Pearl Lake
WIBIC # 195400
Aquatic Plant Survey

Date of survey(s): 27 July 2004
28 July 2004

Site Evaluators: Scott Provost, Water Resources Specialist - Wautoma
Jon Hoffman, Fishery Technician – Wautoma

Author: Scott Provost
Maps: Aaron McCullough

Introduction:
An aquatic plant survey was conducted on Pearl Lake during the summer of 2004. Data was gathered primarily for a Sensitive Area Designation, but can be used for other purposes. Fisheries, wildlife, water regulation and water quality biologist staff in their daily management activities can use these data. Consultants, the Pearl Lake Advancement Association and the public can, and are encouraged to, use these data for information and educational purposes.

When this survey was designed, it was done so using a holistic approach so it can be used to manage the lake on broad scale that encompasses the entire ecosystem. This will allow the benefits to be realized for fish, wildlife, water quality, lake users and future generations more so than if a single objective was the goal. Holistic management may not be appropriate for single objective management such as intense Eurasian Watermilfoil mapping, but it can be used to provide background data in those cases. Using this data to support single objective goals will help people obtain their goals more efficiently, provide a baseline for future reference and ensure adequate protection to the lake and the resource.

General Lake Information:
Pearl Lake is a 92-acre, glacial kettle lake located in central Waushara County, north of the Village of Redgranite. The maximum depth is 49 feet and the lake has a relatively small littoral zone. Observed *Maximum Depth of Colonization* (MDC) of aquatic plants is 26 feet according to data gathered from the survey. The lake is similar of other glacial lakes in Waushara County, which are typically hardwater seepage lakes with good water clarity. *Trophic state* of these lakes are usually late *oligotrophic* to *mesotrophic*.

Water levels fluctuate naturally on these types of lakes provided no water level control device is constructed. From 1975 to 1996, changes in water levels were monitored sporadically thus limited data is available. Records show only minor changes occurred however, anecdotal evidence suggests water levels change more drastically (WDNR files).

Pearl Lake, like others, responded to the low levels caused by the drought of 2002-2003. Lake levels dropped across the region and in many cases Three-square bulrush expanded to this stimulus. Water levels rose slightly in 2004 inundating some of these plants. The flooded stands of emergent plants will be used by fish and wildlife and help protect water quality. Previous data of emergent species such as bulrushes are lacking to quantify this on Pearl Lake thus this is more of a qualitative measure.

The natural water level fluctuation is absolutely critical to the lake. Near shore vegetation such as bulrushes have evolved around this phenomenon and actually require periodic lows to spread. As water levels increase, near shore vegetation is inundated and becomes habitat for fish and wildlife. During times of high water species of fish like northern pike and perch will use these areas intensively to spawn. During drier years when fish can not use the exposed lakebed, other animals such as herps will use these areas. These near shore plants also help filter nutrients out of the water that would otherwise produce algae.

The lake fishery is chiefly composed of largemouth bass, northern pike and panfish. Other game fish species have been stocked over the years but reproduction of those species is probably nonexistent. Walleyes, trout and smallmouth bass have been stocked but none of these were observed in recent DNR surveys. Due to the depth of the lake a two-story fishery is possible if the fish are stocked. Realizing this, the WDNR stocked trout historically until the early 70's. However due to low survival from one year to the next stocking ceased.

Wildlife consists of waterfowl, furbearers, herps, reptiles and raptors. Some areas of the lake are more conducive to certain species of wildlife than others. Development pressure and habitat types play an important role in what kind of wildlife can be expected to utilize an area. For instance, some high value upland areas that are connected to the lake are just as important to wildlife as the lake is. Having a diverse shoreline provides important habitat and a connection from the water to the land. The occasional sightings of eagles and ospreys to animals near the shore are a testament to this.

There is one public boat access on the south side of the lake and several walk-in areas. There is a wide array of uses from the owners and visitors ranging from canoeing, fishing and swimming to motor boating. The lake is typical of highly developed lakes. Near shore vegetation has been sharply reduced from the historic distribution, according to residents. Propwash scars and areas void of plants are common along the shoreline. Woody debris is sparse along developed shorelines with some increases in occurrence on lightly developed shorelines.

Along with use of the lake from the public and riparian owners comes the risk of exotic species introduction. Eurasian Watermilfoil (*Myriophyllum spicatum*) was found in the early 1990's. Since then, milfoil densities have increased until herbicide treatment regimens changed in 2000. Eurasian Watermilfoil (EWM) appears to be decreasing however eradication has not been achieved. This is not unusual as very few lakes, if any, can claim 100% eradication once this plant has been established. The current treatment regimen is having an impact on EWM. However locating isolated stands seems to be a challenge facing managers to date. Increasing efforts to locate isolated EWM beds should be done if chemical treatments are continued.

Chemical use in Pearl Lake has had a sporadic history. The first application was in 1967 for a beach area. Although the species of nuisance plants were not listed, they were more than likely native species. Other treatments seem to have little long term control on the EWM. However, in the last three years treatments have been geared to early season treatments when water temperatures are near 60°F with a 2,4-D granular herbicide (*Navigate*). The applicators seem to have EWM at controllable levels with this treatment regimen.

Pearl Lake has also employed manual removal techniques with divers and weevils in the past. None of these efforts had long term control. However as EWM is now below nuisance levels, diving may be a feasible option to remove or locate the smaller isolated stands that persist from one year to the next.

Water Quality:

Water Clarity

Pearl Lake is a typical hardwater seepage lake that is considered an *oligotrophic* to *mesotrophic* lake. Water quality and clarity is generally good with some decreases in water clarity usually associated with fall turnover. A good set of general water quality data is available from 1986 to present, because of the lake's participation in the Self-Help Program. These volunteers have done an excellent job securing data over the years.

Water clarity averaged 21 feet according to the data provided by Self-Help Volunteers. During the fall turnover, water clarity has a tendency to decrease. This is most likely due to mixing of the lake and not something to be overly concerned with. Nearly 40% of the secchi readings less than 17 feet were recorded after October 1. This coincides with also the peak chlorophyll-A concentrations. Algae that is suspended at the thermocline is redistributed throughout the water column during the turnover creating a more turbid condition. Figure 1 shows how water clarity fluctuates from 1986 to the present. Water clarity best readings were usually encountered in May and June following the

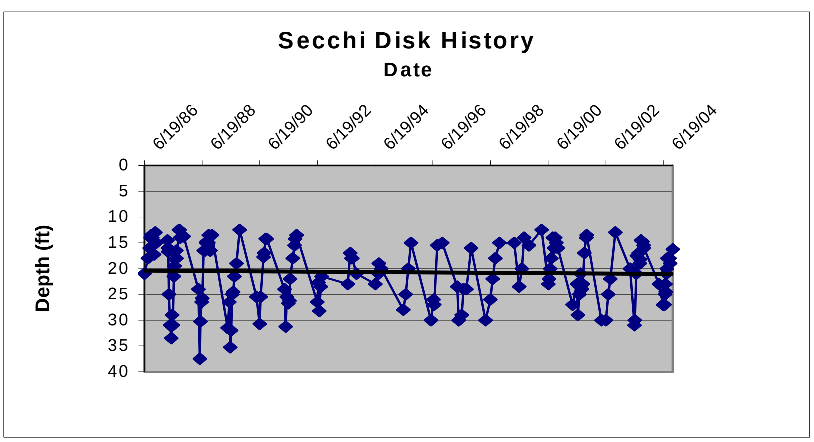


Figure 1. Secchi disk readings from 1986 to 2004 show good water clarity with some seasonal fluctuations.

spring turnover period. This is not unusual. The lake has just become stratified and algae populations still may be low enough that clarity is not yet affected. This is good for aquatic plants. When the plants begin to grow, water clarity is at it's best which can foster plant growth. Keeping the plants healthy will also help increase water clarity (see Roles of Aquatic Plant sections). It may be too early to tell anything conclusively at this time, but the overall trend since secchi data has been recorded, is increasing water clarity. The graph in figure 1 has a trend line that suggests a slight increase, however these data may be too limited at this time to assure this happening. Nonetheless, the data points to good water clarity through 18 years.

Phosphorus

Phosphorus is a nutrient found naturally in lakes. It is considered a limiting factor nutrient for algae growth – only a small amount is needed to trigger am algae bloom. In fact, phosphorus is measured in parts per billion not parts per million like other nutrients. Usually a lake has all the nutrients it needs to for algae growth except phosphorus. Thus the only thing algae really need to bloom is phosphorus, therefore it is important to limit all unnatural additions of phosphorus to the lake. Data provided by the volunteers show that total phosphorus levels might be rising slightly. Again, data may be too limited to tell for sure, however it is important monitor and track the levels over time to determine if indeed an increasing trend is occurring.

