans, P. apihydrus, P. amplifolius*, and *Utricualria sp*. Dominant macrophytes at water depths between 1.5m and 3m include: *Potamogeton amplifolius*, *P. robbinsii*. Other species seen at these depths include: *Najas flexilis* and *Utricularia minor*, and *Utricularia intermedia*. At depths greater than 3mto about 5m, *Najas flexilis* forms a dense carpet.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	67.967	pH	**6.9**	Hardness	-
Max Depth	13.5	Conductivity	29.2	Water Color	-
Secchi Depth	**4**	Alkalinity	-	Color Wheel	-

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	-	**15**	<10	40

Parlemee Lake (16917)

Location: Dickinson, Cooper Country State Forest
Lake Type: coarse till - end moraine, coarse, unconnected, round

Photo: none

Site Description:
Parlemee Lake has uniform habitat with sand substrates, sometimes with a thin layer of organic matter or marl mixed in. There was an island present in the lake. Animals seen include: largemouth bass, bluegill, pumpkinseed, Pyganodon grandis (few). No crayfish or sponge were seen.

Potamogeton amplifolius is present to water depths of 5m often in dense patches. *Chara* forms a dense mat below the *Potamogeton* and is present to water depths of 5.75m, slightly deeper than the *Potamogeton*. Other macrophytes and vegetation present include: *Nuphar variegata* (occasionally abundant), *Polygonum amphibium* (1 plant seen), *Potamogeton natans* (rare), *Carex lasiocaipa* (?), *Juncus*, *Potamogeton pusillus* (abundant where present), *Najas flexilis*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	21.56	pH	**8.72**	Hardness	-
Max Depth	8	Conductivity	140.5	Water Color	-
Secchi Depth	**5**	Alkalinity	-	Color Wheel	-

Spring Lake (16855)

Location: Iron, Cooper Country State Forest
Lake Type: outwash sand and gravel, coarse, unconnected, round

Photo: none

Site Description:
Spring Lake has a large beaver dam in it with several other smaller dams. It appears that the water level may have risen recently and inundated some of the vegetation at the shoreline. Substrates are sandy with some organic matter on top and at times marly.

Dominant macrophyte species are *Nymphaea odorata*, *Potamogeton natans*, and *Chara*. Other macrophytes and vegetation present includes: Carex lasiocarpn, Sparganium sp. (occasionally abundant), Potamogeton pusillus or pectinatus, Potamogeton epihydrus, Potamogeton obtusifulis (?), Utricularia minor, Utricularia intermedia, Najas flexilis (common but not abundant), Brassenia schreberi (common but not abundant), Polygonum amphibium (sparse), Potamogeton natans (occasional), Nuphar variegata (occasional, locally abundant).

Parameter	Value	Parameter	Value	Parameter	Value
Acres	12.3	pH	**7.8**	Hardness	-
Max Depth	10	Conductivity	233	Water Color	-
Secchi Depth	**4.3**	Alkalinity	-	Color Wheel	-

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	-	**35**	-	50

Square Lake (16864)

Location: Iron, Cooper Country State Forest
Lake Type: outwash sand and gravel, coarse, unconnected, round

Photo: none

Site Description:
Square Lake is dark, tannin stained and surrounded by bog and muskeg forest. Woody structure is very limited to two areas with beaver dams present. Substrates are mucky.

Fish collected include: northern redbelly dace, finescale dace, golden shiner, spottail shiner, creek chub, brassy minnow, black bullhead, pumpkinseed, brook stickleback, Iowa darter, central mudminnow, pearl dace, striped shiner. This lake had a very diverse fish community.

Dominant macroinvertebrates include: Chironomidae and Baetisca sp. (Baetiscidae).

Other macroinvertebrates collected include:
Lepidoptera: Pyroderces sp. (Cosmopterigidae), Petrophila sp., Crambus sp., Munroessa sp., Acentria sp. (Pyralidae).

Collembola: Vesicephalus sp. (Sminthuridae).

Emphemerpotera: Caenis sp. (Caenidae).

Trichoptera: Oxyethira sp. (Hydroptilidae), Mystacides sp., Nectopsyche sp., Oecetis sp. (Leptoceridae), Limnephilidae, Banksiola sp., Phyrganea sp. (Phryganeidae), Cernotina sp., Cyrnellus sp., Neureclipsis sp., Polycentropous sp. (Polycentropodidae).

