Aquatic Plant Management Plan

Bear Trap Lake and Lake Wapogasset
Polk County, Wisconsin

2015

Sponsored by the Lake Wapogasset/Bear Trap Lake Sanitary District

Prepared by Ecological Integrity Service LLC, Amery Wisconsin

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Introduction

This Aquatic Plant Management Plan is being developed for Bear Trap Lake and Lake Wapogasset. It presents data about the plant community, fisheries, watershed, and water quality of Bear Trap Lake and Lake Wapogasset. Based on this data and public input, this plan provides goals as well as strategies for the sound management of aquatic plants in the lakes. The plan reviews public input, summarizes data, discusses management options and alternatives, and recommends action items. This plan will guide the Lake Wapogasset/Bear Trap Lake Sanitary District, the Lake Wapogasset/Bear Trap Lake Association, Polk County, and the Wisconsin Department of Natural Resources in aquatic plant management over the next five years (2014-2019).

Both Bear Trap Lake and Lake Wapogasset are drainage lakes that are connected by a channel that is locally referred to as the "narrows". Lake Wapogasset has two inlets, Balsam Branch and Friday Creek. Balsam Branch contributes a very large portion of the water budget with Friday Creek having substantially less flow. A single outlet with substantial flow leaves Lake Wapogasset at the west shoreline. There are no tributaries that flow continuously into Bear Trap Lake.

Figure 1: Aerial photo of Lake Wapogasset and Bear Trap Lake with tributaries and boat landings.

Bear Trap Lake

WBIC: 2618100
Location: T33N R17W S25
Area: 241 acres
Type: Drainage lake
Maximum depth: 25 feet
Mean depth: 10.9 feet

Figure 2: Topographical map of Bear Trap Lake. The east shore and the southeast point have steep elevation changes.

Lake Wapogasset

WBIC: 2618000
Location: T33N R17N S26
Area: 1186 acres
Type: Drainage lake
Maximum depth: 32 feet
Mean depth: 9.8 feet

Figure 3: Topographical map of Lake Wapogasset. The southeast bay and the middle portion of the western shore have steep elevation.

Public Input

In spring 2009, a public survey was conducted to determine lake shore property owner's concern about the lakes. Approximately 650 surveys were distributed and 350 (54%) were returned. The results of the survey indicate that water quality is the greatest concern of lakeshore property owners. In the update of this plan in 2014, a plant committee participated with update reports communicated at Lake Association and Sanitary District meetings. The plan was available for public review for 4 weeks.

Summary of survey results:

Respondents were asked to rate various problems in and around the lake on a scale from 0 to 4 (0 not at all and 4 a great deal). The results of their responses are as follows (mean scale for each category listed):

Lack of water clarity in middle of lake = 1.9
Lack of water clarity at the end of dock = 2.5
Excessive invasive aquatic plant growth in lake = 2.4
Excessive native aquatic plant growth in lake = 2.3
Potentially toxic algae blooms = 2.6

Respondents were asked a question about how much a particular issue may negatively impact their use of the lakes. The scale ranged from 0 (definitely no) to 4 (definitely yes) with the results as follows:

	Lake Wapogasset	Bear Trap
Algae growth	3.1	3.0
Native aquatic plant growth	2.5	2.4
Invasive aquatic plant growth	3.2	3.0

When asked whether or not various activities should be pursued by the Sanitary District and/or Lake Association, the following results were received (0 definitely no to 4 definitely yes):

Spray native aquatic plants = 2.4
Harvest native aquatic plants = 2.5
Spray invasive aquatic plants = 2.6
Harvest invasive aquatic plants = 3.1
Prevent aquatic invasive species introduction = 3.7
Monitor for aquatic invasive species = 3.7
Protect sensitive habitat areas = 3.2

Responses when asked to rate the level of aquatic plants was as follows (1 too few; 2 right amount; 3 too many):

Lake Wapogasset = 2.6
Bear Trap Lake = 2.3

When asked what affect aquatic plants have on participation in various activities around the lakes the following mean values (0 not at all; 4 a great deal):

Activity	Lake Wapogasset	Bear Trap Lake
Swimming	2.5	2.2
Fishing	1.8	1.7
Boating	2.1	2.0
Enjoying the view	1.6	1.3

When property owners were asked about reducing growth of curly leaf pondweed (CLP), the following mean response was received:

Response	Lake Wapogasset	Bear Trap Lake
Definitely no	2%	1%
Maybe no	0%	0%
Not sure	3%	5%
Maybe yes	10%	9%
Definitely yes	71%	55%
No answer	13%	30%

In terms of water quality practices, 44% are familiar with shoreline buffer zones and 35% have them present on their property, although the definition may vary by owner. Of the 350 respondents, 41% are either “fairly” or “very interested” in water quality practice being installed at their property (no designation of which of many listed) and 13% “not” or “not very” interested.

Based on the overall results of the survey, the residents of Lake Wapogasset and Bear Trap Lake are concerned about water quality and aquatic plants. There seems to be little distinction between invasive and native plants but consistent response to reduce their growth. The respondents are very concerned about CLP and want to do something about it. Property owners are also very concerned about new introductions of aquatic invasive species. It is apparent that there needs be some educational components about the native versus invasive aquatic plants. Since harvesting of CLP is not a suggested management method for these lakes, education about the pros and cons of various management methods is needed.

Public involvement in plant development

Lake Wapogasset and Bear Trap Lake have two lake organizations. One is the Lake Wapogasset/Bear Trap Lake Sanitary District, which is a taxing entity. The other is the Lake Wapogasset/Bear Trap Lake Association. Both of these organizations are very active in protection and management of the two lakes. Both have representatives on the committee that was formed in June of 2008 to develop this plan as well as in the 2014 update/rewrite. The members of this committee that are representing their respective organization have been reporting back to those organizations about the components of the plant management plan.

Plant management committee members:

- Dennis Badman-Lake Wapogasset/Bear Trap Lake Sanitary District
- Paul Elbing - Lake Wapogasset/Bear Trap Lake Sanitary District
- David Erspamer-Lake Wapogasset/Bear Trap Lake Sanitary District
- Bob Flatten – Lake Resident
- Beth Holmgren-Lake Resident
- Mike McBrayer – Lake Resident
- Mort Mortenson – Lake Resident
- Dave Nelson – Lake Wapogasset/Bear Trap Lake Association
- Lee Rickard-Lake Resident
- Mike Seidl-Lake Resident
- Mark Tryggestad – Lake Wapogasset/Bear Trap Lake Sanitary District
- Joe Ziglinski-Lake Resident

Upon the completion of the first draft, the plan was made available for public review in hard copy at the Amery public library and electronically on the Lake Wapogasset/Bear Trap Lake website for four weeks (December 2013/January 2014). All meetings of the committee were listed following the open meetings law and published in the Amery Free Press. The plant management committee reported to the Lake Association and to the Sanitary District in meetings following the plan development meetings. There were no comments that led to the need for any changes.

Importance of Aquatic Plants

The lake ecosystem relies extensively on the littoral zone, which is the area of the lake where the water is shallow enough to hold plants. As a result, the aquatic plant community plays a very important role in maintaining a healthy lake ecosystem.

Emergent plants (the ones sticking above the water surface) can help filter runoff that enters the lake from the watershed area. Their extensive root networks can stabilize sediments on the lake bottom. Wave energy can be reduced by emergent plants, thus reducing shoreline erosion. Many of these beds provide important fish habitat and spawning areas, as well as key wildlife habitat. Many birds, waterfowl, and some mammals rely on these plants for nesting materials as well as food.

Floating-leaf plants such as water lily provide shade and cover for invertebrates and fish. Although they appear thick on the surface, the underwater area beneath them is more open. This allows fish and other animals to move about hidden by the leaves above.

Submergent plants provide many benefits to the lake ecosystem. These plants are nature's aerators, producing the essential oxygen byproduct from photosynthesis. Submersed plants absorb nutrients through their roots and in some cases through their leaves, decreasing the nutrients that would otherwise be available for nuisance algae growth. Roots stabilize bottom sediments thus reducing re-suspended sediments. As a result, these plants help maintain water clarity.

Aquatic plants take on many shapes and sizes and provide excellent habitat. Many of the plants, such as the milfoils or water marigold, have fine leaves that provide key invertebrate habitat. These invertebrates comprise a very important level in the food chain and result in excellent forage opportunities for fish. Other plants are adapted to grow in low nutrient substrates such as sand and gravel. These plants maintain important fish and wildlife cover for areas that would otherwise be devoid of plants.

Many fish rely on aquatic plants for reproduction. *Esox sp.* often spawn amongst submergent plants. The Northern Pike even has eggs that are adapted for attachment to the plants themselves. Once fish emerge from their eggs, the plants provide important cover and foraging areas.

Lake Information

Fisheries

Both Lake Wapogasset and Bear Trap Lake have abundant, diverse fish populations. In a population survey conducted in 2008, it was reported that the following fish are present in the two lakes (the fish biologist combined both lake results in the report)[1]:

Walleye
Northern Pike
Muskellunge
Largemouth Bass
Smallmouth bass

[1] Heath Benike. Wisconsin DNR Fisheries Biologist. Draft Report on 2008 fish survey. Feburary 2008.

White bass
Bluegill
Black crappie
Pumpkinseed
Yellow perch
Green sunfish
Warmouth
White sucker
Common carp
Redhorse
Bullheads.

The management of fish in these two lakes has involved a large amount stocking of walleye fry and small fingerlings. The walleye stocking program dates back to 1938. The most recent stocking occurred in 2006 when 41,485 walleyes (35 fish/acre) less than 3" in length were stocked (combined in both lakes). In 2005, a low-level muskellunge stocking program was initiated (<0.5 fish/acre). This was initiated to maintain a low-density fishable population that has been present in the past several decades. Historically muskellunge emigrated from upstream, which has had the stocking reduced.

The most abundant managed game fish in Lake Wapogasset/Bear Trap Lake is largemouth bass at 8.7 fish per acre. A concern was raised by the fish biologist about this population being too dense, leading to a stunted largemouth bass population.

The fish survey management recommendations discussed the importance of maintaining an adult walleye population between 1-2 fish/acre through increased walleye stocking (70 fish/acre) in Lake Wapogasset. Walleye appear to be an integral part of the overall fish management of Bear Trap Lake and Lake Wapogasset.

The survey also recommends that muskellunge stocking continue at a rate of 0.5 fish/acre on alternating years. It is also suggested that the lakes be upgraded to a Class B, 3 muskellunge classification. This reflects priority of the muskellunge in the overall fish management of the two lakes.

The final suggestion is that largemouth bass and smallmouth bass populations be monitored. The largemouth bass population appears to be increasing and may lead to the development of a high density, sub-optimal size population. A very small population of smallmouth bass is present in the lakes. A pulse-stocking event is suggested for a 3-5 year period to increase a several year class strength in smallmouth bass.

When considering fish in the management of plants in Lake Wapogasset and Bear Trap Lake, the following should be considered:

1. Although it appears the natural walleye reproduction is minimal, it may be occurring. Walleye spawn on clean gravel beds. Sedimentation of these beds can render them useless as spawning beds. It is therefore important to keep sedimentation to a minimum by maintaining native shorelines and restoring developed shorelines to native vegetation.

2. Muskellunge reproduce in the spring at water temperatures in the mid-50's F. They also spawn amongst aquatic vegetation and/or woody debris. As a result, the loss of early plant growth such as CLP could affect the limited muskellunge reproduction. In addition, CLP may be used by muskellunge for cover and forage areas early in the spring. As a result, early season treatment of CLP could affect the reproduction success. This probably isn't an issue since the reproduction muskellunge is considered limited.

3. Black crappies also spawn when the water temperature is the same as the recommended CLP treatment. This treatment would need to be timed accordingly, either prior to or after crappie spawning.

4. Northern Pike rely on aquatic plants for spawning. However they spawn when water temperatures are in the 40's F, so treatment of herbicides in the mid 50's F should not coincide with the northern pike spawning activity.

Fish species[2]	**Spawning Temp in °F**	**Spawning substrates**
Black crappie	Upper 50's to lower 60's	Build nests in 1-6 feet on hard bottom
Bluegill, Largemouth bass and Pumpkin seed	Mid 60's to lower 70's	Build nests in less than 3 feet on hard bottom
Muskellunge[3]	Mid 50's to near 60.	Broadcast eggs over organic sediment, woody debris and submerged vegetation.
Northern Pike	Upper 30's to mid 40's soon after ice-out	Broadcast eggs onto vegetation (eggs attach)
Smallmouth Bass	Usually between 62 and 64 but recorded as low as 53	Nests in circular, clean gravel
Walleye	Low 40's to 50 degrees	Gravel/rocky shoals with moving or windswept water 1-6 feet deep
Yellow perch	Mid 40's to lower 50's	Broadcast eggs in submergent vegetation or large woody debris

Table 1: Summary of game fish species spawning temperatures and substrate needs.

[2] Information from Heath Benike. Wisconsin DNR Fisheries Biologist. 2006

[3] Information from: Rust, Ashely J., James Diana, Terry L. Margenau, and Clayton J. Edwards. Lake Characteristics Influencing Spawning Success of Muskellunge in Northern Wisconsin Lakes. *North American Journal of Fisheries Management*. 2002. p834.

Sensitive Habitats and Species

A sensitive area survey was conducted on Lake Wapogasset in 1989 so is quite outdated. There were seven locations around the lake that were recorded as "sensitive area" based upon their importance as habitat in the lake ecosystem. The table below summarizes the seven areas in terms of location, importance and protection. This survey is obviously rather outdated, but may be used for reference.

Lake Wapogasset Sensitive Area	Location/description	Importance	Protection
A	3000 feet of shoreline extending from Friday Creek to YMCA camp	Habitat for centrachid and esocid species of fish; important wildlife habitat	Chemical and mechanical treatments should not be allowed.
B	2000 feet of shoreline out 200 ft on East shore of Wapogasset	Rock and gravel bottom with no silt that provides walleye spawning	No dredging, structures or deposits should occur.
C	1500 feet of shoreline out 200 ft near bible camp.	Rock and gravel bottom with no silt that provides walleye spawning.	No dredging, structures or deposits should occur
D	2000 ft of shoreline out 200 ft on western shore of Wapogasset	Rock and gravel bottom with no silt that provides walleye spawning	No dredging, structures or deposits should occur
E	Entrance of Balsam Branch into Wapogasset and surrounding wetlands/approx. 3500 ft of shoreline	Habitat for centrachid and esocid species of fish for spawning and nursing; important wildlife habitat; wild rice in the area Wild Rice observed	Chemical and mechanical treatments should not be allowed
F	A small bay on north end of Wapogasset/approx. 800 ft of shoreline	Habitat for centrachid and esocid species of fish for spawning and nursing; important wildlife habitat	Chemical and mechanical treatments should not be allowed
G	Located along YMCA camp out 200 ft covering approx. 900 ft of shoreline	Rock and gravel bottom with no silt that provides walleye spawning	No dredging, structures or deposits should occur

Table 2: Sensitive area information for Lake Wapogasset.