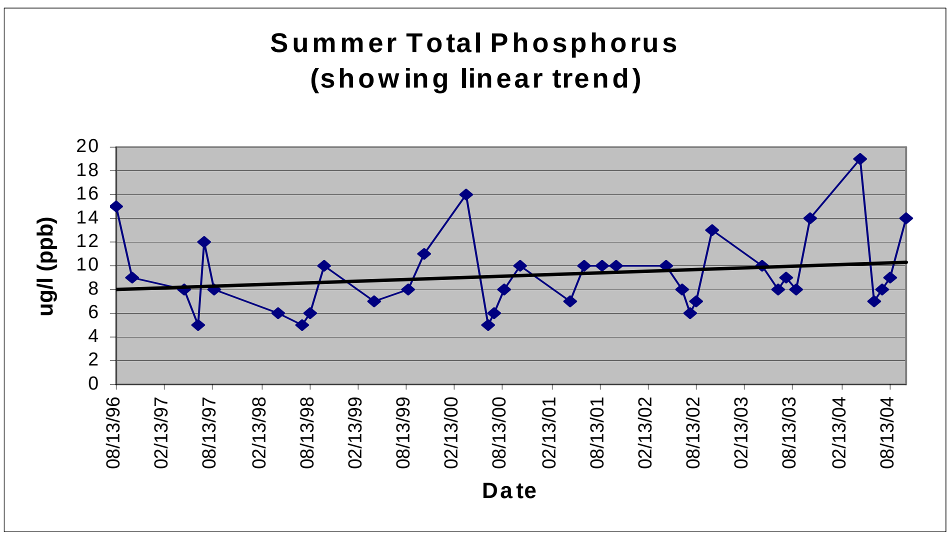


Figure 2 shows total phosphorus in the lake over time during the open water season. High spikes are usually associated with turnover periods.

Limiting unnatural nutrient additions should be a priority to any lake group. There are many ways to do this such as, preserving near shore vegetation in and out of the water. These areas are commonly referred to as buffer strips. The vegetation growing along the shore will help filter water and remove unwanted nutrients. The plants will use these nutrients to grow thus storing them so they do not become suspended in the lake and increase algae growth. Not disturbing native species will also help keep phosphorus levels lower. This would entail reduced raking of shorelines, keeping boat's prop wash from scouring the bottom in shallow water, and limiting shoreline alterations.

Chlorophyll-A

Chlorophyll-A (chl-a) is often used to assess a lakes trophic state (i.e. oligo-, meso-, or Eutrophic); by measuring the amount of chl-a (pigment in plant tissue) coming from algae species in the lake. Total phosphorus (TP) and chl-a are often proportionate to each other and can be used as indicator of water quality. Good water quality usually has low TP and chl-a levels and high water clarity. Conversely, the opposite holds true on poor water quality systems. Figure 3. Shows the chl-a history on Pearl Lake. The slightly increasing trend mimics that of the TP.

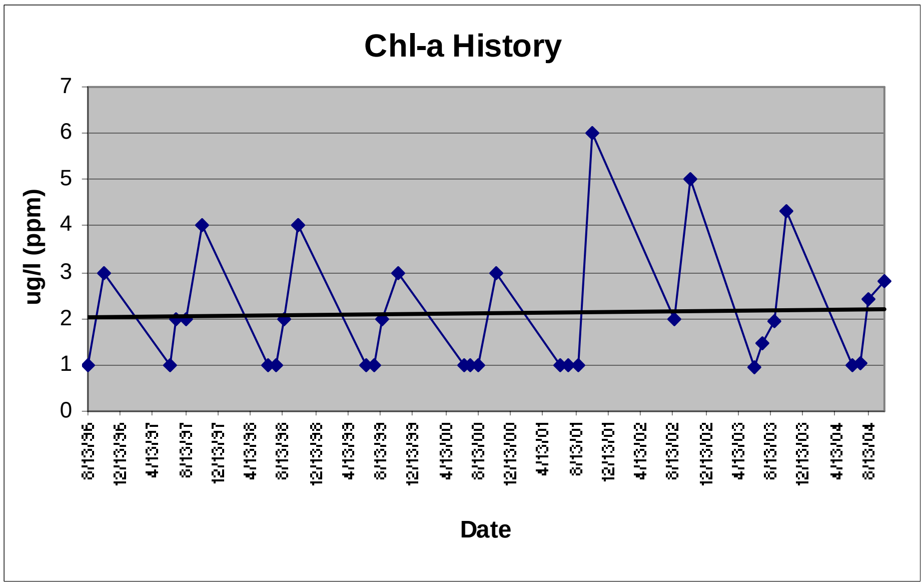


Figure 3 shows the chl-a levels over the past 18 years. The spikes are most likely due to seasonal variations due to turnover.

The large spikes in concentrations are found during the fall turnover. Fall turnover samples average 3.91 ug/l (ppb). That is high for a lake with this water clarity. However when the entire summer is averaged the concentration is 1.34 ug/l, this shows the effect of the fall turnover on water quality in the lake. Algae species that are suspended at the thermocline are redistributed during the fall turnover. As stated before, this is probably why water clarity decreases in the fall. These data will become extremely important in the future to monitor these levels. The Lake Association should make all efforts to continue the monitoring. The Self-Help Volunteers have been doing an outstanding job collecting samples over the years, they should continue to be supported.

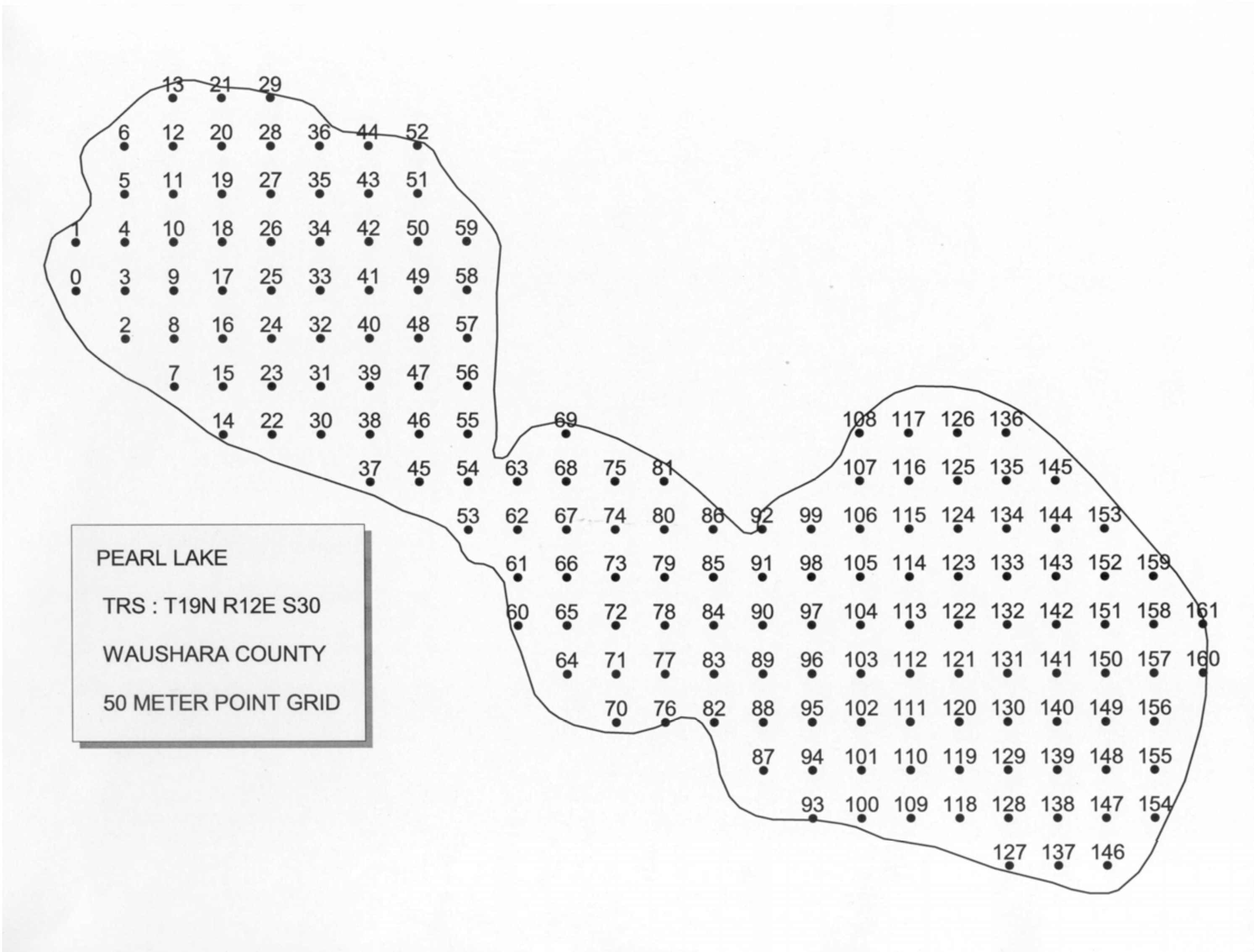
Survey Methods:
The point intercept method was used for this survey. Wisconsin Department of Natural Resources protocol; **Recommended Baseline Monitoring of Aquatic Macrophytes** (Hauxwell, rev. 2004) was used for sampling. Basically this entails using a grid system to define sampling locations on a random basis.