Odonata: Aeshna sp., Boyeria sp. (Aeshnidae), Nehalennia sp., Enallagma sp. (Coenagrionidae), Cordulia sp., Epitheca epicordulia, Epitheca tetragoneuria, Somatochlora sp. (Corduliidae), Ladona sp., Leucorrhinia sp., Libellula sp., Sympetrum sp. (Libellulidae).

Coleoptera: Celina sp. (Dytiscidae), Haliplus sp. (Haliplidae), Scirtes sp. (Scirtidae).

Dipteran: Bezzia sp., Monohelea sp., Serromyia sp. (Ceratopogonidae), Chaoborus americanus (Chaoboridae), Mansonia sp. (Culicidae), Stratiomys sp. (Stratiomyidae), Syrphidae, Chrysops sp., Merycomyia sp., Tabanus sp. (Tabanidae).

Hemiptera: Belostoma sp.(Belostomatidae), Trichocorixica sp. (Corixidae), Rheumatobates sp. (Gerridae), Hydrometra sp. (Hydrometridae), Mesovelia sp. (Mesoveliidae), Microvelia sp. (Microveliidae), Buenoa sp. , Notonecta sp. (Notonectidae), Microvelia sp. (Veliidae).

Dominant macrophyte is *Brassenia schreberi* which has very dense beds with nearly 100% coverage in the littoral zone (10-20m wide), except in the northeast part of the lake where *Potomageton zosteriformis* is present. Other species seen include: *Potamogeton amplifolius/ illinoensis, Sagittaria catitolia, Potamogeton pusillus, Potamogton epihydrus, Chara, Najas, Utricularia vulgaris, Utriularia intermedia, Nuphar variegata, Spaganium sp., Calla palustris, Utricularia minor, Potamogeton natans, Eleocharis smallii, Najas flexilis.*

Parameter	Value	Parameter	Value	Parameter	Value
Acres	9.006	pH	**6.12**	Hardness	-
Max Depth	4.3	Conductivity	84.1	Water Color	dark, tannin stained

Secchi Depth	**1.2**	Alkalinity	-	Color Wheel	-

Escanaba River State Forest

Charley Lake (15355)

Location: Marquette, Escanaba River State Forest
Lake Type: coarse till - ground moraine, coarse, riverine, round

Photo: none

Site Description:
Charley Lake had quite a bit of woody structure and the substrates were mainly cobble. Lots of filamentous algae was present.

Fish collected include: black crappie, brassy minnow, green sunfish, Iowa darter, largemouth bass, and yellow perch.

Dominant macroinvertebrates collected include: snails, leeches, Chironmidae, and Gammarus sp.

Other macroinvertebrates collected include:
Emphemerpotera: Baetisca sp. (Baetiscidae), Heptageniidae

Trichoptera: Nectopsyche sp., Oecetis sp. (Leptoceridae), Oxyethira sp. (Hydroptilidae), Cernotina sp. (Polycentropodidae)

Odonata: Enallagma sp. (Coenagrion), Dromogomphus sp. (Gomphidae), Epitheca sp. (Corduliidae), Aeshnidae, Coenagrionidae

Coleoptera: Dubiraphia sp. (Elmidae)

Dipteran: Bezzia sp. (Ceratopogonidae), Chaoborus americanus (Chaoboridae)

Vegetation present included: *Najas Flexillis, Potamogeton hillii?, P. amplifolius, Nuphar, Chara.*

Parameter	Value	Parameter	Value	Parameter	Value
Acres	7.905	pH	**8.31**	Hardness	-
Max Depth	5.5	Conductivity	442	Water Color	clear
Secchi Depth	**4**	Alkalinity	-	Color Wheel	-

Haywire Lake (15350)

Location: Marquette, Escanaba River State Forest
Lake Type: coarse till - ground moraine, coarse, headwater, round

Photo: none

Site Description:
Haywire Lake is a clear lake with mucky substrates. Macrophytes ring the lake and it has a grassy / shrubby

shoreline with conifers in the riparian zone. There is a beaver dam on the lake. Woody structure is common. Small sponge were seen.

Fish collected include: black bullhead, bluntnose minnow, brook stickleback, creek chub, emerald shiner, fathead minnow, golden shiner, Iowa darter, northern redbelly dace, pearl dace, pumpkinseed, white sucker, and yellow perch.