Bear Trap Sensitive Area	Location/description	Importance	Protection
A	Southern bay of Bear Trap Lake near County F	Habitat for centrachid and esocid species of fish for spawning and nursing; important wildlife habitat	Chemical and mechanical treatments should be limited to navigation channels
B	Along northwest shoreline of Bear Trap Lake including narrows leading to Lake Wapogasset.	Habitat for centrachid and esocid species of fish for spawning and nursing; important habitat forage species; important wildlife habitat	Chemical and mechanical treatments should be limited to 80 feet from shoreline

Table 3: Sensitive area information for Bear Trap Lake

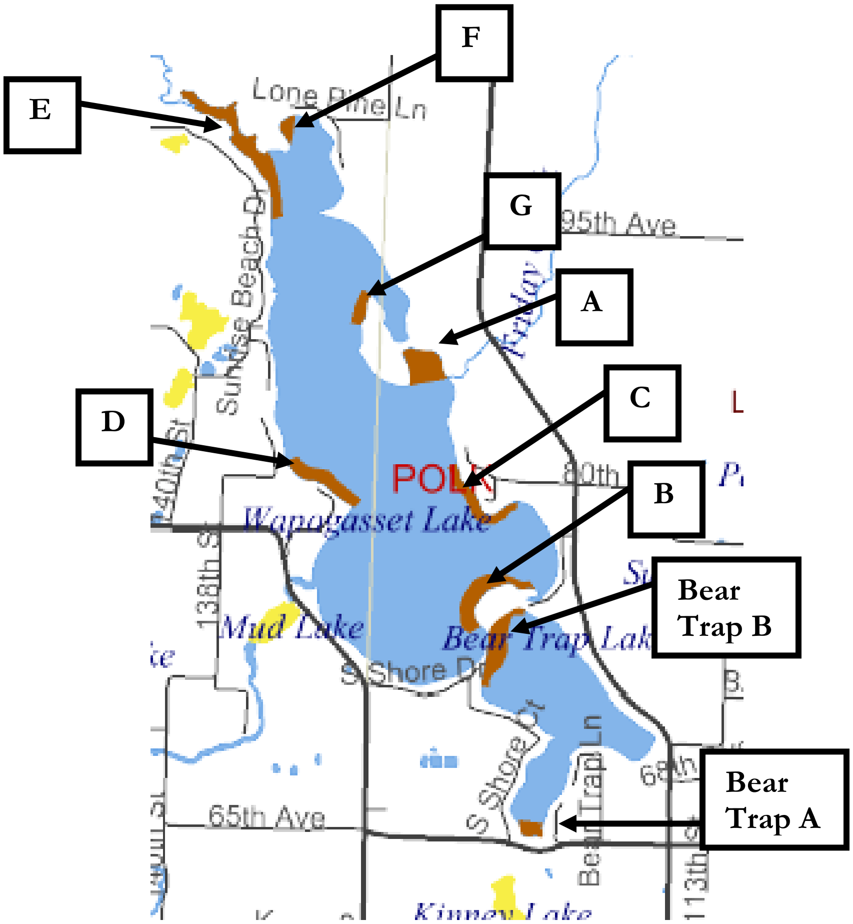

Figure 4: Estimated location of sensitive areas on Lake Wapogasse and Bear Trap Lake.

Rare and endangered species

Wild rice is the only species that has been observed that is considered very sensitive and is a species of concern. This was located in the area where Balsam Branch comes into Lake Wapogasset (sensitive area E). There was only one location with a few plants observed. Refer to figure 5 for the map of where wild rice was located historically. No rare or endangered plant species were viewed, sampled or observed elsewhere on either lake.

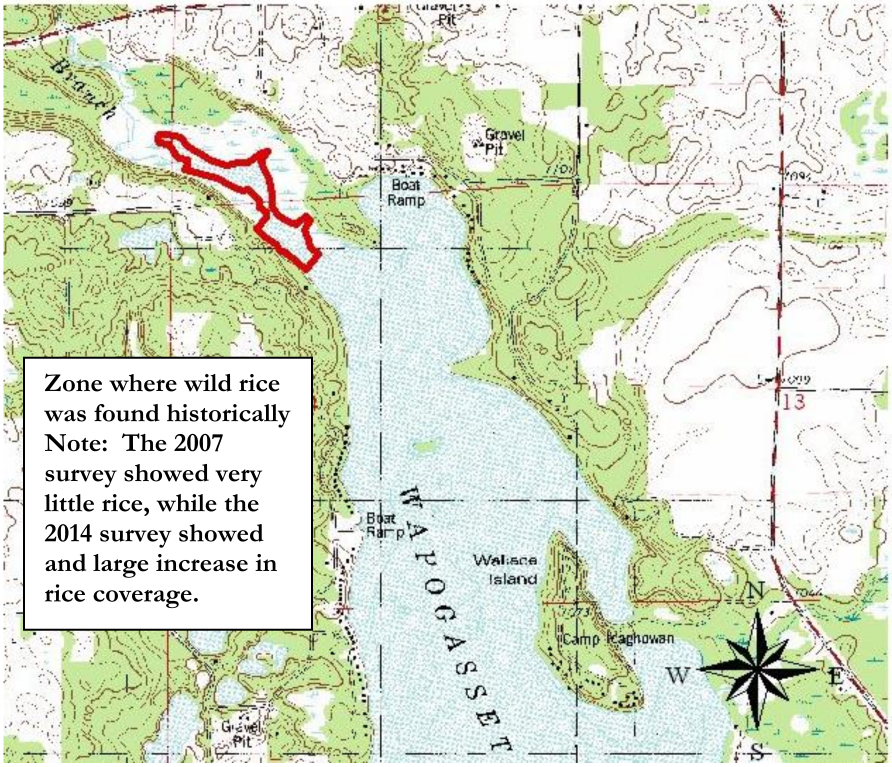

Figure 5: Map of wild rice zone. This is the area were only a few plants were located in the PI survey in 2007 and where wild rice has been observed historically.

There are is some information that the inlet of the Balsam Branch had much more wild rice. The cause of wild rice reduction (assuming it has reduced) is not known. Since this lake is in the ceded territory, there may be some interest in analyzing this change and increasing wild rice growth.

According to the Natural History Survey, the following flora and fauna that are listed as endangered, threatened, rare or of special concern in the township Lake Wapogasset and Bear Trap Lake are located:

Cypripedium parviflorum var. m-Northern yellow lady's slipper
Fondulus diaphams-Banded killifish
Haliaectus leucocephalus-Bald eagle

Watersheds

During the summer of 2007, the land use in the Bear Trap Lake and Lake Wapogasset watersheds was updated. The watershed was divided to sub-watersheds. In addition, the nutrient and water loading from each sub-watershed was updated. This updated nutrient budget used field data from the tributaries and modeling the watershed using BathTub with the corrected land use information.

Tributaries

As mentioned in the methods, the daily flow was weighted for phosphorus load. The daily load vs flow was graphed and a regression analysis was conducted. In Balsam Branch the daily load vs flow was used to give a strong correlation. In Friday Creek, the best correlation came from graphing the log of daily load vs log of flow.

In the case of Total Suspended Solids (TSS), the daily averages and the average loads were used to calculate the total load during the sampling period.
The results of all calculated loads are in table 5.

Test-2007	**Balsam Branch**	**Friday Creek**
Mean Total Phosphorus	0.066 mg/L	0.292 mg/L
Mean Ortho Phosphate	0.061 mg/L	0.226 mg/L
Mean TSS	6.18 mg/L	111.73 mg/L
Mean TVSS	2.0 mg/L	45.36 mg/L

Table 4. Averages for water quality analysis (includes base flow and storm events).

Stream	**Inflow in hm^3**	**Total P load**	**TSS load**	**Peak flow**	**Low flow**	**Mean flow**
Balsam Branch	10.77	1578 kg	66 586 kg	69.95 cfs	10.2 cfs	25.39 cfs
Friday Creek	0.34	166 kg	37 821 kg	3.17 cfs	0.205 cfs	0.68 cfs

Table 5. Calculated loads and flows of tributaries.

A=Balsam Branch watershed

B=Northeast wapogasset

C=Friday Creek watershed

D=Northwest Wapogasset

E=Southeast Wapogasset

F=Northeast Bear Trap

G=Southwest Wapogasset

H=Northwest Bear Trap

I=Southwest Bear Trap

J=Southeast Bear Trap

K=Lake Wapogasset and Bear Trap Lake

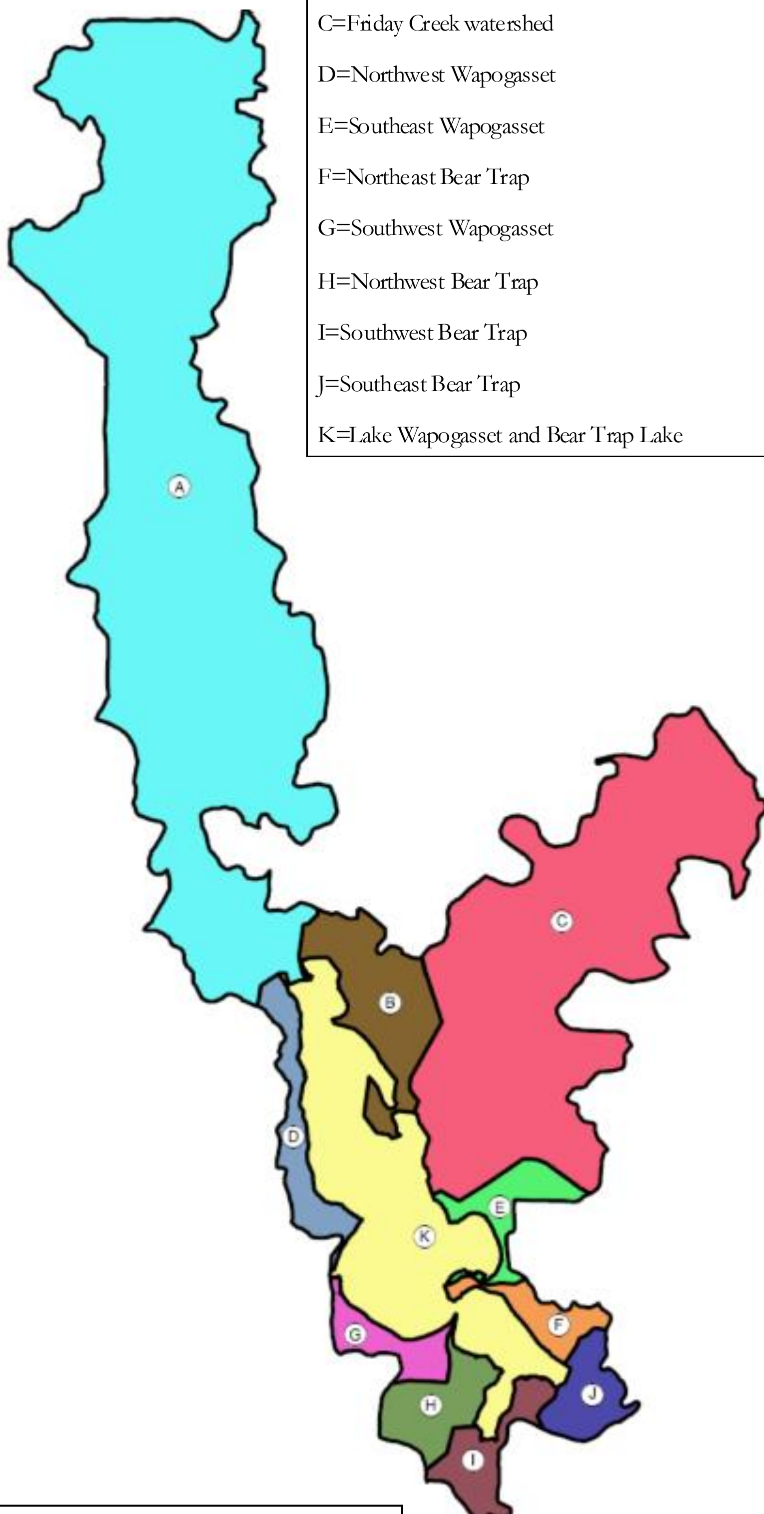

Figure 6: Subwatershed map

Name	Barren	Forage	Forest	Grassland	Open water	Residential	Row crop	Wetland
A - Balsam Branch	0.2	0.68	11.44	4.46	0.44	0.02	0.92	3.56
B - NE wapo	0	0.35	1.11	0.2	0	0.18	0.07	0
C - Friday Creek	0	2.59	2.11	2.29	0.02	0.03	1.68	2.03
D - NW wapo	0	0.15	0.39	0.05	0.01	0.3	0.11	0.04
E - SE wapo	0	0.09	0.23	0.3	0.01	0.16	0.01	0.01
F - NE Bear	0	0.02	0.37	0.04	0	0.14	0.04	0.02
G - SW wapo	0	0.11	0.14	0.11	0	0.19	0.14	0
H - NW bear	0	0.05	0.19	0.41	0.02	0.12	0.26	0
I - SW bear	0	0.02	0.33	0.25	0.09	0.13	0.01	0.07
J - SE Bear	0	0.05	0.32	0.29	0	0.01	0.1	0.04
Percent of Total Land cover	0.5	10.19	41.25	20.83	1.46	3.17	8.28	14.31

Table 6. Land use area for various sub watersheds. Values are in km^2.

Wapogasset Sub-watershed	Annual Load	Inflow (hm3/yr)	Mean daily load	Max daily load	Min daily load	Mean daily flow
A (Balsam Branch)	1577.1 kg/y	23.31	4.32 kg/day	16.96 kg/day	0.11 kg/day	26.10 cfs
B (NE Wapo)	66.9 kg/y	0.17				
C (Friday Creek)	160.1 kg/y	0.68	0.44 kg/day	2.47 kg/day	0.04 kg/day	0.8075 cfs
D (NW Wapo)	85.4 kg/y	0.15				
E (SE Wapo)	33.1 kg/y	0.09				
F (SW Wapo)	85.4 kg/y	0.12				
Precipitation	267.21 kg/y	3.85				
Total external load	2145.21 kg/y	28.37				

Table 7. Nutrient and water budget loads

Bear Trap Sub-watershed	Annual Load	Inflow(hm3/yr)
F (NE Bear Trap)	28.9 kg/y	0.07
H (NW Bear Trap)	141.9 kg/y	0.20
I (SW Bear Trap)	54.0 kg/y	0.15
J (SE Bear Trap)	55.8 kg/y	0.10
Precipitation	56.48 kg/y	0.82
Total external load	337.08 kg/y	1.33

Table 8: Bear Trap Lake subwatershed phosphorus load and water load.

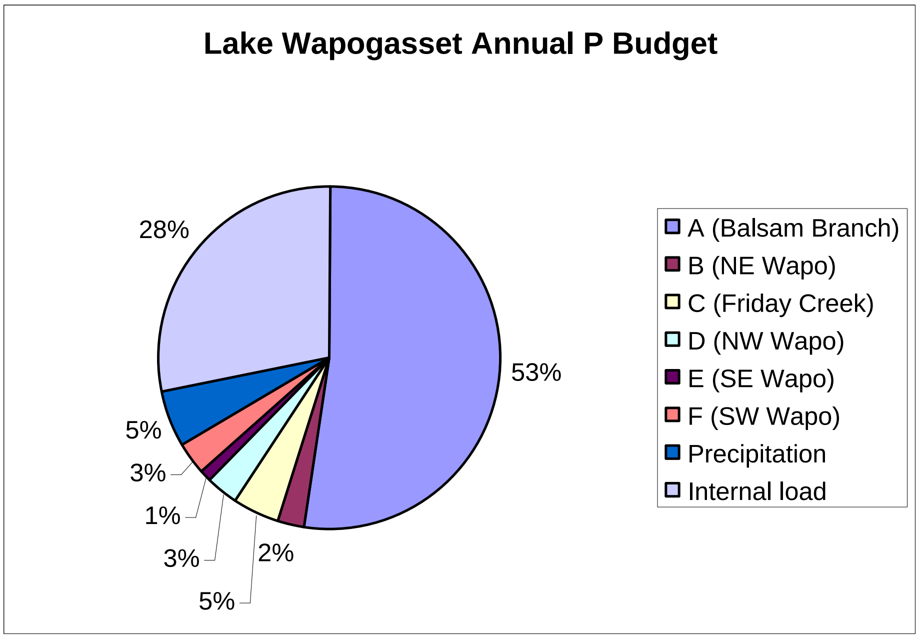

Figure 7: Percent of phosphorus budget (annual) on Lake Wapogasset by source.