Wisconsin Department of Natural Resources calculated the littoral zone to be less than 100 acres. Therefore, according to protocol, the distance between sampling points was 50 meters (50-m grid spacing). A total of 162 points were placed over the entire lake (see figure 4 for a map of the sampling points). Coordinates for each point were assigned based on the North American Datum 1983 (NAD 83); these coordinates can be found in Appendix I – points where Eurasian Watermilfoil were found are highlighted. A sonic depth gauge (Humminbird 100SX fish locator) was used to determined depth at all points. At all points depth was recorded and plants were sampled until enough data was produced to show where the MDC of the plants were. On Pearl Lake the MDC was determined to be 26 feet.

A hand held Garmin 12 GPS was used to locate each sampling point. Upon arrival at a point, the boat was anchored and depth was recorded. A two headed rake constructed from a standard garden rake (14 teeth) with another rake head welded to the top was used to obtain plant material. The rake was tethered by a chord to the sampler and was thrown sufficient distance to rake the lakebed at least 2.5 feet. All plants found on the rake were recorded. This was repeated in all four cardinal directions around the boat.

Presence of a species was recorded by how many times it was found on a rake per sampling point. For example, if Chara spp. (muskgrass) was found three of four tosses it was recorded as a three. If the plant was totally dominant on all throws it was assigned a rating of five. This was done for all submergent and floating leaf species found at each site.

Figure 4. Map of sampling points on Pearl Lake, Waushara County. 2004.



Roles of Aquatic Plants:
Aquatic plants in a lake are equivalent to trees in a forest. They provide the same roles to different animals that live in a lake. Like a forest, if the trees are removed there is no longer a functioning forest ecosystem; if the aquatic plants are removed, there is no longer a functioning lake ecosystem. Aquatic plants are simply that important. In this section the roles plants play in a lake are discussed as well as specific information for each species found in the lake.

Aquatic plants affect water quality. They absorb nutrients such as, phosphorus and nitrogen. These nutrients can cause large algae blooms that cause water clarity to be reduced and degrade the water chemistry. If aquatic plants were not in the lake, algae would use the nutrients, which would soon dominate the system. Many of our prized gamefish are sight feeders and depend on water clarity to find their prey. When a lake becomes very turbid from too much algae, species that rely on scent such as bullheads, carp and catfish do well. This has occurred in other lakes, which caused a species shift in the fish assemblage from gamefish to roughfish. Years of an algae-dominated system can cause this shift to occur.

Aquatic plants can also impact water chemistry. Not only do aquatic plants absorb nutrients that can cause algae blooms, some can actually break down pollutants (Borman et al., 1997). Aquatic plants influence the pH in a lake and dissolved oxygen levels. During the day, aquatic plants absorb carbon dioxide (CO_2) and then convert it to oxygen during photosynthesis. This causes the pH to swing more to the alkaline (basic) side and oxygen levels to go up. At night, as bacteria respire, they give off CO_2 and consume oxygen, which causes the pH to swing back towards the acidic side of the scale. Too many plants or algae can exacerbate these swings and actually become detrimental to the lake. Not enough plants can cause overall productivity of the lake to decrease and fish production to decline. It’s a fine balancing act.

Aquatic plants can be very different in shape and size. This all adds to their uniqueness. Some plants have a great amount of surface area and some have very little. Surface area is important to invertebrates for places to hide and feed. These same invertebrates feed fish and wildlife. The surface area of a plant provides a substrate that traps fine particulate matter that would otherwise decreases water clarity.

Combining all of this, plants act as a sponge to absorb unwanted chemicals and nutrients; trap fine particles that decrease water clarity. They are the pH and dissolved oxygen (DO) regulators of the living lake. They also provide shelter and shade to invertebrates, fish and animals. They are the hardest working organisms in a lake, trying to keep a balanced ecosystem. Disrupting this balance by unneeded removal of native vegetation and introduction of exotic species can damage a lake beyond repair.

Every species that was encountered during the survey is described below with some points that contribute to their uniqueness.

Chara spp. (muskgrass). This plant is actually considered a higher algae lacking conductive tissue. Each segment or node is actually a single cell. It has a very strong odor that smells skunky, hence the common name MUSKgrass. Once you smell it, you won't forget it. Chara has many benefits. It has plenty of surface area to filter particulate matter and offer shelter to small invertebrates. Part of the reproductive organs (oogoniums) is a favorite food for waterfowl. Young trout and bass utilize this plant to feed on the invertebrates and find shelter. This plant can become established rather quickly on disturbed sites and provides a protective bed that helps prevent EWM from becoming rooted.

Najas flexilis (Slender naiad, bushy pondweed). Slender naiad is a thin-stemmed plant with leaves of variable size attaching to the stem. The leaves of the plant vary in size and are affected by water quality conditions. This is the second most frequent plant found in Gilbert Lake. Slender naiad is considered an annual plant that reproduces by seeds every year. This trait can be a benefit and actually a tool to employ when fighting EWM. Slender naiad has a tendency to invade disturbed areas such as an EWM area treated with a selective herbicide, thus adding competition to a treated target species will only make regeneration of that target species more difficult.

Potamogeton natans (Floating-leaf Pondweed): It would appear that this plant is more common because of the presence and easily seen floating leaves. However it is actually the third most frequent plant found on the lake. Like its cousins in the pondweed family it is a valuable species to wildlife, fish and water quality protection. A special trait of this species is that it retains its fruit late in the season, which is a good food source for waterfowl.

Ceratophyllum demersum (Coontail): Coontail gets its name from the appearance of the plant. The plant has a long stem with stiff leaves whorled around the stem, resembling a raccoon tail. The plant lacks true roots, which contributes to its uniqueness. Sometimes the plant is embedded in the sediment, but most of the time the plant is free floating. It is the tied with Floating-leaf Pondweed as the third most frequent species but because of it's mobility, it was not mapped. In eutrophic lakes this species can become a nuisance, but due to its ability to free float it can be hard to manage. Coontail has good qualities as well. It can draw large amounts of nutrients out of the water in fact it has been used in the wastewater industry for treatment of water. It also provides good habitat for invertebrates and cover for fish in shallow waters.

Elodea canadensis (Common waterweed): Is a plant that has a long stem with short leaves attached around the main stem in a whorled fashion. In some cases it can form very dense beds that can become a nuisance. The plant is similar to an evergreen that can photosynthesize year round even under the ice. This allows the plant to provide dissolved oxygen year round also. Elodea can grow on soft mucky substrates that some other species can't, which helps keep the sediment from being disturbed and re-suspended. Fish will uses elodea beds to graze and seeks shelter. Furbearers also graze directly on the plant eating stems and leaves.

Potamogeton gramineus (Variable Pondweed): Fairly frequent occurring plant in Waushara County, as it is in Pearl Lake. Sometimes can be difficult to distinguish from Illinois Pondweed, even hybridizing with it at times. The most distinguishing features are that the leaf lack stalks and has 3-7 veins. This plant has a good deal of surface area due to its many leaves. Invertebrates often colonize these plants, which in turn make these stands a good place for larger fish to feed. The leaves may have material deposited, which is a testament to its ability to filter lake water. The plant usually dies back in late fall but the rich rhizomes and winter buds provide food for furbearers and waterfowl.

Potamogeton amplifolius (Large-leaf pondweed, bass weed, and musky weed): The common names give this plant away almost instantly. This pondweed has a large leaf with usually 25-37 veins. The leaf appears to be sometimes folded along the midvein. Sometimes the leaves are broad enough they resemble cabbage leaves and hence another common name, water cabbage or just plain cabbage. This is one of the premier aquatic plants for fish habitat. Anglers often search for beds of large-leaf to fish for many species of fish.

Potamogeton zosteriformis (Flat-stem Pondweed): Flat-stem is a plant easily distinguished from other pondweeds. As the name suggests, the plant has flat stems and leaves. A species it is sometimes confused with is Water Stargrass. This plant provides excellent cover for fish and invertebrates.

Stuckenia pectinatus (Sago Pondweed): Sago is an important plant species in a lake ecosystem for many reasons. It is starchy tubers that are sought by waterfowl, the plant provides shelter to young fish and a mature plant has a lot of surface area. It can look like a cylindrical, finely leafed plant when in the water, but upon removal falls limp and appears to look like flatten pine boughs. Up until recently, this plant was considered to be in the genus Potamogeton (pondweeds).