Dominant macroinvertebrates include: snails, Gammarus sp., leeches, Chironomidae, Caenis sp. (Ephemeroptera), and Trichoptera: Enallagma sp. (Coenagroinidae), Oxyethira sp. (Hydroptillidae), Nectopsyche sp. (Leptoceridae).

Other macroinvertebrates collected include:
Lepidoptera: Oecetis sp., Triaenodes sp. (Leptoceridae), Parapoynx sp., Munroessa sp., Petrophila sp., Acentria sp. (Pyralidae).

Emphemerpotera: Serratella sp., Ephemerella sp. (Ephemerellidae), Stenonema sp. (Heptageniidae), Baetidae, Heptageniidae.

Trichoptera: Fabria sp., Phryganea sp. (Phryganeidae), Orthotrichia sp., Agraylea sp. (Hydroptilidae), Cernotina sp., Polycentropus sp. (Polycentropodidae).

Odonata: Cordulia sp., Somatochlora sp., Epitheca sp. (Corduliidae),
Gomphus sp. (Gomphidae), Lestes sp. (Lestidae), Libellula sp., Leucorrhinia sp. (Libellulidae), Aeshna sp. (Aeshnidae), Ischnura sp. (Coenagrionidae).

Coleoptera: Dubiraphia sp. (Elmidae), Haliplus sp. (Haliplidae), Gyrinus sp. (Gyrinidae), Donacia sp. (Chrysomellidae).

Dipteran: Bezzia sp., Probezzia sp., Alluaudomyia sp., Serromyia sp. (Ceratopogonidae), Chaoborus americanus (Chaoboridae), Tabanus sp., Chrysops sp. (Tabanindae), Antocha sp., Ormosia sp. (Tipulidae), Dixella sp. (Dixidae), Culicidae, Sciomyzidae.

Hemiptera: Neoplea sp. (Pleidae), Metrobates sp. (Gerridae), Belostoma sp. (Belostomatidae), Corixidae.

Vegetation present included: *Chara, Potamogeton gram?, Scirpus acutis, P. natans, Myrica gale, Carex stricta, Utricularia vulgaris, Nymphaea, Najas flexilis, P. filiformis, Sparganum minimum, Sagittaria lat.*

Parameter	Value	Parameter	Value	Parameter	Value
Acres	10.075	pH	**8.11**	Hardness	-
Max Depth	5	Conductivity	359	Water Color	clear
Secchi Depth	**3**	Alkalinity	-	Color Wheel	-

Johnson Lake (15361)

Location: Marquette, Escanaba River State Forest
Lake Type: coarse till - ground moraine, coarse, unconnected, round

Photo: none

Site Description:
Johnson Lake is a relatively uniform lake with tannin-stained water. Substrates are generally organic matter covering sand. The lake is surrounded by bog. There are some beaver lodges around and there occasional

woody structure areas. Animals seen include: yellow perch, painted turtles, and a few crayfish.

Vegetation present includes: *Eriocaulen septentriaonale, Nuphar variegata, Potamogeton epihydrus, Utricualria vulgaris, Sparganium fluctuans* (more abundant than S. a), *S. angustifolium*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	9.06	pH	**5**	Hardness	-
Max Depth	3	Conductivity	0	Water Color	-
Secchi Depth	**1.1**	Alkalinity	-	Color Wheel	-

Martells Lake (2)

Location: Marquette, Escanaba River State Forest
Lake Type: coarse till - end moraine, coarse, unconnected, round

Photo: none

Site Description:
Martells Lake is an interesting pond. It is uniform, shallow, with undercut banks and very little macrophytes. The water did not seem too turbid, Secchi depth was essentially to the bottom. Substrate is composed of deep organic matter. This lake may have wind action that keeps rooted macrophytes from really establishing. The lake is surrounded by bog and is a short walk from the road. Animals seen include: *Pyganodon grandis*, northern redbelly dace, golden shiner, creek chub, yellow perch, pumpkinseed, white sucker, Iowa darter, fathead minnow, sponge (moderate), crayfish (few), leeches (large), Belostomatidae.