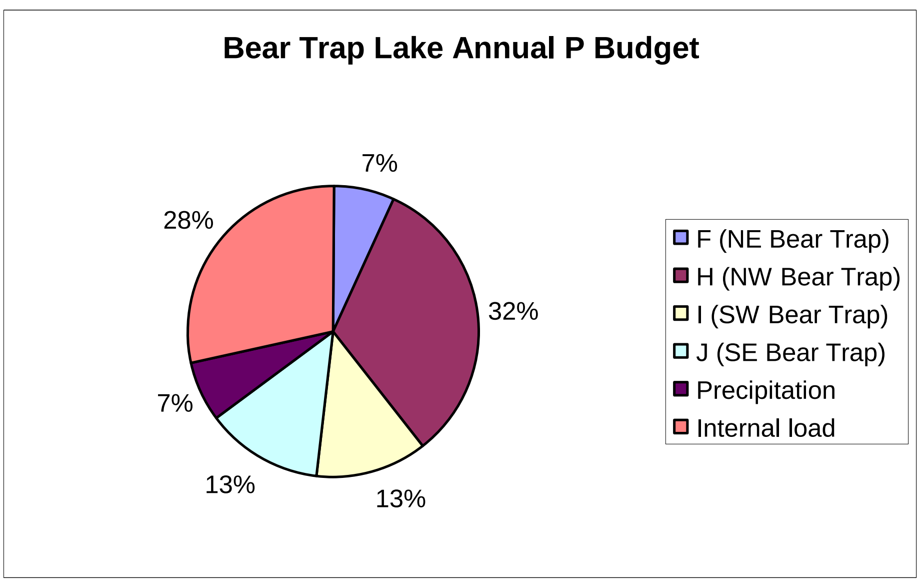

Figure 8: Percent of phosphorus load (annual) Bear Trap Lake by source

Nutrient Loading

External loading

The largest percentage of phosphorus loading into Lake Wapogasset is the Balsam Branch. This tributary accounts for about 74% of the entire phosphorus load annually. The summer of 2006 was extremely dry; therefore the flow was lower than an average year (speculation as no baseline data available). As a result, increased flow in a more normal precipitation year would increase the phosphorus load. In addition, Friday Creek contributes only 6% of the phosphorus to Lake Wapogasset. This could also change immensely with an average year of precipitation. In comparing the two tributaries, Balsam Branch has a rather low phosphorus concentration during base flow. It did increase significantly during rain events, but was still not extremely high. However, its flow is extensive and provides a high flow, low concentration scenario. In some cases, the concentration of phosphorus in Balsam Branch is actually lower than the lake phosphorus concentration. During rain events in mid to late summer, high volumes of water could help contribute to mixing the lake, allowing the release of high phosphorus concentration hypolimnetic water.

Friday Creek has very low flow by comparison to Balsam Branch. However, the phosphorus concentration is higher at base flow, and increases dramatically even with relatively minor rain events. This stream also had less loading based on field data than the model calculated based on land cover. This may be due to the fact that there are many wetlands in the Friday Creek watershed immediately adjacent to the creek. These wetlands appeared to be mostly dry throughout most of the sampling period. During rain events, the runoff may have been absorbed by the wetlands, never reaching the stream. It is for this reason that the drought year may reduce the significance of Friday Creek in the nutrient load and this should be considered when evaluating the load from Friday Creek in the future.

In terms of sediment contributions, Balsam Branch and Friday Creek differ significantly. The mean total suspended solids (TSS) is much lower for Balsam Branch than for Friday Creek (6 mg/L and 111 mg/L). As a result, the total suspended solids flowing toward the lake is higher in Balsam Branch due to much higher flow, but when comparing flows, Friday Creek has a much higher load. In both cases, the stream flow decreases immensely before reaching the lake, which can allow for settling of the solids. This is evident when observing the outlets of both tributaries, with extensive sediment buildup at both locations. The total volatile suspended solids (TVSS) is used to help determine the amount of the suspended solids that may be organic as opposed to inorganic. In Balsam Branch, the mean TVSS is about one third of the mean TSS with the value being so low (6 mg/L and 2 mg/L) that is rather insignificant. In Friday Creek, the mean TVSS is a little less than half of the TSS (111 mg/L and 45 mg/L). This indicates that a large portion of the suspended solids could be organic in nature as opposed to inorganic sediments.

When comparing the total phosphorus values to the dissolved-reactive phosphorus values, some interesting points could be made. Because total phosphorus includes dissolved-reactive phosphorus, one can calculate the percentage of total phosphorus that is dissolved-reactive. In Balsam Branch, the mean dissolved-reactive phosphorus was 92.4 % of the mean total phosphorus. This indicates that most all of the phosphorus in Balsam Branch is dissolved and available for absorption by plant material (algae and macrophytes). In Friday Creek, the mean dissolved-reactive phosphorus was 77% of the mean total phosphorus. Again, the majority of the phosphorus is dissolved and available for absorption, although much lower than Balsam Branch. This would be consistent with the TSS values, since Balsam Branch has such little TSS and Friday Creek has much higher TSS values. This would represent more phosphorus potentially tied up in sediments in the tributary water in Friday Creek.

The remaining watershed has some impact on the phosphorus and water budgets too. In Lake Wapogasset, this impact is much less than the tributaries. Balsam Branch and Friday Creek, according to the field data, accounted for about 75% of the external phosphorus budget. With precipitation accounting for 12% of the phosphorus, the remaining watershed contributed about 13% of the total external phosphorus load. The total mass contributed from the remaining watershed was rather evenly distributed between the various sub watersheds in Lake Wapogasset.

For Bear Trap Lake, there are no major tributaries. A small stream was identified in the southeastern portion of the lake, which locals refer to as Bear Trap Creek. One phosphorus sample was analyzed and it was much lower than the concentration of Bear Trap Lake (0.086 mg/L vs 0.104 mg/L) This does not mean that this stream contributes nothing to the lake. A value of 0.086 mg/L could cause loading. However, in evaluation of the watershed of this stream, it is mostly wetlands and the model does not suggest any significant impact. The flow of the stream is unknown. Further evaluation may be warranted.

The direct watershed of Bear Trap Lake is therefore the major contributor of the external phosphorus with 83% of the external load (17% from precipitation). Comparing the sub-watersheds, the northwest Bear Trap sub watershed contributes 41%. This may be due to the extensive row cropland use, which has one of the highest export coefficients of any land cover type. The phosphorus loading of this sub watershed is much greater than any other sub watershed. Southeast Bear Trap watershed (J), is the next highest with 17%, followed by southwest Bear Trap (I) at 16%.

Upon evaluation of the data for the sewage treatment test wells, as well as the groundwater flow by the engineer in this project, it is inconclusive if the seepage ponds are contributing phosphorus. The well elevations indicate groundwater movement to the southwest, away from the lake. Also, the chloride data supports this conclusion. However, the East well had a very high phosphorus value, which would indicate sewage possible moving that direction. Whether it reaches the lake is unknown. There was positive groundwater pressure at all locations except two in region of concern. This does not necessarily mean that the groundwater below the seepage ponds is flowing into the lake. There is a break in the topography between the ponds and the lake, which could account for the positive flow into the lake and yet flow away from the lake at the pond locations. The overall conclusion is that it doesn't appear the seepage ponds are leeching into the lake, but this is not certain. If the load is occurring as Barr Engineering indicated (20 kg/yr) in 1995, it is less than the precipitation and rather small in comparison to the whole phosphorus load. However, considering the rationalization for a sewage treatment facility, this issue should be resolved through increased monitoring.

Internal loading

The internal loading was not analyzed in this study. This loading has been analyzed extensively due to the alum treatment failure. Based on the data collected, it is significant in both lakes. Also, there are two deep holes in Lake Wapogasset. One of the two deep holes does not appear to stratify based on data collected previously. This makes for an unstable water column potentially allowing mixing of the hypolimnion with the epilimnion prior to fall turnover. The southern-most portion of Lake Wapogasset does appear to stratify, limiting hypolimnetic phosphorus loading to overturn events (fall). In Bear Trap Lake, the lake does seem to stratify earlier, but appears to lose stratification in late summer, which could allow mixing prior to fall turnover. The potential phosphorus load internally in both lakes is extensive.

In 1995, the internal loading of Lake Wapogasset and Bear Trap Lake were determined from a model by Barr Engineering. The results indicated an internal load for Lake Wapogasset of 1058 kg/yr, and for Bear Trap Lake an internal load of 242 kg/yr.[1] In 2004, more extensive data was collected through sediment core sampling. In this study, release rates and area of sediments with those release rates were determined. Taking into consideration the length of anoxic conditions, the calculated internal loads were approximately 792 kg/y and 122 kg/y in Lake Wapogasset and Bear Trap Lake respectively.[2] In the case of either lake, the amount is significant.

[1] Amount taken directly from Barr Engineering. *Wisconsin Lake Planning Grant Final Report. Lake Wapogasset and Bear Trap Lake, Polk County, Wisconsin*. June 1996.

[2] Amount calculated from release rate data from Barr Engineering. *Investigation of Alum in Lake Wapogasset and Bear Trap Lake*. December 2004.

The sewage treatment ponds do not appear to be contributing phosphorus. In addition, if they are, it makes up a very small percentage of the total load. The data is rather inconclusive so it is not certain if the sewage pond load is occurring. However, since the Sanitary District oversees the operation of the sewage treatment facility, and this was installed to reduce nutrient loading from private systems, it would be prudent to further study this issue.

The most valid method to determine if this load is occurring would be to install more monitoring wells between the lake and the sewage treatment ponds. This can become very costly. Therefore, we recommend first testing shallows wells that are already present on properties adjacent to the lake. This would maybe give more insight into the possible loading due to the ponds. If this data would indicate such a load, further study could be included, possibly more monitoring wells.

In an effort to reduce internal loading in these lakes, Aluminum sulfate (Alum) was used as a regimen 1999. Aluminum sulfate will bind phosphate and keep it in the sediment potentially for several years. According to the report at the time of application, the treatment was to last for 7 to 12 years. Records show the water clarity and phosphorus concentrations decreased immensely the first year. Unfortunately the following year the algae blooms and higher phosphorus concentrations returned. The treatment was viewed as a failure. There were many hypothesis provided as to why, but it didn't work nonetheless[4].

Bear Trap Lake appears to have all of its phosphorus coming in internally and from the direct runoff of the watershed. The management practices available for controlling loading are being reviewed, which is important. Potential land purchases and/or conservation easements should be explored to try and implement best management practices on some key properties that have potentially large nutrient loads into Bear Trap Lake. As an example, by changing a parcel from row crop to native grassland could reduce phosphorus loading by approximately 80% per acre. This could be a very large reduction in kilograms of phosphorus reaching Bear Trap Lake. Furthermore, reducing residential influence through buffer installations and infiltration devices could reduce runoff enough to make a difference in nutrient loading from these areas.

Reducing Lake Wapogasset external loading is more complicated since much of the phosphorus is coming from Balsam Branch. During the past several years, the Balsam Branch has had many best management practices implemented as a priority watershed for several years up until a three years ago. This has most definitely reduced the phosphorus concentrations in Balsam Branch, reflected by low average total phosphorus values. However, this stream has a large flow and will always contribute a large total

[4] Failure discussed in: *Investigation of Alum in Lake Wapogasset and Bear Trap Lake.* Barr Engineering. Dec. 2004

load as a result. Better management along Friday Creek would help reduce its loading, but it is a relatively small percentage of the total load. There are a couple of key subwatersheds that could reduce nutrient loading due to large amounts of row crop acreage. These are NW and SW Wapogasset subwatersheds. Reducing the row crop influx, or changing the land use to forage crops could reduce loading from those areas immensely.

There is a plan to study the nutrients in the CLP in both lakes, since there is large coverage and high density of CLP[5]. There has been some indication that the phosphorus load from CLP in July can be substantial in some lakes[6].

Lake Phosphorus Trends

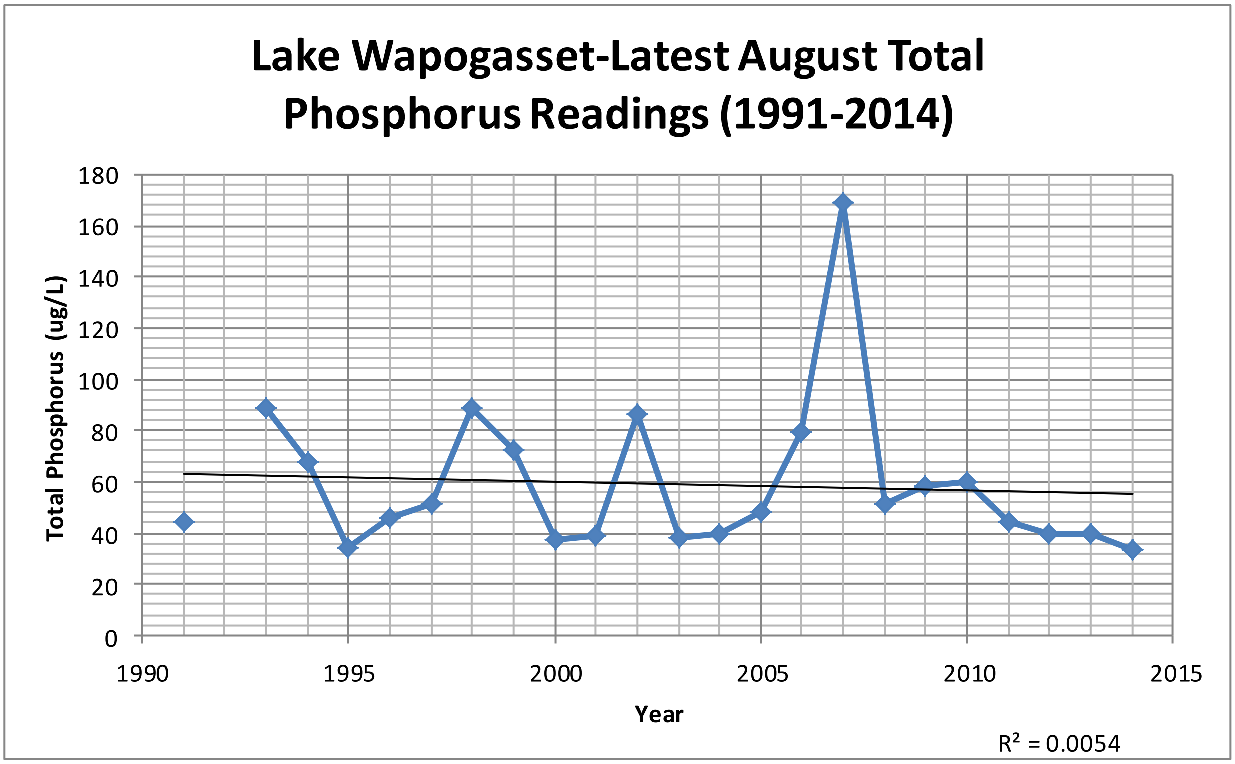

Figure 9: Lake Wapogasset phosphorus trends from 1991-2008.