Vallisneria americana (Water celery, eel-grass, tape-grass): Water celery is an excellent plant to have in a lake. The plant provides excellent cover for fish and is sought after by waterfowl. In fact, the Canvasback duck (*Aythya valisneria*) is named after this plant because it feeds on it so much. You may see this plant in August start to flower. A long leafless spiraled stalk – resembling a long pigtail. After the plant has formed it seeds it floats to the surface after the roots deteriorate. The shoreline may have areas where this material as settled in where muskrats may dine on it.

Myriophyllum spicatum (Eurasian Watermilfoil): Probably the most infamous aquatic plant in Wisconsin. This plant produces long stems with leaves whorled around the stem in a feather like fashion. It is very invasive and can grow much earlier in the season giving it an unfair advantage over native species. These plants reproduce mainly by fragmentation thus spreading of the plant can be intensified by physical disturbances. All fragments found floating should be removed from the water. Recently research is pointing to the direction the reproduction from seed may be more significant than once thought. A few lakes in Waushara County actually have a hybrid of native milfoil and EWM. Care should be taken to clean all watercraft and equipment before launching into the lake to prevent further infestations. Likewise it is absolutely imperative to clean all watercraft and equipment coming from Pearl Lake before being launched in another lake.

Potamogeton illinoensis (Illinois Pondweed): A plant that shares its genus with many other plants – the pondweeds. However, their pondweed namesake minimizes their importance to the lake ecosystem. Illinois Pondweed is often confused with large-leaf pondweed and Variable Pondweed. Major distinguishing features are two ridges along the keel of the larger stipules. Their leaves usually have 9-19 veins and often tipped with needle-like tip. The fruit of this plant is an important food source for waterfowl and furbearers and even deer graze the plant. Fish find this plant attractive for the shelter it provides for defensive hiding to concealment for ambushing smaller prey.

Myriophyllum sibiricum (Northern Watermilfoil): This is one of the native species of milfoil and should not be seen as a threat in Waushara County lakes. It is a beneficial plant that resembles it's cousin EWM but has less leaflets (<12) per leaf than EWM (>12 leaflets/leaf). Anyone removing milfoil should first learn to distinguish the two apart so the native species are not accidentally removed. Northern Watermilfoil is somewhat sensitive to changes in water clarity and can be used as an indicator of water clarity conditions. The fine leaflets per leaf provide ample surface area where particulate matter can be trapped, aiding in increase water clarity.

Zosterella dubia (Water Stargrass): This plant often resembles flat-stem pondweed but the major distinguishing feature is the roundness of the stems compared to flat-stem and the presence of a yellow flower when in bloom. Water Stargrass offers a rich tuber for waterfowl and provides shelter for young-of-the-year fish.

Nuphar variegata (spatterdock): This plant is often called yellow pond lily by mistake. The flower is the easiest way to distinguish it from other lilies. Look for an orange or red patch at the base of the flower sepals (pedals). The leaves differ significantly from white-eater lily. The leaves tend to be oblong in shape and have a winged margin on the leaf stalk. They have many of the same benefits as other floating leaf plant in Pearl Lake.

Results:

The aquatic plant community in Pearl Lake is similar to other lakes in the area. Generally speaking, there tends to be a lack of emergent and floating leaf plants near the shore due to shoreline disturbances. There were 14 species of native submergent and floating leaf aquatic plants and one exotic species - Eurasian Watermilfoil. The most dominant species on the lake was muskgrass or Chara. Chara is readily seen growing along the bottom like a carpet. It is not unusual for the plant to come up with anchors and has a distinct odor, hence the common name muskgrass. The exotic species Eurasian Watermilfoil was the eleventh most frequent plant found. Table 1 lists the plants found in Pearl Lake in order of their frequency.

Table 1 Results of aquatic plant survey.

Common name	Scientific name	% frequency	Rel. frequency	Ave. Density	C
Muskgrass	*Chara spp.*	93.30	35.40	2.84	7
Slender Naiad	*Najas flexilis*	61.30	23.20	1.57	6
Floating-leaf Pondweed	*Potamogeton natans*	22.70	8.60	0.55	5
Coontail	*Ceratophyllum demersum*	22.70	8.60	0.40	3
Waterweed	*Elodea canadensis*	13.30	5.10	0.27	3
Variable-leaf Pondweed	*Potamogeton gramineus*	10.70	4.00	0.20	7
Large-leaf Pondweed	*Potamogeton amplifolius*	10.67	4.00	0.29	7
Flat-stem Pondweed	*Potamogeton zosteriformis*	9.33	3.50	0.11	6
Sago Pondweed	*Stuckenia pectinatus*	8.00	3.00	0.12	3
Water Celery	*Vallisneria americana*	4.00	1.50	0.05	6
Eurasian Milfoil	*Myriophyllum spicatum*	2.67	1.00	0.03	
Illionois Pondweed	*Potamogeton illinoensis*	1.33	0.50	0.03	6
Northern Milfoil	*Myriophyllum sibiricum*	1.33	0.50	0.01	7
Water Star-grass	*Zosterella dubia*	1.33	0.50	0.01	6
Spatterdock	*Nuphar variegata*	1.33	0.50	0.05	6
FQI = 20.8 not including EWM					20.8
FQI = 20.1 including EWM					

When analyzing the data there are several terms used to describe distribution and abundance of aquatic plants. It is important to understand what these terms mean to understand the data. The terms used in this survey are defined below:

Percent Frequency: The number of times a plant is found in all sampling sites expressed as a percent. This number is often used because it can be used to show how much a specie(s) was encountered throughout the littoral zone. In this case, Chara has a percent frequency of 93.3%. This means that 93.3% of the sampling points in the littoral zone had Chara present. This is usually interpreted as 93.3% of the littoral zone has Chara. However, just because a species is found throughout a lake does not mean it is the dominant species. It just means that it is found at 93.3% of the lake in any density (thick or thin).

Relative Frequency: The number of times a species was found among the total number of all plants found. This is a ratio, often expressed as a percentage to demonstrate a single species' abundance in the whole plant community. Using Chara as an example again, the relative frequency is 0.354 or 35.4%. This shows that of all the plant species in the lake, Chara comprises 35.4% of the community. This can be interpreted as 35.4% (slightly more than a third) of all plants in the lake are Chara. Figure 5 illustrates the relative frequency of the plant community.

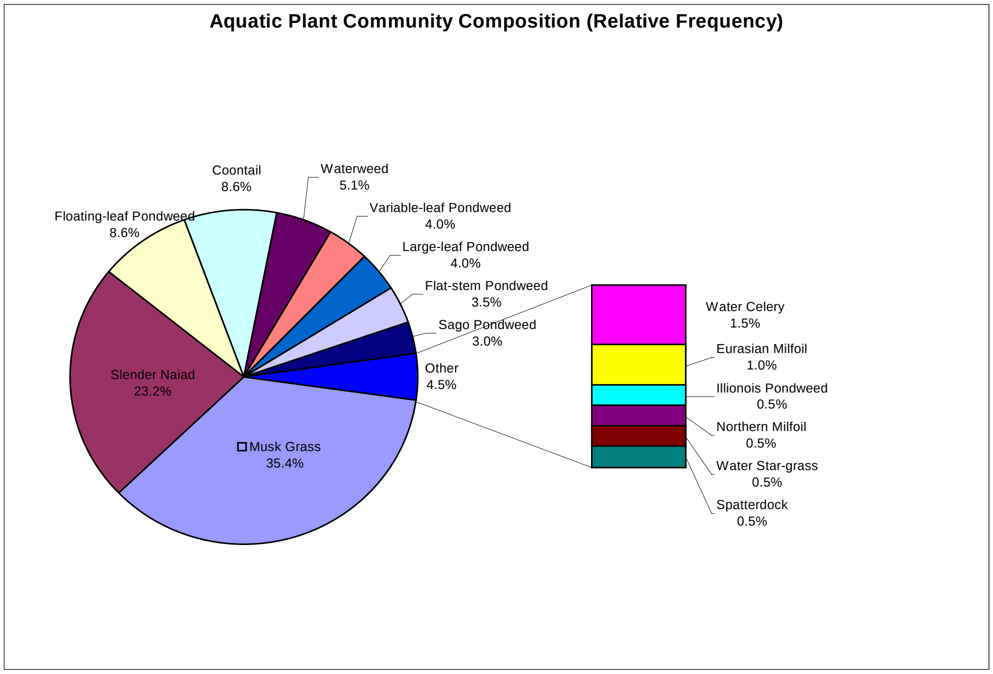


Figure 5. Relative frequency of the Aquatic Plant Community for Gilbert Lake, 2004.