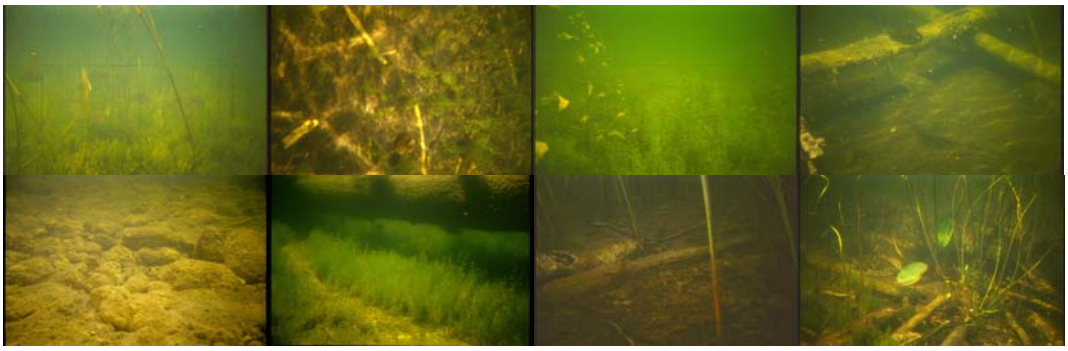
Macrophytes present include: *Nymphaea odonata, Potamogeton pusillus, P. amplifolius, Najas flexilis, and Utricularia vulgaris.*

Parameter	Value	Parameter	Value	Parameter	Value
Acres		pH	**7**	Hardness	-
Max Depth	2	Conductivity	105	Water Color	tannic
Secchi Depth	**1.7**	Alkalinity	-	Color Wheel	-

Porterfield Lake (16881)

Location: Marquette, Escanaba River State Forest
Lake Type: coarse till - end moraine, coarse, unconnected, round

Photo:



Site Description:
Porterfield Lake is a shallow lake dominated by Chara. Substrates are generally sand, gravel, and cobble with some marl mixed in. There is a moderate amount of woody structure throughout the lake. Animals seen include: bluegill, smallmouth bass, pumpkinseed, Iowa darter, bluntnose minnow. Sculpin, largemouth bass, northern pike, yellow perch, common shiners, mudminnow, crayfish.

Macrophytes present: *Chara* (dominant), *Potamogeton illinoensis*, and *Utricularia vulgaris*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	33.285	pH	**8.4**	Hardness	-
Max Depth	8.5	Conductivity	275	Water Color	Green/brown
Secchi Depth	**3.7**	Alkalinity	-	Color Wheel	-

Round Lake (17194)

Location: Marquette, Escanaba River State Forest
Lake Type: coarse till - ground moraine, coarse, unconnected, round

Photo: none

Site Description:
Round Lake is surrounded by a narrow wet meadow (not a floating mat). This lake has a lot of flocculant material in water.

Fish collected include: northern redbelly (very abundant), brassy minnow, brook stickleback, central mudminnow, finescale dace.

Dominant macroinvertebrates include: Chironomidae, snails, Bezzia sp. (Ceratopogonidae).

Other macroinvertebrates collected include:
Collembola: Vesicephalus sp. (Sminthuridae)

Emphemerpotera: Pseudocentroptiloides sp. (Baetidae), Baetisca sp. (Baetiscidae).

Trichoptera: Oxyethira sp. (Hydroptilidae), Cernotina sp. (Polycentropodidae).

Odonata: Aeshna sp., Boyeria sp. (Aeshnidae), Amphiagrion sp., Argia sp., Enallagma sp. (Coenagrionidae), Epitheca tetragoneuria, Somatochlora (Corduliidae), Ladona, Leucorrhinia frigida, Libellula pulchella, Plathemis lydia, Sympetrum sp. (Libellulidae).

Coleoptera: Donacia sp., Hydrothassa sp. (Chrysomellidae), Gyrinus sp. (Gyrinidae), Brychius sp., Peltodytes sp. (Haliplidae), Staphylinidae.

Dipteran: Bezzia sp., Probezzia sp., Serromyia sp. (Ceratopogonidae), Chaoborus americanus (Chaoboridae), Wyeomyia sp., Mansonia sp. (Culicidae), Odonotomyia sp. (Stratiomyidae), Chrysops sp., Merycomyia sp., Tabanus sp. (Tabanidae).

Hemiptera: Belostoma sp. (Belostomatidae), Neocorixa sp., Trichocorixa sp. (Corixidae), Metrobates sp., Trepobates sp. (Gerridae), Mesovilia sp. (Mesoveliidae), Notonecta sp. (Notonectidae), Naucoridae.