In Lake Wapogasset, Figure 9 shows a high late August phosphorus value most years. Again this would support a large internal load. There appears to be a decrease trend over the last four years. The very low correlation shows that there is no real downward trend from 1991 to 2014.

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[5] This study was conducted in 2010, and the result are contained in the appendix of this document.
[6] Schieffer, S. *Determination of Potential Phosphorus Contribution From* *Potamogeton crispus*. 8/2010.

Figure 10 shows that the total phosphorus in late August varies widely in Bear Trap Lake. This would support a large internal load with mixing or lack of mixing. It also shows that there seems to be a trending decrease in August phosphorus the last 4 years or so. The correlation factor is very low, which indicates there is really no trend. As a result, the data doesn't show long-term decline in phosphorus.

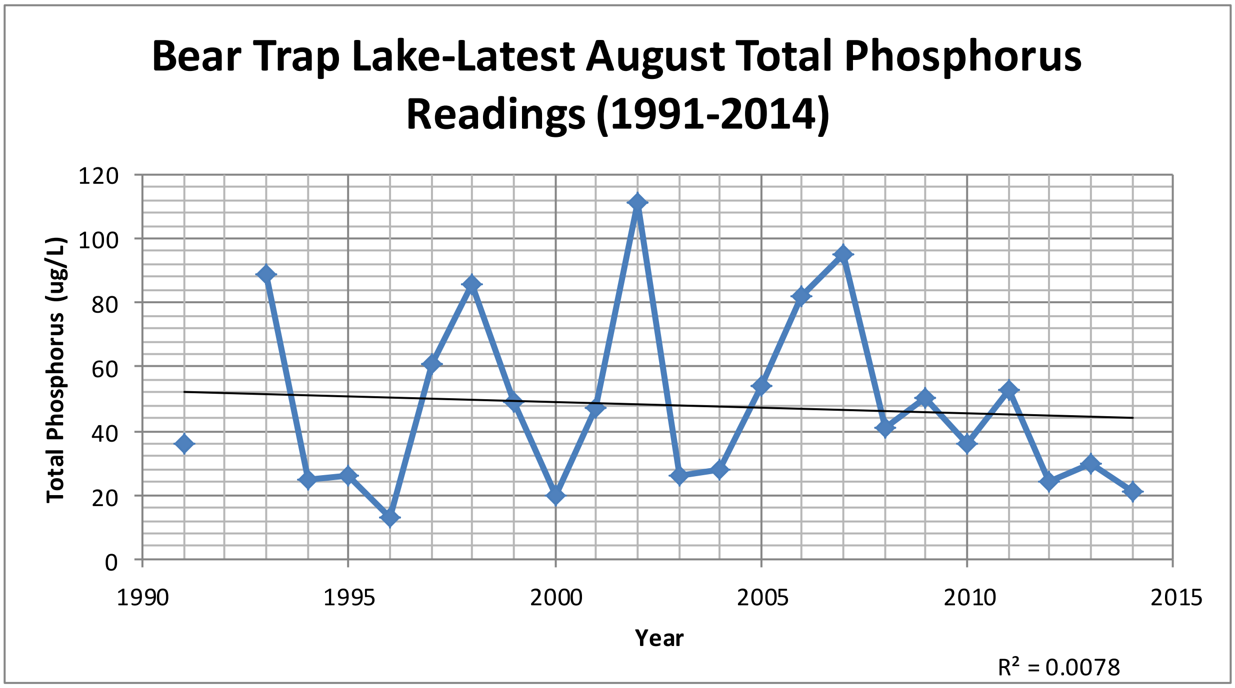
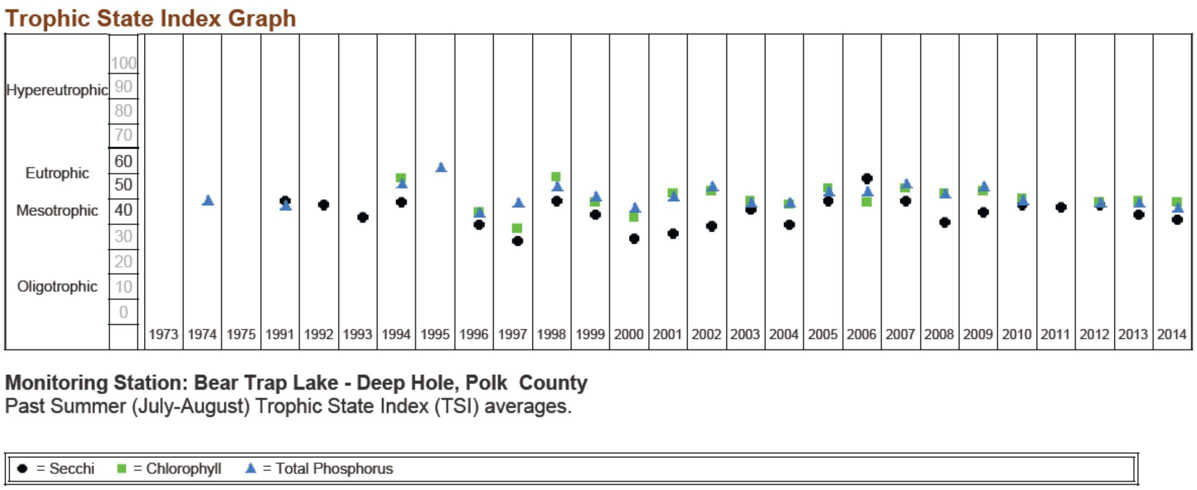


Figure 10: Bear Trap Lake latest August total phosphorus from 1991-2014.

Trophic status

The trophic status of a lake describes the productivity. Oligotrophic lakes have very little nutrients and as a result very little production. The algae growth and macrophyte growth in these lakes is very low (low production). Eutrophic lakes have very high productivity. These lakes have ample macrophyte growth and can have nuisance algae blooms. Mesotrophic lakes fall between oligotrophic and eutrophic lakes. Wisconsin uses the Carlson Trophic Status. The value obtained is used to classify the category as to the trophic status. More productive (eutrophic) lakes are represented by higher trophic values.



■=Chlorophyll a

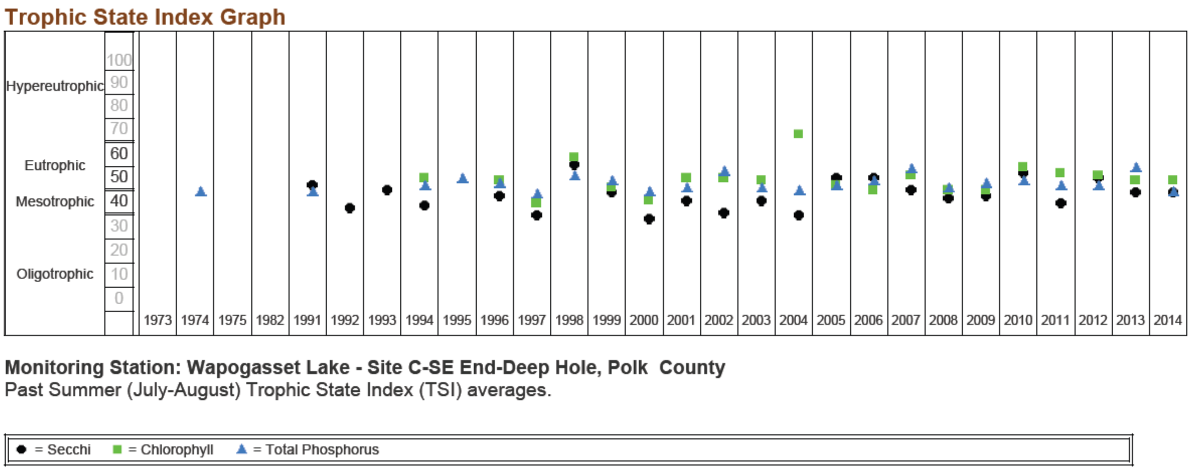
●= Secchi disc

▲=Total Phosphorus

Figure 11: Trophic status of Bear Trap Lake using chlorophyll a, Secchi disk, and total phosphorus[7].

Figure 11 shows the trophic status of Bear Trap Lake from 1974 to 2014, with a decade missing. Most values fall within the eutrophic and some in the mesotrophic range. The chlorophyll a and the total phosphorus are usually very similar, but the Secchi disk mean is often times lower (the water clarity indicates less productivity). This is somewhat unusual as more chlorophyll a indicates more algae, which should lower the Secchi depth. However, the type of algae (larger) could allow for more clarity but more chlorophyll at same time.

[7] From Wisconsin Self Help Monitoring Database. Wisconsin DNR.



■=Chlorophyll a

●= Secchi disc

▲=Total Phosphorus

Figure 12: Lake Wapogasset trophic status graph from 1974 (missing decade of 1980's) to 2009.

Most of Lake Wapogasset's trophic values fall within the eutrophic level, with some Secchi depth readings in the mesotrophic level. There doesn't appear to be any trends with rather consistent fluctuations up and down of all TSI values.

The data over many years supports the fact that Bear Trap Lake and Lake Wapogasset are both eutrophic lakes. They have water clarity issues most years with severe algae blooms occurring in late July to late August. It is evident that excess nutrients are an issue. As a result, plant management schemes in these lakes should consider this fact. One approach would be to preserve as much plant growth (native) as possible to help reduce excess nutrients. In addition, management of the non-native plant curly leaf pondweed could have nutrient reduction ramifications.

Historical Nutrient Management

In October 1999, aluminum sulfate (alum) was applied to Bear Trap Lake and Lake Wapogasset in order to reduce the internal loading of both lakes. The dosages applied were 16 g per square meter was applied between 5 and 15 feet, while 40 g per square meter in depths greater than 15 feet. This resulted in a total alum application of 744,000 gallons. The lake water clarity improved in 2000, but declined immensely in 2001.

The lack of alum success was attributed to a couple of potential causes. First it was determined that the dosage in the deeper areas of the lake was not high enough. It was also speculated that the sediment is too unstable and the phosphorus is very mobile.[8]

[8]This description is from Barr Engineering. *Investigation of Alum in Lake Wapogasset and Bear Trap Lake.* December 2004.

Plant Community

Aquatic macrophyte surveys were conducted on both Bear Trap Lake and Lake Wapogasset in the summer of 2014. Both surveys were using the point intercept method with the sample grid generated by the Wisconsin DNR. A separate point intercept survey was done in June to evaluate the distribution of *Potamogeton crispus*-curly-leaf pondweed. The data and analysis are presented and reviewed in this section.

Bear Trap Lake

The sample grid created by the Wisconsin DNR was comprised of 396 sample points. The maps below (Figure 13) show the sample grid and the locations plants were actually sampled. The green, yellow and red dots are sample points with plants while the white dots are sample points where plants were not present. The statistics representing the amount of plants coverage based on these locations is contained in Table 9.

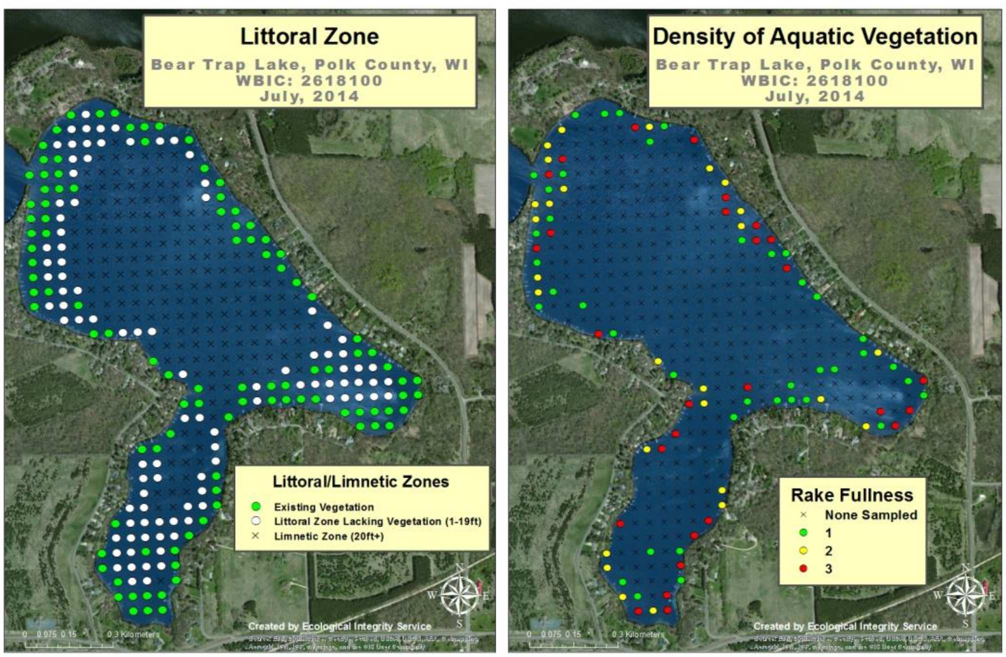


Figure 13: Maps of littoral zone and density where plants were sampled-Bear Trap Lake.

The littoral zone is the area of the lake that is shallow enough to accommodate plant growth. For Bear Trap Lake, this area includes 207 of the 396 total sample points (66.9%). Plants were found growing at 102 of these points, which is 49.3% of the littoral zone. As this value demonstrates, plant coverage is Bear Trap Lake is not very extensive. The littoral zone is very narrow, with the exception of Bear Trap Lake's two large bays and the narrows near Lake Wapogasset. This is due to the contour of the lake, since a large percentage of Bear Trap Lake is too deep to support plant growth.

SUMMARY STATISTICS:	
Total number of sites visited	212
Total number of sites with vegetation	102
Total number of sites shallower than maximum depth of plants	195
Frequency of occurrence at sites shallower than maximum depth of plants	52.31
Simpson Diversity Index	0.88
Maximum depth of plants (ft)**	18.40
Average number of all species per site (shallower than max depth)	1.41
Average number of all species per site (veg. sites only)	2.70
Average number of native species per site (shallower than max depth)	1.20
Average number of native species per site (veg. sites only)	2.46
Species Richness	22
Species Richness (including visuals)	22

Table 9: Plant survey statistics Bear Trap Lake.