Comparing frequency with relative frequency: In Pearl Lake, the likelihood of seeing a plant (frequency) is proportional to the portion that particular plant comprises of the entire aquatic plant community (relative frequency). The graph in figure 6 illustrates how frequency and relative frequency are related in the littoral zone of the lake.

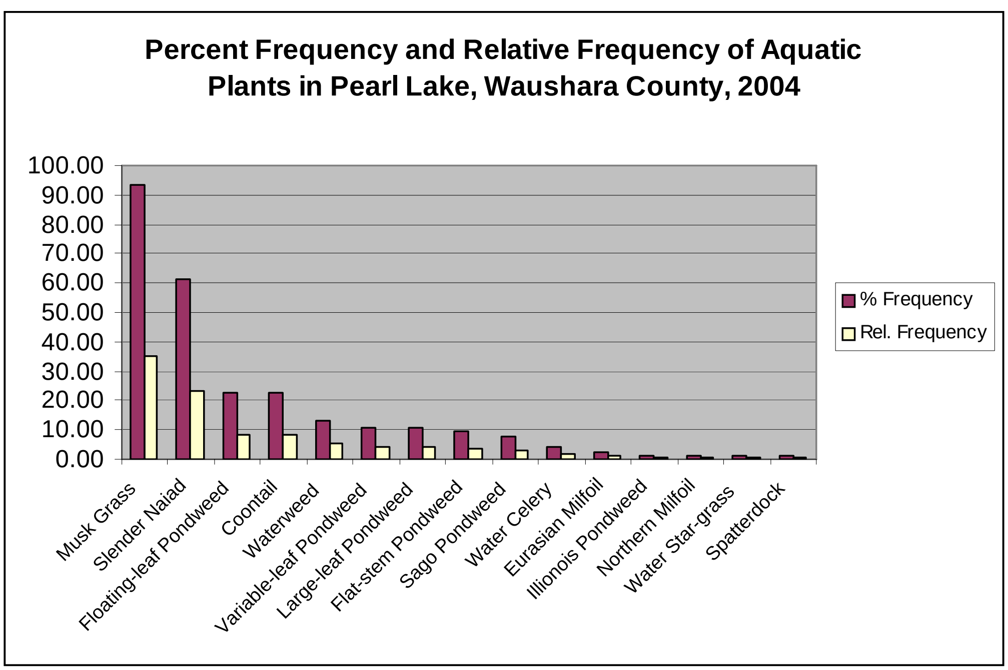


Figure 6. Percent Frequency and Relative Frequency of plants found in the submergent aquatic plant community.

The frequency and relative frequency is usually, but not always, the same in other lakes. This tells us a certain species of plant that is commonly found, is in fact the most common plant in the entire community. This becomes important when gauging aquatic plant management activities such as herbicide treatments. With Naiad being an important component to the aquatic plant community, any treatment that may compromise the plant's distribution or density should be discouraged. These native plants are absolutely necessary to help prevent re-infestations and help control the spread of EWM.

Average Density: Average density is used to show how much of a plant is found at the sampling points. You can interpolate this to indicate how much (how thick) a species is in the lake. The numbers are based on a scale of zero through five. Zero is equivalent to absent and 5 would be very dense (thick) coverage of a plant. Rarely would average densities exceed four even though the possibility exists. Chara had an average density of 2.84. This means across all the sampling points, Chara density (on the 0 to 5 scale), averaged 2.84.

*Coefficient of Conservatism (**C**):* This is a number, based on a scale of 0 through 10 that is assigned to a species. This number reflects the probability a plant would be found in a disturbed or undisturbed system. A ***C*** of 0 indicates very low probability the community is undisturbed. A ***C*** of 10 indicates a very high probability a certain species is of an undisturbed community, which would indicate a high quality natural area indicative to pre-settlement conditions.

Floristic Quality Index (FQI): is a product of the mean ***C*** multiplied by the square root of the number of species found. This number can be used to compare a plant community to statewide or regional trends. The FQI for the lake will be used to compare it to other lakes as an overall aquatic plant community assessment.

The FQI uses the ***C*** for only native species. Exotic species are not included in the calculation. However, by including exotic species in the calculation it is possible to compare the FQI with and without exotic species.

If an exotic such as EWM is encountered the ***C*** is in essence zero. Thus when calculating the mean (average) it will cause the FQI to be lower than if the exotic species was not found. A FQI of 20.1 is calculated when EWM is included in the formula. When EWM is excluded, the FQI yields 20.8. The difference seems minor but when it is compared to the regional North Central Hardwood Forest and Southeastern Wisconsin Till Plains (NCSE) of 20.9 the difference becomes obvious. With EWM presence in Gilbert Lake the FQI is below the regional value and very close to the regional value if EWM was not present.

Summarizing Data: When combining all these terms, a manager or lake resident can gain a better understanding of the distribution (frequency), the portion of the plant makes up of the entire community (relative frequency) and thickness (density) the plant is found in the lake. As an example, summarizing the data for Chara we can see it the most commonly found plant, covering most of the littoral zone of the lake and exhibits fairly vigorous growth compared to all other species. This is all becomes important to a fish biologist who is interested in evaluating how much cover there is for young of the year fish. A wildlife biologist may be interested in food supply for waterfowl. The aquatic plant management coordinator realizes the benefit Chara has to controlling the spread of EWM and will use this information when reviewing permit applications.

Muskgrass (*Chara spp*.), Slender Naiad (*Najas flexilis*), and tied for third was Coontail (*Ceratophyllum demersum*) and Floating Leaf Pondweed (*Potamogeton natans*) were the three most commonly occurring plants found in Pearl Lake. All three of these species are important to fish and wildlife (see Roles of Aquatic Plant section).

Aquatic Plant Distribution and Discussion:
The most diverse aquatic plant areas were found near the center, northeast and southeast part of the lake. Floating leaf and submergent species were common with moderate density. Emergent species such as three-square bulrush (*Scirpus americana*) are found sporadically around the shoreline. Other areas that seem to be protected from wave energy such as the smaller bay on the south side of the lake exhibit similar characteristics. Map 1 shows the overall vegetation distribution for Pearl Lake. This map only shows the presence or absence of submergent or floating leaf species and does not show density of plants.

The vegetative cover map shows that plants are found throughout most of the littoral zone. This can be deceiving when densities are not factored in. The mere presence indicates distribution or location. It does not indicate density, which determines if there are enough plants in sufficient amount, to provide their benefits. Figure 7 shows how densities of plants change with depth. For the three most frequent species found the shallow water (0-2 feet) and the deepest water (12-26 feet) had the lowest densities. The highest densities of plants were found in the 2 – 5 and 5-12 foot depths.

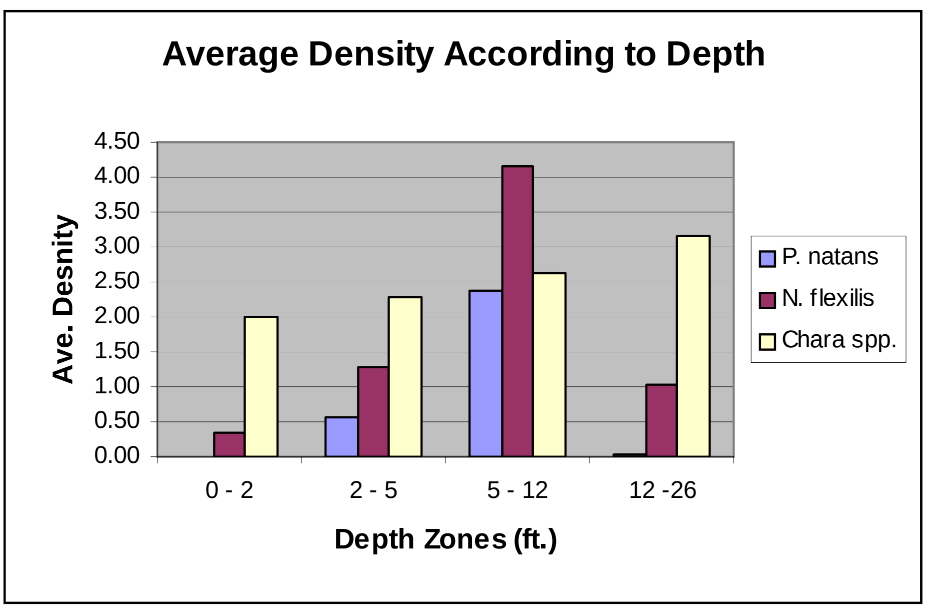


Figure 7. Average density of P. natans, N. flexilis and Chara spp. relative to depth zones.