Macrophytes present include: *Nymphaea odorata* (abundant), *Najas flexilis* (forms dense beds in north part of lake), *Eleocharis smallii* (localized nearshore), *Potamogeton natans* (occasional), *Nuphar variegata* (common within 5m of shore), *Chara* (sparse near shore), *Potamogeton amphilisus* (only present near shore), *Sagittaria latifolia* (common along shore), *Sparganium angustifolium, Utricularia intermedia* (only in marsh/wet meadow).

Parameter	Value	Parameter	Value	Parameter	Value
Acres	8.675	pH	**7.99**	Hardness	-
Max Depth	2.5	Conductivity	238	Water Color	clear
Secchi Depth	**2**	Alkalinity	-	Color Wheel	-

Twin Lakes, North (16877)

Location: Marquette, Escanaba River State Forest
Lake Type: coarse till - end moraine, coarse, unconnected, round

Photo: none

Site Description:
Twin Lake (N) has clear water, little macrophytes, and substrates consisting of organic matter over sand. There are some areas with sand, gravel, and cobble substrates and there is quite a bit of woody structure in this lake. This lake has a relatively steep sloped bottom. Animals seen include: Iowa darter, bluntnose minnow, pumpkinseed, bluegill, yellow perch.

Vegetation present includes: Utricularia minor, Nuphar, Najas.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	17.2	pH	**7**	Hardness	-
Max Depth	29	Conductivity	0	Water Color	-
Secchi Depth	**5.3**	Alkalinity	-	Color Wheel	-

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance

max-depth	-	**3**	-	10

Unnamed Lake (3)

Location: Marquette, Escanaba River State Forest
Lake Type: peat and muck, peat, unconnected, round

Photo: none

Site Description:
This small, deep, tannin lake has organic substrates and a red pine dominated riparian zone. Woody structure was common. Sponge were present.

Yellow perch were the only fish present in the lake.

Dominant macroinvertebrates included: Chironomidae, Chaoborus americanus (Chaoboridae), Enallagma sp. (Coenagrionidae), and Microvelia sp. (Veliidae).

Other macroinvertebrates collected include:
Lepidoptera: Archips sp. (Tortricidae).

Collembola: Podura (Poduridae), Sminthuridae.

Megaloptera: Chauliodes (Corydalidae), Sialis sp. (Sialidae).

Neuroptera: Climacia sp. (Sisyridae).

Emphemerpotera: Caenis sp. (Caenidae).

Trichoptera: Cernotina sp., Neureclipsis sp. (Polycentropodidae), Oxyethira sp. (Hydroptilidae), Hydrophilidae, Glossosomitidae, Leptoceridae.

Odonata: Somatochlora sp., Cordulia sp. (Corduliidae), Chromagrion sp. (Coenagrionidae), Anax sp., Aeshna sp. (Aeshnidae), Leucorrhinia sp., Pachydiplax (Libellulidae), Lestidae.

Dipteran: Bezzia sp., Serromyia sp., Alluaudomyia sp., Sphaeromias sp. (Ceratopogonidae), Culiseta sp. (Culicidae).

Hemiptera: Trepobates sp. (Gerridae), Corixidae.

Macrophytes present include: *Brasenia schreberi, Sparganium fluctuans, Nuphar variegatum, Potamogeton epihydrus.*

Parameter	Value	Parameter	Value	Parameter	Value
Acres		pH	**4.5**	Hardness	-
Max Depth	13.5	Conductivity	16.9	Water Color	dark, tannin stained
Secchi Depth	**4.5**	Alkalinity	-	Color Wheel	-

Lake Superior State Forest

Brush Lake (13817)

Location: Luce, Lake Superior State Forest
Lake Type: ?, Fine, unconnected, round

Photo:

Site Description:
Brush Lake is relatively deep with a small littoral zone. There is a connection to another bigger lake that if the water levels were up another 3-4ft the two lakes would be one. The riparian area is a dense mix of shrub and pine. There are a few areas in the lake where woody structure is present. No beaver activity was noticed. There doesn't appear to be much human use.

Dominant vegetation includes: spike rush, *Nymphaea, Utricularia, Brasenia, Potamogeton* (variable leaf – uncommon).