Table 10: Bear Trap Lake species richness

Species	% Veg. areas	% littoral	Rel. Freq	# sampled	Mean density
***Ceratophyllum demersum*, Coontail**	70.60	34.80	26.20	54	1.69
***Potamogeton crispus*,Curly-leaf pondweed**	40.20	19.80	14.90	40	2.35
***Potamogeton zosteriformis*, Flat-stem pondweed**	30.40	15.00	11.30	25	1.08
***Potamogeton richardsonii*, Clasping-leaf pondweed**	21.57	10.63	8.00	18	1.06
***Potamogeton pusillus*, Small pondweed**	14.61	11.50	5.70	13	1.31
***Vallisneria americana*, Wild celery**	12.75	6.28	4.70	13	1.08
***Heteranthera dubia*, Water star-grass**	8.82	4.35	3.30	8	1.13
***Chara sp.*, Muskgrasses**	6.86	3.38	2.50	7	1.29
***Myriophyllum sibiricum*, Northern water-milfoil**	9.80	4.83	3.60	7	1.14
***Najas flexilis*, Slender naiad**	8.82	4.35	3.30	7	1.00
***Nymphaea odorata*, White water lily**	5.88	2.90	2.20	6	1.17
***Potamogeton foliosus,* Leafy pondweed**	5.88	2.90	2.20	6	1.00
***Ranunculus aquatilis*, White water crowfoot**	8.82	4.35	3.30	5	1.00
***Lemna trisulca*, Forked duckweed**	4.90	2.42	1.80	4	1.00
***Stuckenia pectinata*, Sago pondweed**	8.82	4.35	3.30	4	1.00
***Potamogeton illinoensis*, Illinois pondweed**	2.94	1.45	1.10	3	1.00
***Potamogeton praelongus*, White-stem pondweed**	2.94	1.45	1.10	3	1.00
***Elodea canadensis*, Common waterweed**	0.98	0.48	0.40	1	1.00
***Lemna minor*, Small duckweed**	0.98	0.48	0.40	1	1.00
***Potamogeton amplifolius*, Large-leaf pondweed**	0.98	0.48	0.40	1	1.00
***Potamogeton friesii*, Fries' pondweed**	0.98	0.48	0.40	1	1.00
***Sagittaria rigida*, Sessile-fruited arrowhead**	0.98	0.48	0.40	1	1.00

Boat Survey
***Phragmites australis*-Common reed**
***Sparganium eurycarpum*-Common bur-reed**
***Typha augustifolia*-Narrow leaf cattail**
***Typha latifolia*-Broad leaf cattail**
***Myosotis scorpioides*-Aquatic for-get-me-not**

Table 11: Boat survey species list-Bear Trap Lake.

Bear Trap Lake has a fairly diverse plant community. There were 22 different species of macrophytes (20 plants and 2 algae species) sampled. The lake's Simpson's diversity index is 0.88 which is fairly high.

Table 10 lists the species sampled and the statistics associated with each, the number of sites at which the plant was sampled, the frequency of occurrence, and the relative frequency. Plants that were merely viewed and not sampled do not have statistical values associated with them.

The most dominant plant was *Ceratophyllum demersum*-Coontail. Coontail is effective at absorbing nutrients from the water column, and its dominance can indicate high nutrients, especially if it reaches nuisance levels. There are a number of areas that coontail had a density rating of three, which is supported by the high nutrient content of Bear Trap Lake.

Potamogeton crispus-curly leaf pondweed was the second most dominant plant sampled. With a relative frequency of 19.8%, curly leaf pondweed is widespread and dense in some locations but is only growing the lake until late June and then it dies.

Curly-leaf pondweed was followed in relative frequency by *Potamogeton zosteriformis* (flatstem pondweed) and *Vallisneria americana* (wild celery). Figures 14-16 map the distribution of the three most common plants sampled in Bear Trap Lake and their density. All of these dominant plants, except curly leaf pondweed (invasive species) are desirable plants.

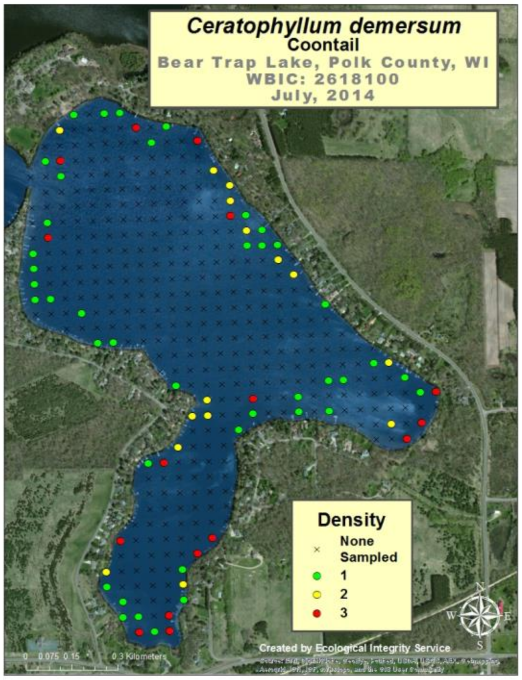


Figure 14: 2014*Ceratophyllum demersum*-coontail distribution, 2014.

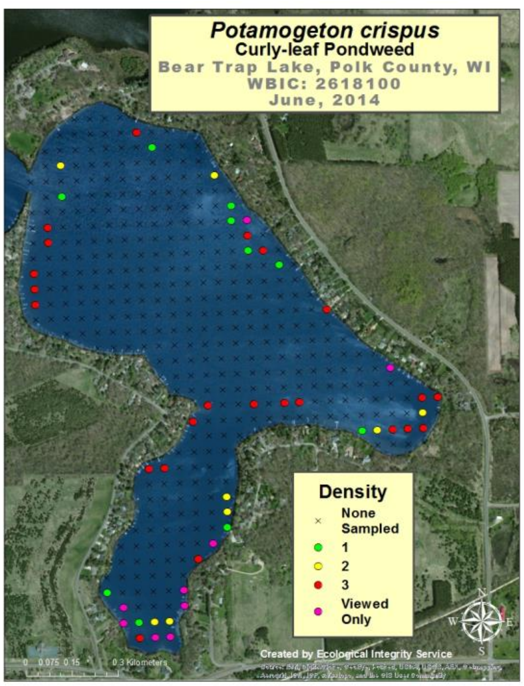


Figure 15*:* *Potamogeton crispus*-curly leaf pondweed distribution, June

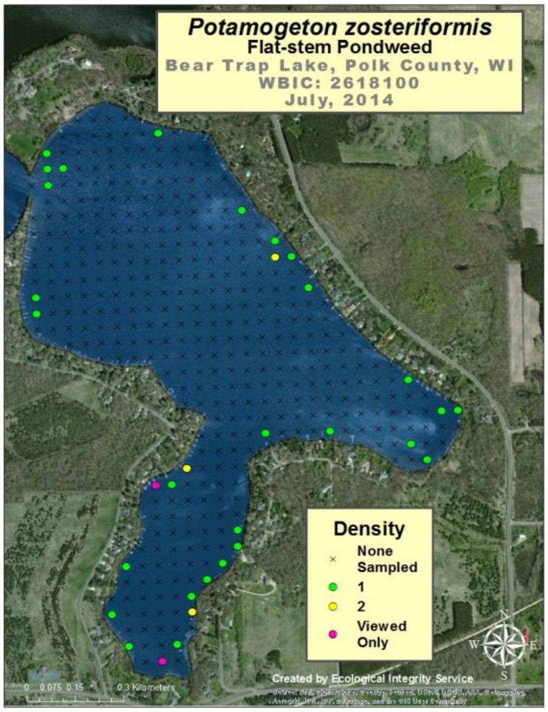


Figure 16: *Potamogeton zosteriformis*-flat-stem pondweed distribution, 2014.

Figure 17 shows the number of species per sampling point. The points with the highest plant diversity appear to be evenly dispersed around the lake. There are no visible habitat quality issues that could lead to a lack of diversity in certain areas of the lake. Most of the high diversity areas are most likely related to the substrate type.

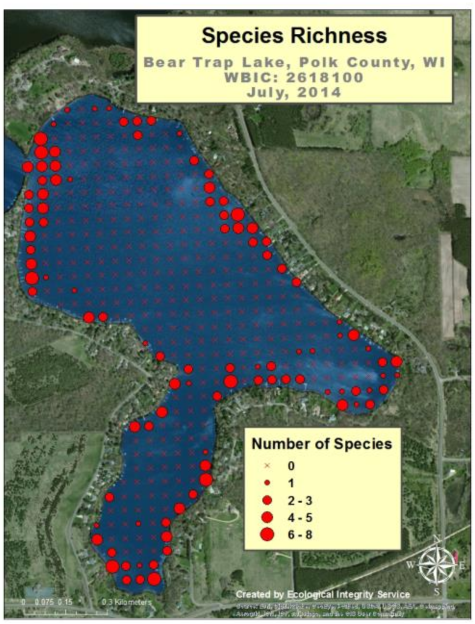


Figure 17: Number of species per sample point. Green dots show no plants while the red dot of larger size indicates more species.

The Floristic Quality Index (FQI) is a measure of the plant community response to development and human influence on the lake. It takes into account the species of aquatic plants present, and their tolerance for changing water quality and habitat characteristics. A plant's tolerance is expressed as a coefficient of conservatism (C). Native plants in Wisconsin are assigned a conservatism value between 0 and 10. A plant with a high conservatism value has more specialized habitat requirements and is less tolerant of disturbance and/or water quality changes. Those with lower values are more able to adapt to disturbed or changing conditions and can be found in a wider range of habitats.

The FQI is calculated using the number of species present and these plants' species conservatism values. A higher FQI generally indicates a heathier aquatic plant community.

There were 21 species of plants sampled that could be used in the floristic quality index calculation. These species ranged from a low conservatism value of "3" (common waterweed and sago pondweed) to a high conservatism value of "8" (Fries' pondweed, whitestem pondweed, crowfoot and sessile fruited arrowhead). The number of species (N), the average conservatism(C), and the FQI were all higher than the median for the eco-region (see Figure 16). Table 12 lists the species and their conservatism values.

Table 12: Floristic Quality Index for Bear Trap Lake.

Species	Common Name	C
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrasses	7
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton foliosus	Leafy pondweed	6
Potamogeton friesii	Fries' pondweed	8
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton zosteriformis	Flat-stem pondweed	6

Species	Common Name	C
Ranunculus aquatilis	White water crowfoot	8
Sagittaria rigida	Sessile-fruited arrowhead	8
Stuckenia pectinata	Sago pondweed	3
Vallisneria americana	Wild celery	6

FQI Value	Bear Trap Lake	Median Ecoregion
Number FQI species	21	14
mean Conservatism	5.95	5.6
FQI	27.28	20.9

Table 13: Comparison of Bear Trap FQI to ecoregion median.

Lake Wapogasset

The sample grid created by the Wisconsin DNR was comprised of 750 sample points. The maps below (Figure 18) show the sample grid and the locations at which plants were actually sampled. The statistics representing the plants coverage based in these locations is contained in Table 12.

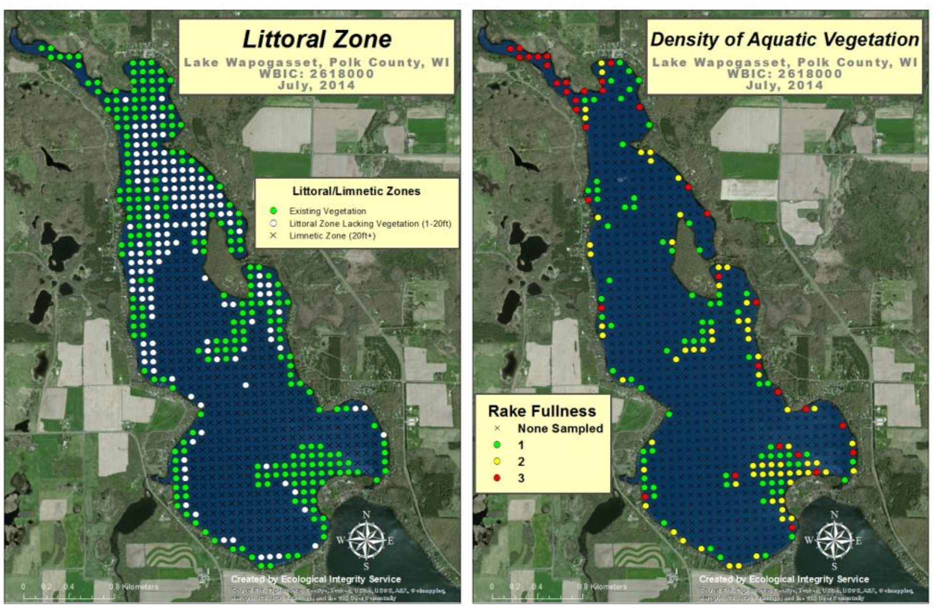


Figure 18: Sample points and points with plants (and density) in Lake Wapogasset.

SUMMARY STATS:	
Total number of sites visited	466
Total number of sites with vegetation	235
Total number of sites shallower than maximum depth of plants	393
Frequency of occurrence at sites shallower than maximum depth of plants	59.80
Simpson Diversity Index	0.89
Maximum depth of plants (ft)	20.10
Average number of all species per site (shallower than max depth)	1.42
Average number of all species per site (veg. sites only)	2.40
Average number of native species per site (shallower than max depth)	1.03
Average number of native species per site (veg. sites only)	2.54
Species Richness	27
Species Richness (including visuals)	28

Table 14: Lake Wapogasset PI survey statistics-2014

The Lake Wapogasset littoral zone includes 406 of the lake's 750 total points (53.6%). Plants were found growing at 235 of these points, which is 57.9% of the littoral zone. As these values demonstrate, plant coverage in Lake Wapogasset is high enough to provide a wide array of habitat throughout the lake.

Lake Wapogasset has a diverse plant community. There were 27 different species of macrophytes (25 plants and 2 algae species) sampled. By including the plants that were viewed but not sampled, the species richness increases to 28 species. There were nine species of plant observed in a shoreline/boat survey. The lake's Simpson's diversity index of 0.89 also indicates good diversity.

Table 15 lists the species sampled and the statistics associated with each, the number of sites the plant was sampled, the frequency of occurrence, and the relative frequency. Plants that were merely viewed and not sampled do not have statistical values associated with them.

The most dominant plant is *Potamogeton crispus*-curly leaf pondweed, until it dies in June. With a relative frequency of 27.94%, curly-leaf dominates the lake in spring and early summer. The second most common plant is *Vallisneria americana*-wild celery. *Ceratophyllum demersum* –coontail is the third most common plant and is effective at absorbing nutrients from the water column, and its dominance can indicate high nutrients, especially if it reaches nuisance levels. There are a number of locations that coontail had a density rating of 3, which can indicate high nutrient content. All of the species that dominate the lake are desirable plants (with the exception of curly leaf pondweed in spring). Figures 19-21 map the distributions of the three most common plants sampled and the density.