It is basic reasoning to suggest that the deeper water would have fewer plants than shallower areas due to the lower intensity of light. Even factoring depth preferences for species into the observation, other factors could be contributing to the low density in shallow water. Substrate types appeared to be similar throughout depths in the same area and plant frequency did not change much suggesting that some other factor is responsible for lower densities in shallow water. Besides natural conditions such as wind-derived waves and ice scouring, what is common in this area is a general lack of plants in the shallow near shore area due to human impacts. Raking the shore to remove aquatic plants or leaves, making wakes in shallow water, and shoreline alterations are common causes of lower densities and frequencies of plants species. This has a direct impact on fish and wildlife also.

The three most frequently occurring plant species have also been mapped. There abundance or density has been mapped also to show where the plant(s) and how much of the plant(s) was found. The areas that are shaded and/or color-coded are general mapping units. There are small areas that are totally void of plants within the mapping units. It would be nearly impossible to show at this scale every area that was void of plants. Most of the areas void of plants can be attributed to high use areas from such activities as boating and physical plant removal.

Chara spp. Distribution: Chara was found throughout most of the sampling points (93.3%) in the littoral zone and comprises 35.4% of the total plant community. Chara was also the most abundant (highest density) of all other plants in the survey. Map 2 shows this relative to the lake. Chara can help reduce the spread of EWM by competing against it due to its nature of growth. Chara has a tendency to grow along the bottom like a carpet. This helps prevent fragments of EWM from rooting into the sediment. It is not totally effective as it is not unusual to see EWM associated with it, but it does help slow the spread by competing against it. Due to the other benefits it has, this is a good species to have in the lake. Very rarely does it ever become a nuisance.

Najas flexilis Distribution: Slender naiad, called bushy pondweed by some, was the second most frequent plant found in the lake. It comprises 23.2% of the total aquatic plant species found and can be found in over half (61.3%) of all the sampling points. Map 3 shows the frequency of occurrence and density throughout the lake. Slender naiad is species of plant that can spread relatively quickly. It often responds to EWM treatment by vigorous growth due to the decline of competition from the treated EWM. This is only the case when a herbicide is applied that will not kill naiad along with the EWM. Herbicide selectivity is important if they are considered. On Map 3 stands of EWM that were found during the survey are also plotted. The occurrences of EWM were always associated with naiad. This may not be the case all of the time, but it nevertheless are found consistently with EWM during the point-intercept survey of 2004.

Potamogeton natans Distribution: Floating Leaf Pondweed was the third most frequent plant found in Pearl Lake. It was found in 22.7% of the sampling points and comprised 8.6% of the aquatic plant community. Having a mix of species such as pondweeds, which are considered monocots and other plants like native water milfoil and lilies, which are dicots is a healthy plant community. This becomes important when applications for chemical treatment are reviewed.

Pondweeds are also very diverse amongst their genus. Many pondweeds have no resemblance toward each other, but are very similar in their morphology. Different pondweeds provide different food sources and cover to a wide variety of fish and wildlife. When we combine the genus of *Potamogetons* (pondweeds, including Sago Pondweed), it represents almost a quarter (23.6%) of the aquatic plant community. Other pondweeds in Pearl Lake may make up a small percentage of the plant assemblage but they are good indicators of environmental conditions.

Floating Leaf Vegetation: This is a categorical term given to plants that are mostly floating. Spatterdock (*Nuphar variegata*) was the floating leaf species found during the survey. Map 4 shows the distribution and density throughout the lake. Spatterdock (sometimes called yellow pond lily) only was found in one location near the shore along the southwest end of the lake.

Floating leaf vegetation has the ability to shade out other species. Species such as EWM can be associated with lilies but are usually at lower densities than EWM plants growing in the same conditions without lilies. Protecting the floating leaf vegetation should be a high priority. Not only do these plants help compete against milfoil, they also provide excellent habitat for fish and wildlife.

Like the milfoils, these plants are dicots and are sensitive to some of the same herbicides. However, higher rates of a herbicide such as 2,4-D (Navigate) are needed to kill the lilies than what is needed for EWM. Timing can play an important role as well. In many cases EWM is actively growing early in the spring when lilies have not yet begun to start growing. If possible, any treatments should utilize this window of opportunity. Thus it is important when treating EWM in areas with dicots that rates of application and timing of the application are closely monitored to minimize or eliminate the risk of damage to these plants.

Woody debris: Woody debris is often excluded from discussion when dealing with aquatic plants because it is not considered a benefit. In fact, woody debris is very important to most of the living things in a lake. Most aquatic life either directly or indirectly benefits from woody debris. Many species of organisms that feed fish and other wildlife depend on woody debris for food, nesting areas, shelter and basking. Without fallen trees and other woody debris these organisms would be reduce affecting the overall population of fish and wildlife in the lake. A fallen tree can absorb wave energy that would otherwise pummel the shore and scour the bottom. Plants can colonize these areas to provide essential habitat and contribute to increase water quality by filtering water and stabilizing sediments.

Pearl Lake has a noticeable lack of woody debris along the shoreline. Woody debris along the shore is essential for a diverse aquatic plant community that benefits everyone from the angler to the boater. Like all lakes in Waushara County, much of the woody debris has been removed, which has had a negative impact to the aquatic plant community and ultimately the lake as a whole. It is important to remember than trees have been falling into the lake for thousands of years. Fish, wildlife and aquatic plants have evolved around these natural conditions. Removing this material removes a needed component to the lake's ecosystem.

Conclusion:
Pearl Lake has a moderately healthy aquatic plant community. Fourteen native species of submergent vegetation were recorded and one exotic species – Eurasian Watermilfoil. The most frequent and dominant species was Chara spp., followed by Najas flexilis (slender naiad), and Potamogeton natans (Floating Leaf Pondweed). Although the point intercept method showed that plant coverage was very extensive throughout the littoral zone, the density of these plants are low in the shallow areas (0-5 feet) when compared to the deeper depths (>5 feet) of the littoral zone. The Floristic Quality Index (FQI) was calculated using only the native species. A FQI of 20.8 was calculated. As a comparison, this is slightly below the average FQI for the North Central Hardwood Forest/Southeastern Wisconsin Till Plain (NCSE) of 20.9.

Pearl Lake could substantially increase the density of native species by protecting sensitive areas, avoiding herbicide applications that would jeopardize native species, and restoring woody debris along the shoreline. Increasing the native species density, would enhance fishery and wildlife opportunities near the shore, increase water clarity and quality, and help slow or control the spread of Eurasian Watermilfoil.

Pearl Lake residents should utilize opportunities from the State to participate in a Clean Boats – Clean Waters Workshop to develop a watercraft inspection team that can be used to prevent further reintroductions of Aquatic Invasive Species (AIS). This team can also be used in an information and education campaign to educate users about other AIS's, and prevention methods.

Recommended Readings:
Through the Looking Glass, A Field Guide to Aquatic Plants. Susan Borman, Robert Korth, Jo Temte. 1999. University of Wisconsin – Extension, University of Wisconsin – Stevens Point. College of Natural Resources. Phone: 715.346.2116

Glossary:
Maximum Depth of Colonization (MDC): Depth in the lake to which aquatic plants can grow. This is often times the depth of the littoral zone.

Trophic State: Measure of the lakes fertility or an expression of "age". This can be expressed as a numerical figure such as a trophic state index or as a descriptor such as oligotrophic.

Oligotrophic: A lake with low fertility often characterized by clear water and low to moderate plant growth. Nutrient levels tend to be low in these lakes.

Mesotrophic: A lake in with mid level fertility characterized by moderately clear water and moderate plant growth. Algae blooms can occur when nutrient levels may spike.

Eutrophic: A high level of fertility, sometimes with low water clarity. Algae blooms may be more frequent and plant growth is generally abundant.

References:

Broman, S.; Korth, R.; Temte, J. 1999. Through the Looking Glass, A Field Guide to Aquatic Plants, PUB# FH –207-97. University of Wisconsin – Extension. University of Wisconsin – Stevens Point.

Hauxwell, J. 2004. Recommended Baseline Monitoring of Aquatic Macrophytes. Integrated Science Services – Wisconsin Department of Natural Resources.

Nichols, S.A. 1998. Floristic quality assessment of Wisconsin lake plant communities with example applications. Lake and Reserv. Manage. 15(2):133-141.

Nichols, S.A. 1999. Distribution and habitat descriptions of Wisconsin lake plants. Wisconsin Geological and Natural History Survey, Bulletin 96. Madison, WI.