Parameter	Value	Parameter	Value	Parameter	Value
Acres	8.4	pH	**6.94**	Hardness	20
Max Depth	7.4	Conductivity	16.86	Water Color	
Secchi Depth	**4.7**	Alkalinity	**4**	Color Wheel	8

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance

max-depth	1.32	**18**	9	26
mid-depth	0.46	**8.6**	4	13

Pratt Lake (13813)

Location: Luce, Superior State Forest
Lake Type: ?, fine, unconnected, round

Photo:

Site Description:
Pratt lake is a deep, seep bank lake with a very small littoral zone. The lake is surrounded by forest. There is lots of bare soil around shoreline. And a small amount of woody structure. Water is blue/green in color.

Dominant vegetation was spike rush and hardstem bulrush.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	17.151	pH	**7.91**	Hardness	20
Max Depth	7.1	Conductivity	15.33	Water Color	blue/green
Secchi Depth	**6.6**	Alkalinity	**8**	Color Wheel	8

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	0.55	**6**	5	7
mid-depth	0.3	**3**	3	3

Rainy Lake (13756)

Location: Luce, Superior State Forest
Lake Type: ?, fine, unconnected, round

Photo:

Site Description:
Rainy Lake is a round pond with sandy substrates and a very small littoral zone. There were significant exposed logs around entire pond, as well as large algae blooms. Water level appeared lower than usual. Shores were sandy.

Dominant macrophytes were Vallisneria and Nympheae.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	11.7	pH	**6.24**	Hardness	20
Max Depth	4	Conductivity	10.24	Water Color	-
Secchi Depth	**2.5**	Alkalinity	**4**	Color Wheel	5

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	0.45	**6**	2	8
mid-depth	0.23	**3.3**	3	4

Ready Lake (13762)

Location: Luce, Superior State Forest
Lake Type: ?, fine, unconnected, round

Photo:

Site Description:
Ready Lake is a clear, shallow lake without a littoral zone. There were Potamogeton beds in the middle of the lake. The substrate was green/brown algae and smelly. The shoreline is sandy and exposed around the entire lake. The lake is surrounded by forest. Yellow perch, minnows, and mussels were seen.

Vegetation present includes: horsetail, Nuphar, Potamogeton Illinoisis, and Typha.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	20.138	pH	**9.28**	Hardness	40
Max Depth	1.1	Conductivity	68.4	Water Color	clear
Secchi Depth	**1.1**	Alkalinity	**32**	Color Wheel	8

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	0.01	**4**	4	4

Mackinaw State Forest

Jackson Lake (9192)

Location: Montmorency, Mackinaw State Forest
Lake Type: coarse till - ground moraine, coarse, unconnected, round

Photo:

Site description:
Jackson Lake is a very clear lake with lots of algae covering substrates. There is very little vegetation throughout the lake but the littoral zone is large. The mucky substrates smell of sulfur.

Dominant vegetation includes: *Chara*, *Nymphaea*, *Typha*, rush, and sedge.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	29.8	pH	**8.66**	Hardness	140
Max Depth	6.7	Conductivity	198.7	Water Color	clear
Secchi Depth	**4.7**	Alkalinity	**110**	Color Wheel	10

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.42	**55.2**	15	96
mid-depth	1.1	**30.8**	8	53

Twin Tomahawk Lake (9159)

Location: Montmorency, Mackinaw State Forest
Lake Type: coarse till - ground moraine, coarse, riverine, round

Photo:



Site Description:
In Twin Tomahawk Lake the macrophyte beds tend to be more in the middle than around the outside of the lake. And the macrophyte beds in the middle tend to come to the surface. There are two stream connections to this lake. The lake is surrounded by forest and dead tree stands.

Dominant vegetation includes: *Chara, Potamogeton, Nymphaea, Utricularia,* and rush.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	19.1	pH	**8.58**	Hardness	280
Max Depth	5.6	Conductivity	242	Water Color	-
Secchi Depth	**2**	Alkalinity	**168**	Color Wheel	30

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.66	**74**	32	107
mid-depth	0.88	**49.6**	18	75

Michigamme State Forest

Chain of Lakes, East (1)

Location: Marquette, Michigamme State Forest
Lake Type: coarse till - end moraine, coarse, headwater, round

Photo: none

Site Description:
Chain of Lakes (east) had fairly diverse macrophyte beds, especially in the small protected embayments. Connected to Chain of Lakes (M). Animals seen include: Iowa darter, yellow perch, bluntnose minnow, largemouth bass, northern pike, pumpkinseed, Phygonodon grandis, sponge, crayfish.