Species	% veg areas	% littoral	Rel. freq	# sampled	Mean density	Viewed
Potamogeton crispus,**Curly-leaf pondweed**	66.81	38.67	27.94	157	2.29	12
Vallisneria americana, **Wild celery**	17.87	10.34	7.47	42	1.05	1
Ceratophyllum demersum, **Coontail**	17.45	10.10	7.30	41	1.68	2
Potamogeton zosteriformis, **Flat-stem pondweed**	15.74	9.11	6.58	37	1.14	
Potamogeton pusillus, **Small pondweed**	14.89	8.62	6.23	35	1.37	
Najas flexilis, **Slender naiad**	14.04	8.13	5.87	33	1.03	
Potamogeton richardsonii, **Clasping-leaf pondweed**	12.34	7.14	5.16	29	1.10	7
Chara sp., **Muskgrasses**	11.06	6.40	4.63	26	1.23	
Potamogeton foliosus, **Leafy pondweed**	9.36	5.42	3.91	22	1.36	
Myriophyllum sibiricum, **Northern water-milfoil**	7.66	4.43	3.20	18	1.22	6
Lemna minor, **Small duckweed**	7.23	4.19	3.02	17	1.00	1
Potamogeton friesii, **Fries' pondweed**	6.81	3.94	2.85	16	1.38	1
Nymphaea odorata, **White water lily**	5.11	2.96	2.14	12	1.00	5
Zizania palustris, **Northern wild rice**	5.11	2.96	2.14	12	2.50	
Waternet	4.68	2.71	1.96	11	1.18	
Nitella sp., **Nitella**	4.26	2.46	1.78	10	1.10	1
Potamogeton strictifolius, **Stiff pondweed**	3.83	2.22	1.60	9	1.33	
Stuckenia pectinata, **Sago pondweed**	3.83	2.22	1.60	9	1.00	3
Heteranthera dubia, **Water star-grass**	2.98	1.72	1.25	7	1.00	1
Potamogeton amplifolius, **Large-leaf pondweed**	1.70	0.99	0.71	4	1.00	
Elodea canadensis, **Common waterweed**	1.28	0.74	0.53	3	1.00	
Potamogeton illinoensis, **Illinois pondweed**	1.28	0.74	0.53	3	1.00	3
Potamogeton praelongus, **White-stem pondweed**	1.28	0.74	0.53	3	1.00	
Wolffia columbiana, **Common watermeal**	1.28	0.74	0.53	3	1.00	
Lemna trisulca, **Forked duckweed**	0.85	0.49	0.36	2	1.00	
Sagittaria rigida, **Sessile-fruited arrowhead**	0.43	0.25	0.18	1	1.00	
Nuphar variegata, **Spatterdock**	0.42	0.25	0.18	1	1.00	
Utricularia vulgaris, **Common bladderwort**						2
Filamentous algae	27.23	15.76		64	1.23	

Table 15: Species list with statistics-Lake Wapogasset.

Boat survey
Sagittaria latifolia
Blue flag iris
Swamp loosestrife
Carex camosa
Bulb bearing rush
Eleocharis acicularis
Typha augustifolia
Aquatic dock
Typha latifolia

Table 16: Boat survey species list-Lake Wapogasset

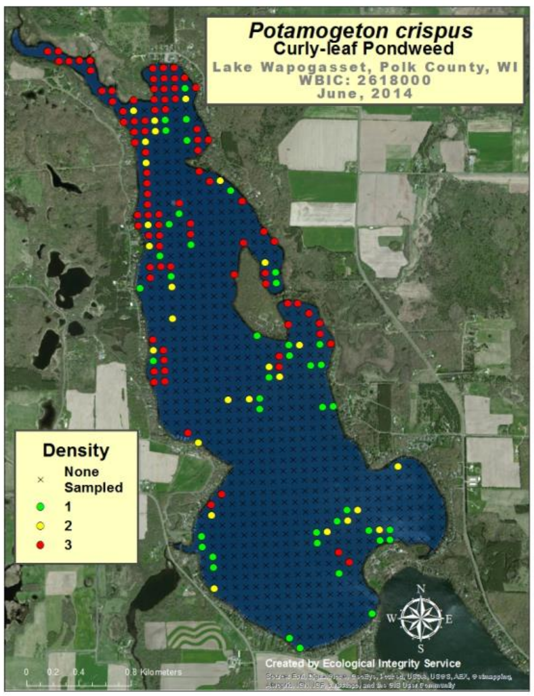


Figure 19: *Potamogeton crispus*-curly-leaf pondweed distribution, June 2014

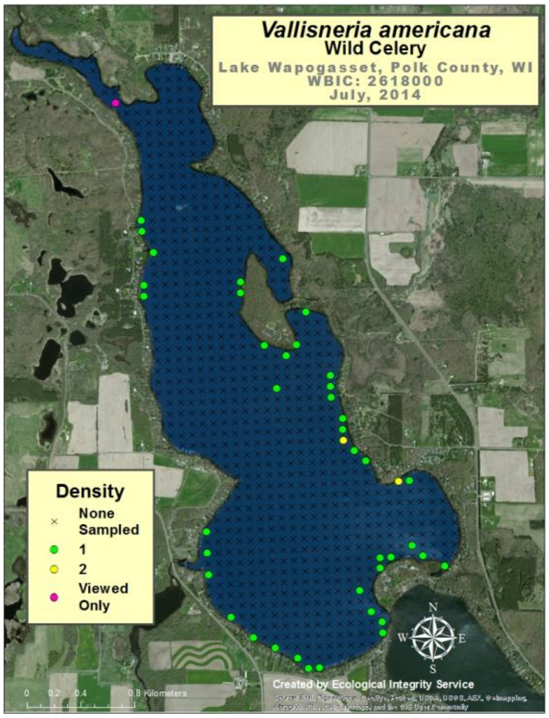


Figure 20: ***Vallisneria americana*-wild celery distribution, 2014.**

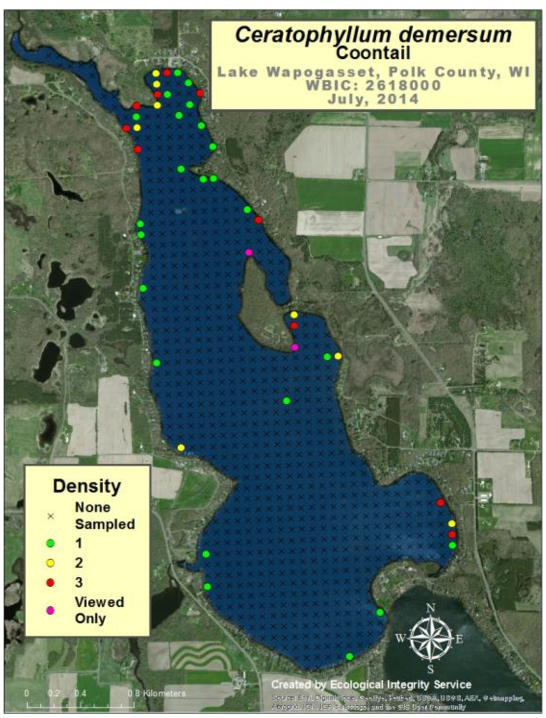


Figure 21: ***Ceratophyllum demersum*-coontail distribution, 2014**.

As Figure 22 indicates, there are many points where several macrophyte species were sampled. This high diversity seems relatively dispersed around the lake. Therefore, there is no strong indication of adverse habitat changes leading to more limited diversity in certain areas of the lake.

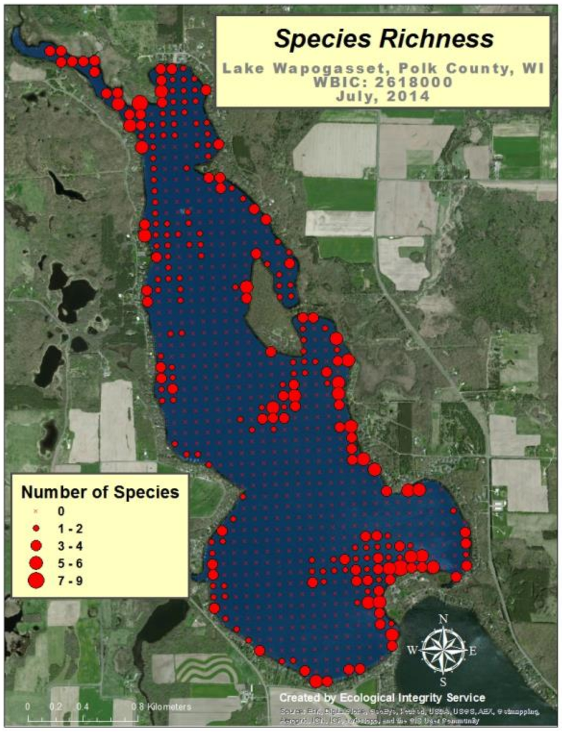


Figure 22: Lake Wapogasset number of natives per sample point

Floristic quality

There were 25 species of plants sampled that could be used in the floristic quality index (FQI) calculation. These species ranged from a low conservatism value of 3 (coontail, sago pondweed and common waterweed) to a high conservatism value of 8 (Fries' pondweed, whitestem pondweed, sessile fruited arrowhead and northern wild rice). The number of species (N), the average conservatism (C), and the FQI value were higher than the median for the eco-region (see table 18). Table 17 lists the species used and their conservatism values.

FQI Species		Conservatism
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrasses	7
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton foliosus	Leafy pondweed	6
Potamogeton friesii	Fries' pondweed	8
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton strictifolius	Stiff pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Sagittaria rigida	Sessile-fruited arrowhead	8
Stuckenia pectinata	Sago pondweed	3
Vallisneria americana	Wild celery	6
Wolffia columbiana	Common watermeal	5
Zizania palustris	Northern wild rice	8

Table 17: Floristic Quality Index List for Lake Wapogasset.

FQI Value	Lake Wapogasset	Median Ecoregion
Number FQI species	25	14
mean Conservatism	6.04	5.6
FQI	30.2	20.9

Table 18: Comparison of FQI Lake Wapogasset and Ecoregion lake median.

Wild rice was sampled at numerous locations in and near the mouth of the Balsam Branch. This coverage is significantly higher than observed in past years. The distribution is shown in figure 23 and pictures document what was observed.

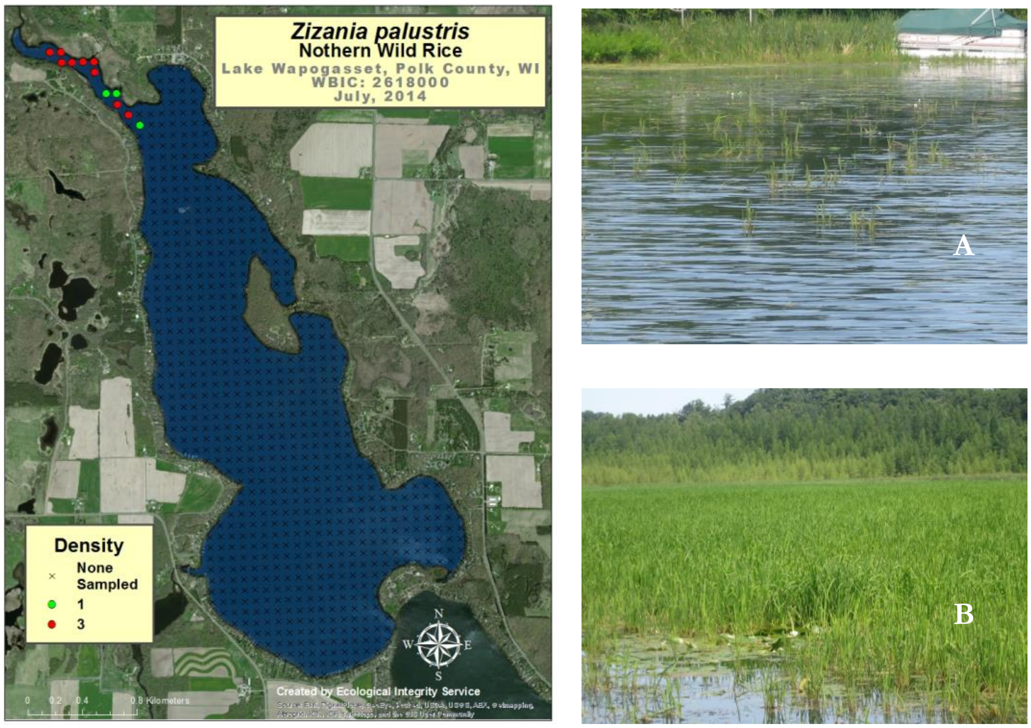


Figure 23: Wild rice distribution-2014 and pictures showing observed rice growth. Photo A is just out into Lake Wapogasset and photo B is up into the Balsam Branch mouth.

Exotic and invasive species

Curly-leaf pondweed (CLP) is an aquatic invasive species (AIS) that is common throughout Wisconsin. If the CLP grows very dense with high coverage in the lake, it can adversely affect the lake ecosystem. This plant grows during early spring into the early summer when most natives are dormant or just coming out of dormancy. This could result in competition between the native species and CLP. Later in the summer (July) CLP undergoes senescence. When this happens a large amount of phosphorus can be released, leading to a phosphorus load. On rare occasions, the decomposition could lead to lower oxygen levels the lake, but would have to involve very extensive biomass of CLP. Furthermore, CLP may crowd out native plants in early summer, causing later emergence of native plants in the summer.

One other non-native plant was viewed. This plant was *Myosotis scorpoides(*Aquatic forget-me-not). This plant does not appear to be invasive as only one single plant was viewed in a bay near the Bible Camp. Its location has been marked and is not well known for becoming a serious problem in Wisconsin lakes.

Narrow leaved cattail-*Typha augustifolia* was also observed. Narrow-leaved cattail is considered a potentially invasive species in Wisconsin and is restricted. There is some evidence from research that suggests it can compete extensively with the native broad-leaved cattail (*Typha latifolia*).

Comparison of 2014 survey to 2007 survey

Comparing subsequent aquatic macrophyte surveys is important, especially when herbicide treatment and other management methods have been implemented. By comparing the plant communities over time, any major changes may reflect adverse impact or positive impact from the management of the plant community.

Bear Trap Lake Species	2007 Freq.	2014 Freq.	P value	Significant change	Change
Ceratophyllum demersum, Coontail	0.87	0.72	0.52	**n.s**	**-**
Potamogeton zosteriformis, Flat-stem pondweed	0.54	0.30	0.014	*	**-**
Potamogeton richardsonii, Clasping-leaf pondweed	0.28	0.22	0.60	**n.s.**	**-**
Potamogeton pusillus, Small pondweed	0.26	0.15	0.12	**n.s.**	**-**
Vallisneria americana, Wild celery	0.51	0.13	0.00000	***	**-**
Heteranthera dubia, Water star-grass	0.23	0.07	0.01	*	**-**
Chara sp., Muskgrasses	0.14	0.06	0.21	**n.s.**	**-**
Myriophyllum sibiricum, Northern water-milfoil	0.04	0.06	0.24	**n.s.**	**+**
Najas flexilis, Slender naiad	0.26	0.09	0.005	**	**-**
Nymphaea odorata, White water lily	0.02	0.06	0.098	**n.s.**	**+**
Potamogeton foliosus, Leafy pondweed	0.03	0.05	0.21	**n.s.**	**+**
Ranunculus aquatilis, White water crowfoot	0.31	0.09	0.0005	***	**-**
Lemna trisulca, Forked duckweed	0.03	0.05	0.35	**n.s.**	**+**
Stuckenia pectinata, Sago pondweed	0.09	0.09	n/a	**n.s.**	**n/c**
Potamogeton illinoensis, Illinois pondweed	0.25	0.03	0.00005	***	**-**
Potamogeton praelongus, White-stem pondweed	0.01	0.03	0.25	**n.s.**	**+**
Elodea canadensis, Common waterweed	0.21	0.01	0.00003	***	**-**
Lemna minor, Small duckweed	0.02	0.01	0.65	**n.s.**	**-**
Potamogeton amplifolius, Large-leaf pondweed	0.01	0.01	n/a	**n.s.**	**n/c**
Potamogeton friesii, Fries' pondweed	0.09	0.01	0.02	*	**-**
Sagittaria rigida, Sessile-fruited arrowhead	0.00	0.01	0.28	**n.s.**	**+**
Native species significant reduction in yellow					

Table 19: Bear Trap Lake comparison of 2007 and 2014 PI macrophyte surveys. This table shows the results of a chi-square analysis to evaluate any significant changes in plant frequency.