Appendix I

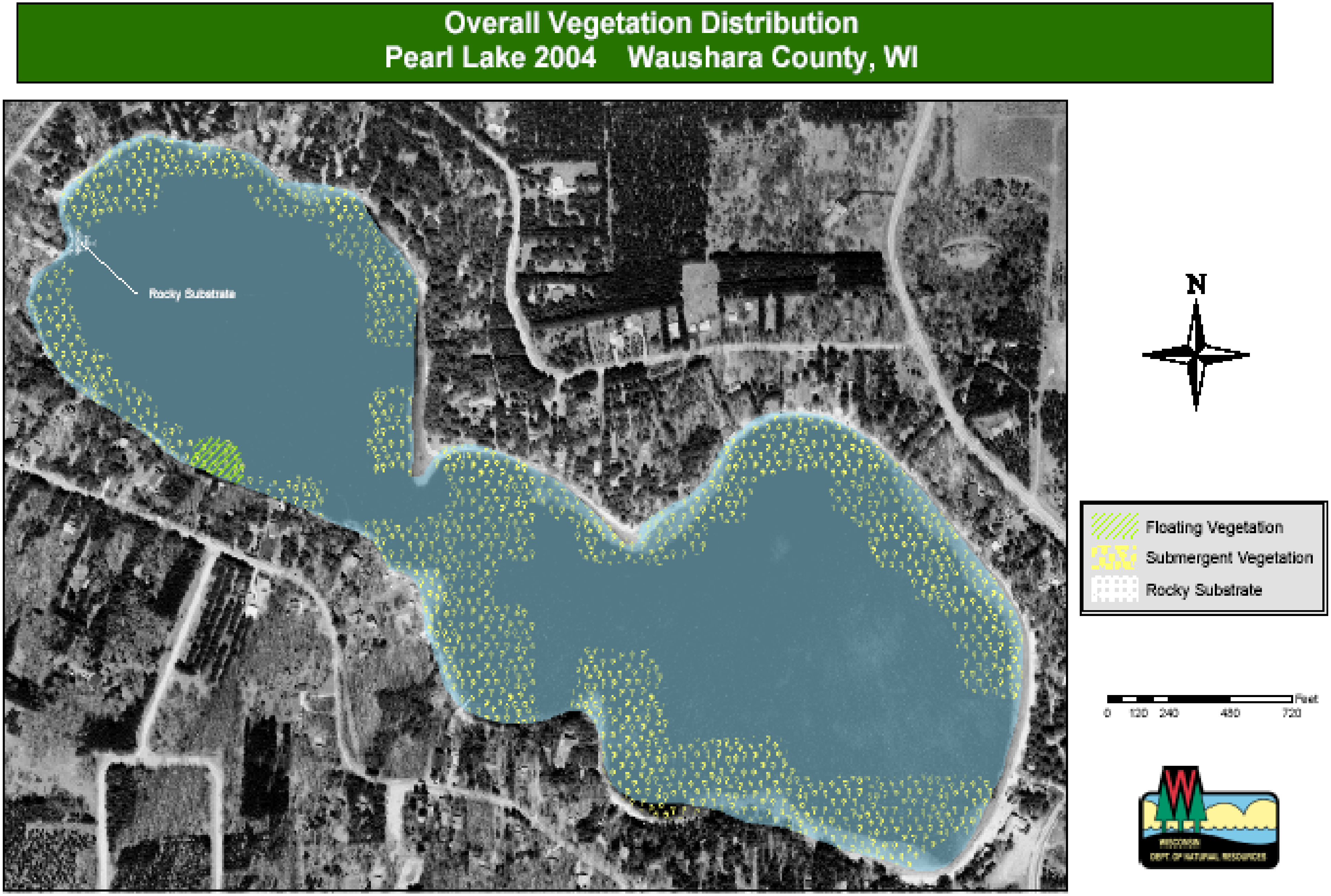
Coorinates for sampling points

ID	Latitude	Longitude
0	44.09069597	-89.12544353
1	44.09114609	-89.12543689
2	44.09024107	-89.12482564
3	44.09069119	-89.124819
4	44.0911413	-89.12481237
5	44.09159142	-89.12480573
6	44.09204154	-89.12479909
7	44.08978617	-89.12420777
8	44.09023629	-89.12420113
9	44.0906864	-89.12419448
10	44.09113652	-89.12418784
11	44.09158663	-89.1241812
12	44.09203675	-89.12417455
13	44.09248687	-89.12416791
14	44.08933127	-89.1235899
15	44.08978138	-89.12358326
16	44.0902315	-89.12357661
17	44.09068161	-89.12356996
18	44.09113173	-89.12356331
19	44.09158184	-89.12355667
20	44.09203196	-89.12355002
21	44.09248208	-89.12354337
22	44.08932647	-89.1229654
23	44.08977659	-89.12295874
24	44.09022671	-89.12295209
25	44.09067682	-89.12294544
26	44.09112694	-89.12293879
27	44.09157705	-89.12293213
28	44.09202717	-89.12292548
29	44.09247728	-89.12291883
30	44.08932168	-89.12234089
31	44.08977179	-89.12233423
32	44.09022191	-89.12232757
33	44.09067202	-89.12232092
34	44.09112214	-89.12231426
35	44.09157226	-89.1223076
36	44.09202237	-89.12230095
37	44.08886676	-89.12172304
38	44.08931688	-89.12171638
39	44.08976699	-89.12170972
40	44.09021711	-89.12170306
41	44.0906672	-89.1216964
42	44.0911173	-89.12168973
43	44.0915675	-89.12168307
44	44.0920176	-89.12167641
45	44.088862	-89.12109854
46	44.0893121	-89.12109187
47	44.0897622	-89.12108521
48	44.0902123	-89.12107854
49	44.0906624	-89.12107188
50	44.0911125	-89.12106521
51	44.0915627	-89.12105854
52	44.0920128	-89.12105188
53	44.088407	-89.12048071
54	44.0888572	-89.12047404
55	44.0893073	-89.12046737
56	44.0897574	-89.1204607
57	44.0902075	-89.12045403
58	44.0906576	-89.12044735
59	44.0911077	-89.12044068
60	44.087502	-89.11986956
61	44.0879521	-89.11986289
62	44.0884022	-89.11985621
63	44.0888523	-89.11984954
64	44.0870471	-89.11925175
65	44.0874972	-89.11924507
66	44.0879473	-89.11923839
67	44.0883974	-89.11923171
68	44.0888475	-89.11922503
69	44.0892977	-89.11921835
70	44.0865921	-89.11863395
71	44.0870423	-89.11862727
72	44.0874924	-89.11862059
73	44.0879425	-89.1186139
74	44.0883926	-89.11860722
75	44.0888427	-89.11860053
76	44.0865873	-89.11800948
77	44.0870374	-89.11800279
78	44.0874876	-89.1179961
79	44.0879377	-89.11798941
80	44.0883878	-89.11798272
81	44.0888379	-89.11797603