Vegetation present included: *Iris versicolor, Alnus rugos, Lycopus uniflora, Triadenum fraseri, Potamogeton graminea, P. zosteriformis, Najas flexilis, Nymphaea odorata, Sagitaria Lat., Nuphar variegata, Chara, Utricularia vulgaris, P. amplifolius, Plygonum amphibium (flowering), Equisteum.*

Parameter	Value	Parameter	Value	Parameter	Value
Acres		pH	**8.2**	Hardness	-
Max Depth	7	Conductivity	0	Water Color	-
Secchi Depth	**2.6**	Alkalinity	-	Color Wheel	-

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	-	**10**	-	-

Chain of Lakes, middle (17210)

Location: Marquette, Michigamme State Forest
Lake Type: coarse till - end moraine, coarse, headwater, round

Photo: none

Site Description:
Chain of Lakes (middle) is larger than the east lake. Substrates were variable and included sand, organic matter, gravel, boulders, and cobble. There was some marl on rocks. Woody structure was relatively common. There were scattered macrophyte beds across the lake. Animals seen include: sponge, largemouth bass, bluntnose minnow, northern pike, Pyganodon grandis.

Vegetation present includes: *Scirpus acutus, Nymphaea odoratus, Potamogeton gramineus, Najas flexicallis* (entire water column), *Chara, Scirpus subterminalis* (entire water column), *Lobelia inflata* (?), *Alnus rugosa, Calamogrostis canadensis, Glyceria borgalis, Mentha aruensis, Carex lasiocarpa, Carex aquatilis, Utricularia intermedia* (protected edges), *Nuphar variegata, Potaomgeton amplifolius* (entire water column), *Typha latifolia, Elodea, Nitela sp., Potaomogeton natans* (primary floating leaves), *Sparganium fluctuans, Eleocharis smalli, Carex comosa, Sparganium angustifolium* (fruiting), *Campanula, Juncus brevicaudatus* (keyed).

Parameter	Value	Parameter	Value	Parameter	Value
Acres	11.79	pH	**8.2**	Hardness	-
Max Depth	3.5	Conductivity	0	Water Color	-

Secchi Depth	**2.3**	Alkalinity	-	Color Wheel	-

Pere Marquette State Forest

Papoose Lake (8380)

Location: Kalkaska, Pere Marquette State Forest
Lake Type: Coarse, unconnected, round

Photo:

Site Description:
Papoose Lake is quite different from all the other ponds seen in 2007. The lake is round and fairly uniform, with very little complexity. Small balls of algae are floating everywhere. Littoral zone is dominated by *Nymphaea*. The shoreline is grassy/sedgy/rushy. The riparian zone is a very dense forest comprised of oaks, pines, maples, and birch. Lilly roots have come free and form floating mats.

Macrophytes include: *Nymphaea*, three-square rush, *Brasenia*.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	24.674	pH	**7.81**	Hardness	40
Max Depth	4.3	Conductivity	45.4	Water Color	clear

Secchi Depth	**4.1**	Alkalinity	**25**	Color Wheel	0

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	1.36	**31**	14	59
mid-depth	0.72	**15.5**	7	31

National Forest Lands

Hiawatha National Forest

Salt Lake (14115)

Location: Chippewa, Hiawatha National Forest
Lake Type: Coarse, unconnected, round

Photo:

Site Description:
Salt Lake is round with muck substrates and small patches of sand along the edge. Bottom of lake is covered entirely by filamentous algae with a few small patches of spike rush along shore. No fish were seen, and there is no littoral zone anywhere. Water depth is no more than 1 m deep anywhere in lake. In the riparian zone of this lake is marshy with grasses and small shrubs leading to shrub and forest.

Macrophytes: spike rush.

Parameter	Value	Parameter	Value	Parameter	Value
Acres	10.3	pH	**4.75**	Hardness	-
Max Depth	0.7	Conductivity	30.2	Water Color	-
Secchi Depth	**0.7**	Alkalinity	**4**	Color Wheel	4

Habitat point	Average Depth	Average Distance	Minimum Distance	Maximum Distance
max-depth	0.7	**3**	-	-