Comparing the Bear Trap Lake PI survey from 2007, to the Bear Trap Lake PI survey from 2014, shows there are major differences, nearly all of which are declines in the plant community. A chi-square analysis was completed to compare the two surveys and this analysis reflects a significant reduction in eight native plant species (*Potamogeton zosteriformis, Vallisneria Americana, Heteranther dubia, Najas flexilis, Ranunuculus aquatilis, Potamogeton illinoensis, Elodea canadensis, and Potamogeton freisii* (very low number so not a concern)) . This could be a concern due to the importance of maintaining a robust native plant community in Bear Trap Lake.

Bear Trap PI Surveys	2007	2014
Number points with plants	118	102
% of littoral zone with plants	63.8%*	52.3%
Simpson's diversity index	0.91	0.88
Species Richness	23	22
Maximum depth of plants	17.6	18.4
*More shallow depth of plants reduces Number of points in littoral zone causing some of this big difference from 2014.		

Table 20: Bear Trap Lake 2007 to 2014 survey summary comparison.

The cause of this decline is not known. It is unlikely that it is due to previous herbicide treatments for curly-leaf pondweed, because that treatment occurred in only 6 acres. The decline in the plants listed is lake-wide. It is possible that the very late spring and timing difference of the two surveys could account for some of this. Many of these plants rely on seeds or rhizomes to germinate for new growth. With a very late start and an earlier survey time in 2014 (which was the case), the plants were maybe not picked up on the rake due their lack of growth. This coupled with the thick curly leaf pondweed growth in many areas, could account for some differences.

In the case of *Ceratopyllum demersum, Potamogeton zosteriformis, and Vallisneria americana*, the change is so extensive it causes consideration other possible causes. One known cause of plant reduction in lakes is rusty crayfish. These crayfish are exotic and can reach large numbers in lakes. In some lakes, this infestation can lead to considerable reduction in aquatic plants (Lodge and Lorman 1987). It is not known if rusty crayfish are present in Bear Trap Lake and so there is no evidence this is the cause, but should be considered and evaluated. Common carp can also reduce plants and are present in Bear Trap Lake.

Bear Trap FQI	**2007***	**2014**
Number of species	22	21
Mean conservatism	6.04	5.95
FQI	28.33	27.3

Table 21: Bear Trap Lake FQI comparison, 2007-2014.

Wapogasset PI Surveys	2007	2014
Number points with plants	265	235
% of littoral zone with plants	65.9%	57.9%
Simpson's diversity index	0.91	0.89
Species Richness	30	27
Maximum depth of plants	21.2	21.0

Table 22: Lake Wapogasset 2007-2014 survey summary comparison.

The results of the chi-square analysis in Lake Wapogasset are similar. There was a significant reduction in the frequency of nine native plants species (*Vallisneria americana, Ceratophyllum demersum, Potamogeton zosteriformis, Potamogeton pusillus, Najas flexilis, Potamogeton freisii, Elodea canadensis, Lemna trisulca, and Ranunculus aquatilis)*. *Vallisneria americana, Ceratophyllum demersum, Potamogeton zosteriformis and Potamogeton pusillus* were substantially lower in frequency in 2014 as compared to 2007.

Again, the cause of this is not known. It is unlikely it is from the herbicide treatments in previous years as only 8 acres were treated in one location. It could be due to seasonal differences, but the reduction is so significant with some species, it is cause for other reasons to be considered, such as rusty crayfish. Common carp are present in Lake Wapogasset and can reduce aquatic plants.

Lake Wapogasset FQI	**2007***	**2014**
Number of species	27	25
Mean conservatism	6.0	6.04
FQI	31.2	30.2
*Adjusted as calculation protocol changed since 2007		

Table 23: Lake Wapogasset FQI comparison, 2007-2014.

Lake Wapogasset Species	2007 Freq.	2014 Freq.	Chi-square P value	2007-2014 Change	Significant change
Vallisneria americana, Wild celery	0.36	0.18	0.00001	-	***
Ceratophyllum demersum, Coontail	0.63	0.17	0.00000	-	***
Potamogeton zosteriformis, Flat-stem pondweed	0.38	0.16	0.00000	-	***
Potamogeton pusillus, Small pondweed	0.34	0.15	0.00000	-	***
Najas flexilis, Slender naiad	0.25	0.14	0.00320	-	**
Potamogeton richardsonii, Clasping-leaf pondweed	0.17	0.12	0.14470	-	n.s.
Chara sp., Muskgrasses	0.11	0.11	0.85795	n/c	n.s.
Potamogeton foliosus, Leafy pondweed	0.02	0.09	0.00057	+	***
Myriophyllum sibiricum, Northern water-milfoil	0.06	0.08	0.36885	+	n.s.
Lemna minor, Small duckweed	0.03	0.07	0.05372	+	n.s.
Potamogeton friesii, Fries' pondweed	0.15	0.07	0.00235	-	**
Nymphaea odorata, White water lily	0.01	0.05	0.00324	+	**
Zizania palustris, Northern wild rice	0.00	0.05	0.00020	+	***
Waternet	0.03	0.05	0.22181	+	n.s.
Nitella sp., Nitella	0.004	0.04	0.00317	+	**
Potamogeton strictifolius, Stiff pondweed	0.00	0.04	0.00131	+	**
Stuckenia pectinata, Sago pondweed	0.04	0.04	0.97383	n/c	n.s.
Heteranthera dubia, Water star-grass	0.02	0.03	0.61628	+	n.s.
Potamogeton amplifolius, Large-leaf pondweed	0.01	0.02	0.33152	+	n.s.
Elodea canadensis, Common waterweed	0.14	0.01	0.00000	-	***
Potamogeton illinoensis, Illinois pondweed	0.02	0.01	0.58732	-	n.s.
Potamogeton praelongus, White-stem pondweed	0.02	0.01	0.58732	-	n.s.
Wolffia columbiana, Common watermeal	0.02	0.01	0.58732	-	n.s.
Lemna trisulca, Forked duckweed	0.05	0.01	0.01286	-	*
Sagittaria rigida, Sessile-fruited arrowhead	0.00	0.004	0.28779	+	n.s.
Nuphar variegata, Spatterdock	0.004	0.004	0.93212	-	n.s.
Ranunculus aquatilis, Stiff-water crowfoot	0.12	0.00	0.00000	-	***
Brasneria schreberi, Watershield	0.004	0.00	0.34587	-	n.s.
Eleocharis palustris, Creeping spikerush	0.004	0.00	0.34587	-	n.s.
Potamogeton alpinus, Alpine pondweed	0.004	0.00	0.34587	-	n.s.
Spirodela polyrhiza, Large duckweed	0.03	0.03	0.81955	n/c	n.s.
Sparganium eurycarpum. Common bur-reed	0.004	0.00	0.34587	-	n.s.
Native species significant increase in green					
Native species significant decrease in gray					

Table 24: Lake Wapogasset comparison of 2007 and 2014 PI macrophyte surveys. This table shows the results of a chi-square analysis to evaluate any significant changes in plant frequency.

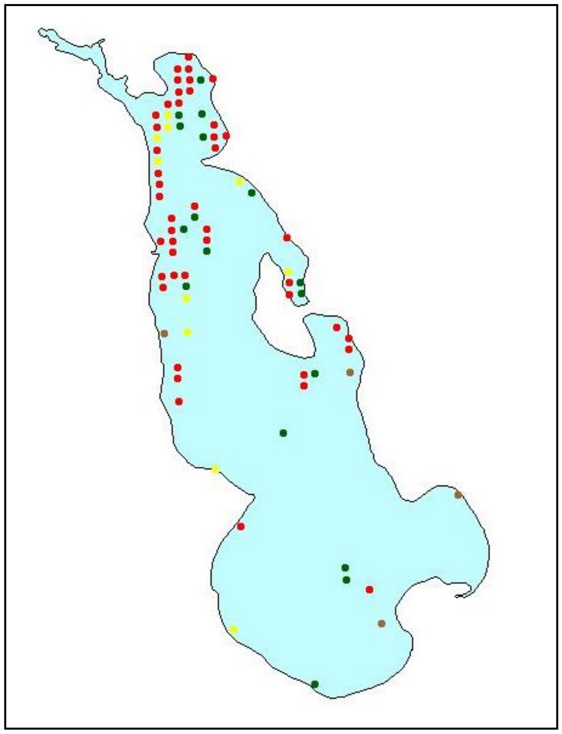


Figure24: Points on Lake Wapogasset with CLP in June and no plants in July-2014.

Discussion of 2014 PI Survey

Both Bear Trap Lake has a fairly diverse plant community and Lake Wapogasset has a slightly more diverse aquatic macrophyte community. Lake Wapogasset has higher species richness, but this would be expected as it has more plant habitat than Bear Trap Lake. Both lakes have a fairly high Simpson's diversity index of 0.88 and 0.89. Furthermore, all floristic quality index values are above the median for the eco-region these lakes are contained within. This demonstrates the habitat for plants has not degraded too drastically over the time of human development.

In comparing the 2014 survey to a previous survey in 2007, there are some significant differences. The plant coverage is both lakes is much lower in 2014, with a statistically significant reduction in numerous species of native plants in both lakes. The reason for this reduction is not known. Possible reasons are seasonal variation and timing of the survey. The growing season started later in the spring with many aquatic plants significantly late in growth. Also, the survey was conducted a couple of weeks earlier than in 2007. The plant community needs to be evaluated in another 5 years to determine if this is a trend.

These lakes have a history of high nutrients. It is very important that a robust native plant community be maintained to help enhance water quality. During algae blooms, the light penetration is reduced and can reduce plant growth. It is important to try and reduce nutrients in both of these lakes to help enhance the plant growth. Plants can help facilitate this as plant growth can absorb excess nutrients that would otherwise be available for nuisance algae growth.

Curly leaf pondweed was the only invasive species sampled. It covers much of both lakes and its management may be warranted. CLP can contribute large phosphorus loads if it grows too extensively and then decomposes rapidly after senescence. These lakes should also be monitored for Eurasian watermilfoil (EWM). The use of the lakes is extensive and the probability of introduction of EWM is high. With the proximity to the Twin Cities area, which has a large number of lakes with EWM, and the increased occurrence in Wisconsin Lakes, both lakes are susceptible from extensive boat launching.

Invasive Species of Concern

Curly leaf pondweed

The seriousness of curly leaf pondweed infestation is somewhat unclear. The lack of clarity on the issue rests on the likelihood of further spread of curly leaf pondweed throughout Lake Wapogasset and Bear Trap Lake, and the resultant impacts on native plants and fish and wildlife habitat. A related question is whether treatment in the form of herbicide application is likely to be effective for long-term, whole lake control and if the result will cause more harm than good to native plant populations. Clear answers regarding these potential impacts are not available. However, it is unlikely that herbicide application will result in complete elimination of curly leaf pondweed. It is possible that management can reduce the spreading of the non-native plant, especially in the main portion of the lake. In the management area (east bay), the growth of curly leaf pondweed is so extensive that treatment would probably have minimal impact and would have adverse effects on the native plant community.

Curly leaf pondweed is specifically designated as an invasive aquatic plant (along with Eurasian water milfoil and purple loosestrife) to be the focus of a statewide program to control invasive species in Wisconsin. Invasive species are defined as a "non-indigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health (23.22(c)."

The Wisconsin Comprehensive Management Plan for Aquatic Invasive Species describes curly leaf pondweed impacts as follows:

It is widely distributed throughout Wisconsin lakes, but the actual number of waters infested is not known. Curly-leaf pondweed is native to northern Europe and Asia where it is especially well adapted to surviving in low temperature waters. It can actively grow under the ice while most plants are dormant, giving it a competitive advantage over native aquatic plant species. By June, curly-leaf pondweed can form dense surface mats that interfere with aquatic recreation. By mid-summer, when other aquatic plants are just reaching their peak growth for the year, it dies off. Curly-leaf pondweed provides habitat for fish and invertebrates in the winter and spring when most other plants are reduced to rhizomes and buds, but the mid-summer decay creates a sudden loss of habitat. The die-off of curly-leaf pondweed also releases a surge of nutrients into the water column that can trigger algal blooms and create turbid water conditions. In lakes where curly-leaf pondweed is the dominant plant, the summer die-off can lead to habitat disturbance and degraded water quality. In other waters where there is a diversity of aquatic plants, the breakdown of curly-leaf may not cause a problem.[1]

The state of Minnesota DNR web site explains that curly leaf pondweed often causes problems due to excessive growth. At the same time, the plant provides some cover for fish and some waterfowl species feed on the seeds and winter buds.

The following description is taken from a Great Lakes Indian Fish and Wildlife Commission handout.
Curly leaf pondweed (*Potamogeton crispus*)

<u>Identification:</u>
Curly leaf pondweed is an invasive aquatic species found in a variety of aquatic habitats, including permanently flooded ditches and pools, rivers, ponds, inland lakes, and even the Great Lakes. Curly leaf pondweed prefers alkaline or high nutrient waters 1 to 3 meters deep. Its leaves are strap-shaped with rounded tips and undulating and finely toothed edges. Leaves are not modified for floating, and are generally alternate on the stem. Stems are somewhat flattened and grow to as long as 2 meters. The stems are dark reddish-green to reddish-brown, with the mid-vein typically tinged with red. Curly

[1] Wisconsin's Comprehensive Management Plan To Prevent Introductions and Control Existing Populatins of Aquatic Invasive Species. Prepared by: Wisconsin Department of Natural Resource. September 2003.

leaf pondweed is native to Eurasia, Africa and Australia and is now spread throughout most of the United States and southern Canada.

Characteristics:

New plants typically establish in the fall from freed turions (branch tips). The winter form is short, with narrow, flat, relatively limp, bluish-green leaves. This winter form can grow beneath the ice and is highly shade-tolerant. Rapid growth begins with warming water temperatures in early spring – well ahead of native aquatic plants.

Reproduction and dispersal:

Curly leaf pondweed reproduces primarily vegetatively. Numerous turions are produced in the spring. These turions consist of modified, hardened, thorny leaf bases interspersed with a few to several dormant buds. The turions are typically 1.0 – 1.7 cm long and 0.8 to 1.4 cm in diameter. Turions separate from the plant by midsummer, and may be carried in the water column supported by several leaves. Humans and waterfowl may also disperse turions. Stimulated by cooler water temperatures, they germinate in the fall, over-wintering as a small plant. The next summer they mature, producing reproductive tips of their own. Curly leaf pondweed rarely produces flowers.

Ecological impacts:

Rapid early season growth may form large, dense patches at the surface. This canopy overtops most native aquatic plants, shading them and significantly slowing their growth. The canopy lowers water temperature and restricts absorption of atmospheric oxygen into the water. The dense canopy formed often interferes with recreational activities such as swimming and boating.

In late spring, curly leaf pondweed dies back, releasing nutrients that may lead to algae blooms. Resulting high oxygen demand caused by decaying vegetation can adversely affect fish populations. The foliage of curly leaf pondweed is relatively high in alkaloid compounds possibly making it unpalatable to insects and other herbivores.

Curly leaf pondweed control:

Small populations of curly leaf pondweed in otherwise un-infested water bodies should be attacked aggressively. Hand pulling, suction dredging, or spot treatments with contact herbicides are recommended. Cutting should be avoided because fragmentation of plants may encourage their re-establishment. In all cases, care should be taken to remove all roots and plant fragments, to keep them from re-establishing.

Aquatic Plant Management

Permitting requirements

The Wisconsin Department of Natural Resources regulates the removal of aquatic plants when chemicals are used and when plants are removed mechanically, or when plants are removed manually from an area greater than thirty feet in width along the shore. The requirements for chemical plant removal are described in Administrative Rule NR 107-Aquatic Plant Management. A permit is required for any aquatic chemical application in Wisconsin.