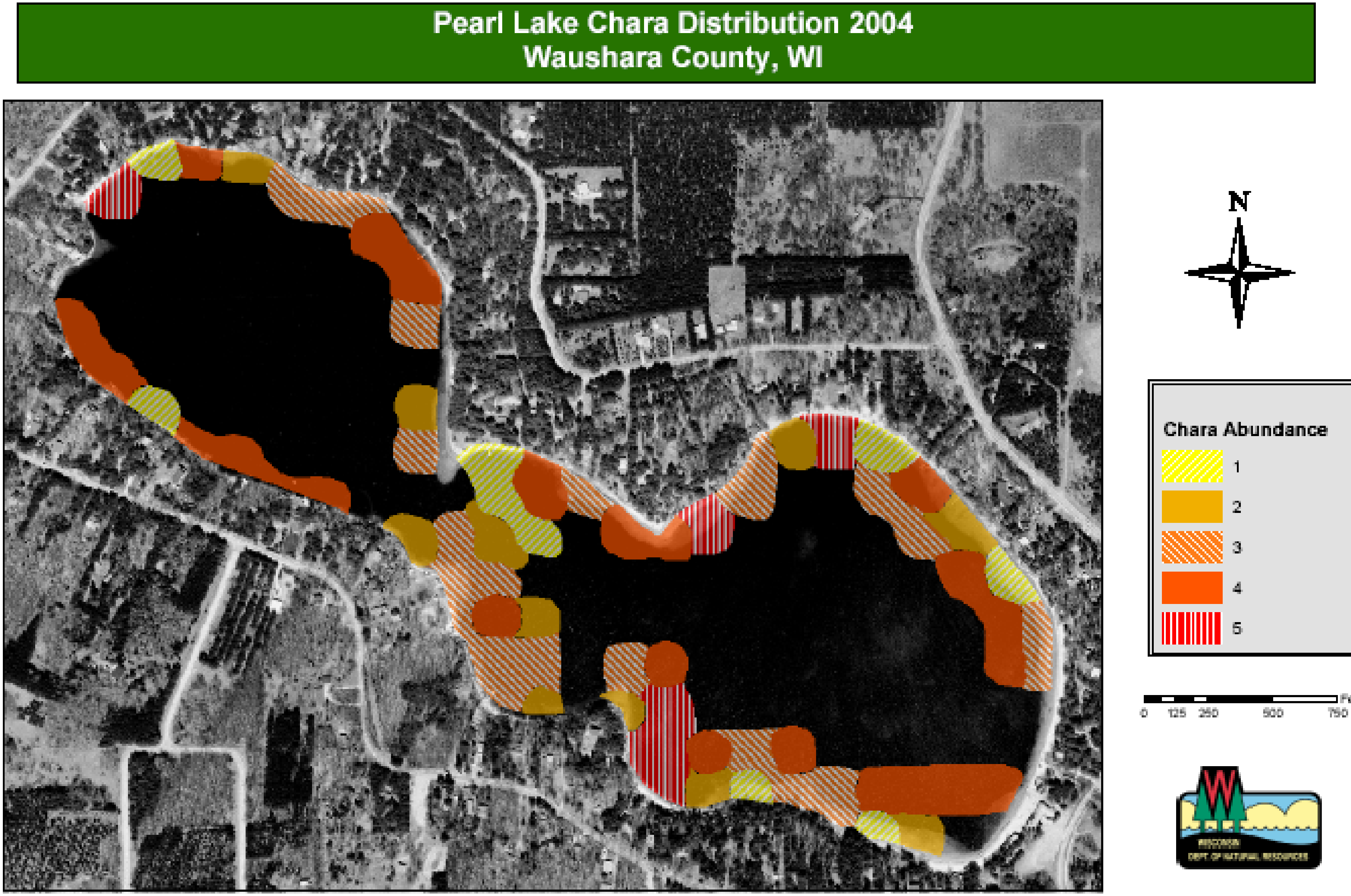
ID	Latitude	Longitude
82	44.0865825	-89.117385
83	44.08703261	-89.11737831
84	44.08748273	-89.11737161
85	44.08793284	-89.11736492
86	44.08838296	-89.11735822
87	44.08612756	-89.11676722
88	44.08657767	-89.11676052
89	44.08702779	-89.11675382
90	44.0874779	-89.11674713
91	44.08792802	-89.11674043
92	44.08837813	-89.11673373
93	44.08567261	-89.11614945
94	44.08612273	-89.11614275
95	44.08657284	-89.11613605
96	44.08702296	-89.11612934
97	44.08747307	-89.11612264
98	44.08792319	-89.11611594
99	44.0883733	-89.11610923
100	44.08566778	-89.11552498
101	44.08611789	-89.11551828
102	44.08656801	-89.11551157
103	44.08701812	-89.11550486
104	44.08746824	-89.11549815
105	44.08791835	-89.11549144
106	44.08836847	-89.11548474
107	44.08881858	-89.11547803
108	44.0892687	-89.11547132
109	44.08566294	-89.11490052
110	44.08611306	-89.1148938
111	44.08656317	-89.11488709
112	44.08701329	-89.11488038
113	44.0874634	-89.11487367
114	44.08791352	-89.11486695
115	44.08836363	-89.11486024
116	44.08881375	-89.11485353
117	44.08926386	-89.11484681
118	44.0856581	-89.11427605
119	44.08610822	-89.11426933
120	44.08655833	-89.11426261
121	44.08700845	-89.1142559

ID	Latitude	Longitude
122	44.0874586	-89.11424918
123	44.0879087	-89.11424246
124	44.0883588	-89.11423574
125	44.0888089	-89.11422903
126	44.089259	-89.11422231
127	44.0852031	-89.1136583
128	44.0856533	-89.11365158
129	44.0861034	-89.11364486
130	44.0865535	-89.11363814
131	44.0870036	-89.11363142
132	44.0874537	-89.11362469
133	44.0879038	-89.11361797
134	44.088354	-89.11361125
135	44.0888041	-89.11360453
136	44.0892542	-89.1135978
137	44.0851983	-89.11303384
138	44.0856484	-89.11302711
139	44.0860985	-89.11302039
140	44.0865486	-89.11301366
141	44.0869988	-89.11300693
142	44.0874489	-89.11300021
143	44.087899	-89.11299348
144	44.0883491	-89.11298675
145	44.0887992	-89.11298003
146	44.0851935	-89.11240938
147	44.0856436	-89.11240265
148	44.0860937	-89.11239592
149	44.0865438	-89.11238919
150	44.0869939	-89.11238245
151	44.087444	-89.11237572
152	44.0878941	-89.11236899
153	44.0883443	-89.11236226
154	44.0856387	-89.11177818
155	44.0860888	-89.11177145
156	44.0865389	-89.11176471
157	44.0869891	-89.11175797
158	44.0874392	-89.11175124
159	44.0878893	-89.1117445
160	44.0869842	-89.11113349
161	44.0874343	-89.11112675

Map 1. Vegetative cover on Pearl Lake

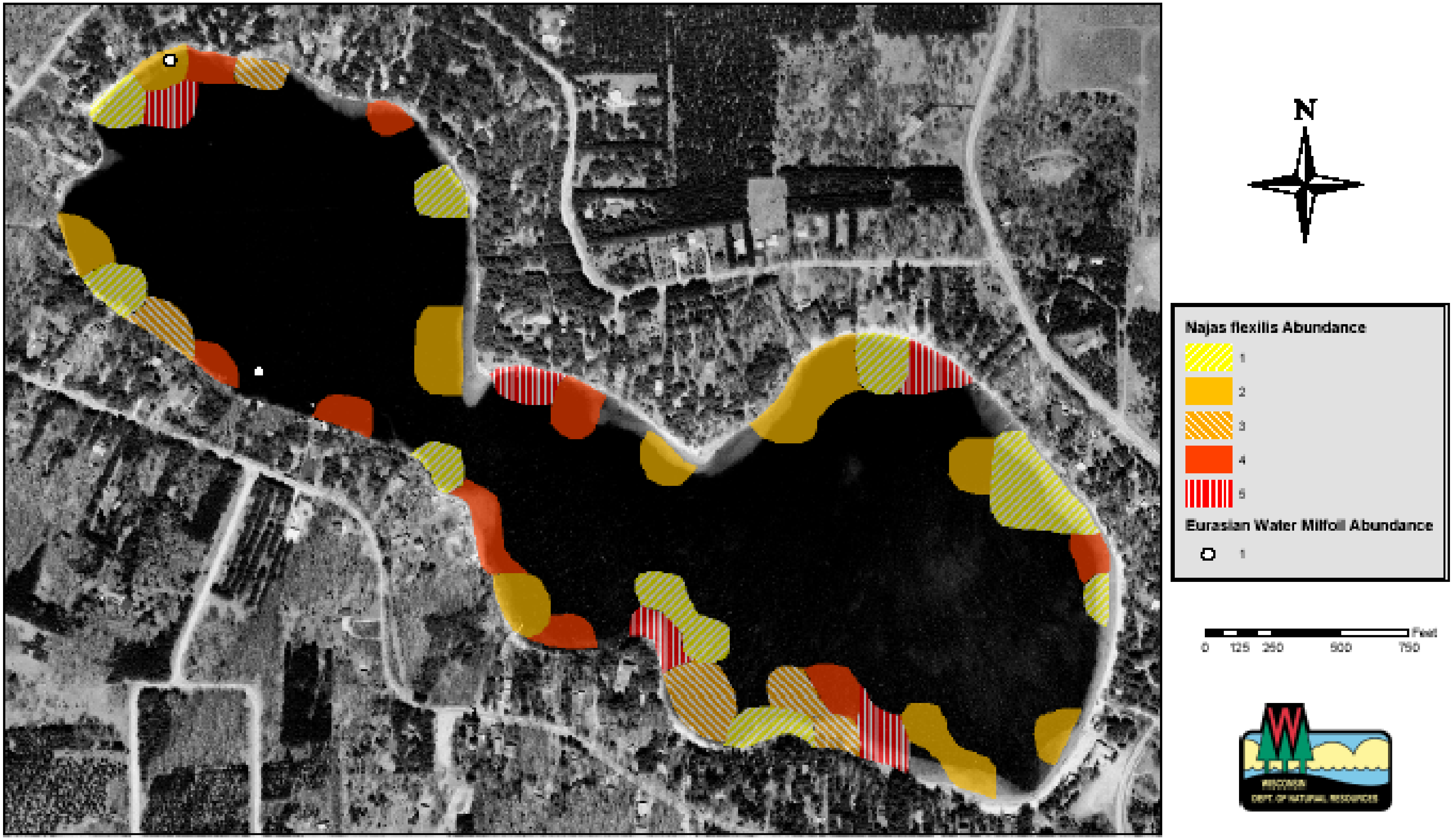


Map 2. Chara distribution on Pearl Lake. 2004.



Map 3. Najas distribution on Pearl Lake. 2004

Najas flexilis and Eurasian Water Milfoil Distribution
2004 Pearl Lake   Waushara County, WI



Map 4. Floating Leaf Vegetation distribution Pearl Lake. 2004.