The requirements for manual and mechanical plant removal are described in NR 109-Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations. A permit is required for manual and mechanical removal except for when a riparian (waterfront) landowner manually removes or gives permission to someone to manually remove plants, (with the exception of wild rice) from his/her shoreline limited to a 30-foot corridor. A riparian landowner may also manually remove the invasive plants Eurasian watermilfoil, curly leaf pondweed, and purple loosestrife along his or her shoreline without a permit. Manual removal means the control of aquatic plants by hand or hand-held devices without the use or aid of external or auxiliary power.

The *Northern Region of the Wisconsin DNR* has established a management strategy for future plant management and can affect permitting for management. Their approach is as follows:[4]

1. After January 1, 2009, no individual permits for control of native aquatic plants will be issued. Treatment of native species may be allowed under the auspices of an approved lake management plan, and only if the plan clearly documents “impairment of navigation” and/or “nuisance conditions.” Until January 1, 2009, individual permits will be issued to previous permit holders, only with adequate documentation of “impairment of navigation” and/or “nuisance conditions.” No new individual permits will be issued during the interim.

2. Control of aquatic plants (if allowed) in documented sensitive areas will follow the conditions specified in the report. (Note: Lake Wapogasset and Bear Trap Lake has several documented sensitive areas)

3. Invasive species must be controlled under an approved lake management plan, with two exceptions:

    a. Newly discovered infestations: If found on a lake with an approved plan, the invasives can be controlled via an amendment to the approved plan. Without

[4] Aquatic Plant Management Strategy. Northern Region of Wisconsin DNR. 2007.

an approved plan, they can be controlled under the WDNR's Rapid Response protocol.

b. Individuals holding past permits for control of invasive aquatic plants and/or "mixed stands" of native and invasive species will be allowed to treat via individual Permit until January 1, 2009, if "impairment of navigation," and/or "nuisance conditions" is (are) adequately documented.

4. Control of invasive stands or "mixed stands" of invasive and native plants will follow current best management practices approved by the Department and contain an explanation of the strategy to be used. Established stands of invasive plants will generally use a control strategy based on spring treatment (water temperatures of less than 60 degrees F).

5. Manual removal (by definition) is allowed. However, wild rice may not be removed.

Management Options

Biological control[5]

Biological control is the purposeful introduction of parasites, predators, and/or pathogenic microorganisms to reduce or suppress populations of plant or animal pests. Biological control counteracts the problems that occur when a species is introduced into a new region of the world without a complex or assemblage of organisms that feed directly upon it, attack its seeds or progeny through predation or parasitism, or cause severe or debilitating diseases (i.e., pathogenic microorganisms). With the introduction of native pests to the target invasive organism, the exotic invasive species may be maintained at lower densities.

While this theory has worked in application for control of some non-native aquatic plants, results have been varied (Madsen, 2000). Beetles are commonly used to control purple loosestrife populations in Wisconsin with good success. Weevils are used as an experimental control for Eurasian watermilfoil once the plant is established. Tilapia and carp are used to control the growth of filamentous algae in ponds. Grass carp, and herbivorous fish are sometimes used to feed on pest plant populations. Grass carp introduction is not allowed in Wisconsin.

There are advantages and disadvantages to the use of biological control as part of an overall aquatic plant management program. Advantages include longer-term control relative to other technologies, lower overall costs, as well as plant-specific control. On the other hand, there are several disadvantages to consider, including control times of

[5] Information from APIS(Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005.

years instead of weeks, lack of available agents for particular target species, and relatively strict environmental conditions for success.

Biological control is not without risks; new non-native species introduced to control a pest population may cause problem of its own. Biological control is going to be explored for Eurasian watermilfoil control.

Re-vegetation with native plants

Another aspect to biological control is native plant restoration. The rationale for re-vegetation is that restoring a native plant community should be the end goal of most aquatic plant management programs (Nichols, 1991; Smart and Doyle, 1995). However, in communities that have only recently been invaded by non-native species, a propagule bank probably exists that will restore the community after non-native plants are controlled (Madsen, Getsinger, and Turner, 1994). Re-vegetation following plant management implementation should not be necessary as both lakes have extensive native populations and any management will involve selection for target species only.

Physical control[6]

In physical management, the environment of the plant is manipulated, which in turn acts upon the plants. Several physical techniques are commonly used: dredging, draw down, benthic (lake bottom) barriers, and shading or light attenuation. Because they involve placing a structure on the bed of a lake and/or affect lake water level, a Chapter 30 or 31 DNR permit is required.

Dredging removes accumulated bottom sediments that support plant growth. Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, need deepening, or require removal of toxic substances (Peterson, 1982). Dredging is not a viable option for Bear Trap Lake and Lake Wapogasset since this isn't recognized as an aquatic plant management tool alone and is not regarded as an effective tool for these lakes.

Drawdown, or significantly decreasing lake water levels can be used to control nuisance plant populations. Essentially, the water body has all of the water removed to a given depth. It is best if this depth includes the entire depth range of the target species. Drawdowns, to be effective, need to be at least 1 month long to ensure thorough drying (Cooke 1980a). In northern areas, a draw down in the winter that will ensure freezing of sediments is also effective. Although draw down may be effective for control of hydrilla for 1 to 2 years (Ludlow 1995), it is most commonly applied to Eurasian watermilfoil (Geiger 1983; Siver et al. 1986) and other milfoils or submersed evergreen perennials (Tarver 1980). Drawdown requires that there be a mechanism to lower water levels.

[6] Information from APIS (Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005.

Although it is inexpensive and has long-term effects (2 or more years), it also has significant environmental effects and may interfere with use and intended function (e.g., power generation or drinking water supply) of the water body during the drawdown period. Lastly, species respond in very different manners to draw down and often not in a consistent fashion (Cooke 1980a). Drawdowns may provide an opportunity for the spread of highly weedy or adventive species, particularly annuals. When drawbacks are weighed against the benefits, other options appear better for Bear Trap Lake and Lake Wapogasset as the primary management tool.

Benthic barriers or other bottom-covering approaches are another physical management technique. The basic idea is that the plants are covered over with a layer of a growth-inhibiting substance. Many materials have been used, including sheets or screens of organic, inorganic and synthetic materials, sediments such as dredge sediment, sand, silt or clay, fly ash, and combinations of the above (Cooke 1980b; Nichols 1974; Perkins 1984; Truelson 1984). The problem with using sediments is that new plants establish on top of the added layer (Engel and Nichols 1984). The problem with synthetic sheeting is that the gasses evolved from decomposition of plants and sediment decomposition collects under and lifts the barrier (Gunnison and Barko 1992). Benthic barriers will typically kill plants under them within 1 to 2 months, after which they may be removed (Engel 1984). Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively (Carter et al. 1994). Sites from which barriers are removed will be rapidly re-colonized (Eichler et al. 1995). In addition, synthetic barriers may be left in place for multi-year control but will eventually become sediment-covered and will allow colonization by plants. Benthic barriers, effective and fairly low-cost control techniques for limited areas (e.g., <1 acre), may be best suited to high-intensity use areas such as docks, boat launch areas, and swimming areas. However, they are too expensive to use over widespread areas, and heavily affect benthic communities by removing fish and invertebrate habitat. A Department of Natural Resources permit would be required.

Although a benthic barrier may be a potential option for riparian owners, there is no plan to use this as a management tool for Bear Trap Lake and Lake Wapogasset. Since the main use of management tools will be to reduce CLP, benthic barriers are not prudent as the coverage is too extensive and would be too labor intensive.

Shading or light attenuation reduces the light plants need to grow. Shading has been achieved by fertilization to produce algal growth, by application of natural or synthetic dyes, shading fabric, or covers, and by establishing shade trees (Dawson 1981, 1986; Dawson and Hallows 1983; Dawson and Kern-Hansen 1978; Jorga et al. 1982; Martin and Martin 1992; Nichols 1974). During natural or cultural eutrophication, algae growth alone can shade aquatic plants (Jones et al. 1983). Although light manipulation techniques may be useful for narrow streams or small ponds, in general these techniques are of only limited applicability. As a result, management of Bear Trap Lake and Lake Wapogasset will not use this management tool.

Manual removal[7]

Manual removal involving hand pulling, cutting, or raking plants will remove plants from small areas. It is likely that plant removal will need to be repeated during the growing season. Best timing for hand removal of herbaceous plant species is after flowering but before seed head production. For plants that possess rhizomatous (underground stem) growth, pulling roots is not generally recommended since it may stimulate new shoot production. Hand pulling is a strategy recommended for rapid response to a Eurasian water milfoil infestation. If curly leaf pondweed or Eurasian watermilfoil is present at near shore locations in low density, hand pulling by residents may be effective. Caution needs to be exercised in removing the entire plant and any fragments to reduce spreading through fragmentation.

Mechanical control

Larger-scale control efforts require more mechanization. Mechanical cutting, mechanical harvesting, diver-operated suction harvesting, and rotovating (tilling) are the most common forms available. Department of Natural Resources permits under Chapter NR 109 are required for mechanical plant removal.

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water. The cutter head uses sickles similar to those found on farm equipment, and generally cuts from one to six feet deep. A conveyor belt on the cutter head is always in motion, bringing the clippings onboard the machine for storage. Once full, the harvester travels to shore to discharge the load of weeds off of the vessel.

Harvesters come in a variety of sizes, with cutting swaths ranging from four to twelve feet in width. The onboard storage capacity varies as well, and is measured in both volume and weight. Harvester storage capacities generally range from 100 to 1000 cubic feet of vegetation by volume, or from one to eight tons. They are usually propelled by two paddle wheels that provide excellent maneuverability and will not foul in dense plant growth.

Mechanical harvesting is a possible option for Lake Wapogasset and Bear Trap Lake. It may be evaluated as a tool for reducing curly leaf pondweed. Since curly leaf pondweed may contribute to algae blooms in July, reducing its density with mechanical harvesting may help reduce the impact of this plant toward nutrient loading, exacerbating these blooms.

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[7] Information from APIS (Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005.

Mechanical harvesting may be an effective way to reduce CLP nutrient loading since the biomass of CLP is removed the lake, thus removing the phosphorus that would have otherwise been released by those plants. A two major drawbacks of mechanical harvesting for CLP reduction are: 1. Will need to be done annually to be effective as the CLP will always return as it is not being eliminated; 2. Cut and dislodged plants can accumulate along shorelines near residents which can create aesthetic issues. Also, harvesting does not allow for targeting just CLP, so other native plants will be removed at the same time. Monotypic beds of CLP are the desirable beds to harvest so a minimal amount of native plants are removed with the CLP. Fish that are in the harvested beds can also get removed unintentionally during harvest operations.

Diver dredging operations use pump systems to collect plant and root biomass. The pumps are mounted on a barge or pontoon boat. The dredge hoses are from 3 to 5 inches in diameter and are handled by one diver. The hoses normally extend about 50 feet in front of the vessel. Diver dredging is especially effective against pioneering infestations of submersed invasive plant species. When a weed is discovered in a pioneering state, this methodology should be considered. To be effective, the entire plant, including the subsurface portions, should be removed.

Plant fragments can be formed from this type of operation. Fragmentation is not as great a problem when infestations are small. Diver dredging operations can be an ongoing mission. When applied toward a pioneering infestation, control can be complete. However, periodic inspections of the lake should be performed to ensure that all the plants have been found and collected.

Lake substrates can play an important part in the effectiveness of the operation. Soft substrates are very easy to work in. Divers can remove the plant and root crowns with little problem. Hard substrates, however, pose more of a problem. Divers may need hand tools to help dig the root crowns out of hardened sediment. Many areas of Bear Trap Lake and Lake Wapogasset that need management are far too large for this method. However, in some sporadic regions, this method may be useful. Since actual dredging calls for other permits for removal of lake basin material, dredging would not be performed. Instead, the use of a suction device to move plants to the surface without removing bottom material would be utilized.

Rotovation involves using large underwater rototillers to remove plant roots and other plant tissue. Rotovators can reach bottom sediments to depths of 20 feet. Rotovating may significantly affect non-target organisms and water quality as bottom sediments are disturbed. However, the suspended sediments and resulting turbidity produced by rotovation settles fairly rapidly once the tiller has passed. Tilling sediments that are contaminated could possibly release toxins to the water column. If there is any potential of contaminated sediments in the area, further investigation should be performed to determine potential impacts from this type of treatment. Tillers do not operate effectively in areas with many underwater obstructions such as trees and stumps. There may be a need to collect the plant material that is tilled from the bottom. If operations are releasing large amounts of plant material, harvesting equipment should be on hand to collect this material and transport it to shore for disposal.

Rotovation is not typically permitted by the Wisconsin Dept. of Natural Resources.

Herbicide and algaecide treatments

Herbicides are chemicals used to kill plant tissue. Currently, no product can be labeled for aquatic use if it poses more than a one in a million chance of causing significant damage to human health, the environment, or wildlife resources. In addition, it may not show evidence of biomagnification, bioavailability, or persistence in the environment (Joyce, 1991). Thus, there are a limited number of active ingredients that are assured to be safe for aquatic use (when used according to the label) (Madsen, 2000).

An important caveat is that these products are safe when used according to the label. The U.S. Environmental Protection Agency (EPA)-approved label gives guidelines protecting the health of the environment, the humans using that environment, and the applicators of the herbicide. In most states, additional permitting or regulatory restrictions on the use of these herbicides also apply. Most states require these herbicides be applied only by licensed applicators. Wisconsin Department of Natural Resources permits under Chapter NR 107 are required for herbicide application.

General descriptions of chemical control are included below.

Contact Herbicides

Contact herbicides act quickly and are generally lethal to all plant cells that they contact. Because of this rapid action, or other physiological reasons, they do not move extensively within the plant and are effective only where they contact plants. For this reason, they are generally more effective on annuals (plants that complete their life cycle in a single year). Perennial plants (plants that persist from year to year) can be defoliated by contact herbicides but they quickly re-sprout from unaffected plant parts. Submersed aquatic plants that are in contact with sufficient concentrations of the herbicide in the water for long enough periods of time are affected, but regrowth occurs from unaffected plant parts, especially plant parts that are protected beneath the sediment. Because the entire plant is not killed by contact herbicides, retreatment is necessary, sometimes two or three times per year. **Endothall, diquat** and **copper** are contact aquatic herbicides.

Systemic Herbicides

Systemic herbicides are absorbed into the living portion of the plant and move within the plant. Different systemic herbicides are absorbed to varying degrees by different plant parts. Systemic herbicides that are absorbed by plant roots are referred to as soil active herbicides and those that are absorbed by leaves are referred to as foliar active herbicides. Some soil active herbicides are absorbed only by plant roots. Other systemic herbicides, such as glyphosate, are only active when applied to and absorbed by the foliage. **2,4-D, dichlobenil, fluridone, and glyphosate** are systemic aquatic herbicides. When applied correctly, systemic herbicides act slowly in comparison to contact herbicides. They must move to the part of the plant where their site of action is. Systemic herbicides are generally more effective for controlling perennial and woody plants than contact herbicides. Systemic herbicides also generally have more selectivity than contact herbicides. A combination approach for CLP with contact and systemic may be considered.

Broad spectrum herbicides

Broad spectrum (sometimes referred to as nonselective) herbicides are those that are used to control all or most vegetation. This type of herbicide is often used for total vegetation control in areas such as equipment yards and substations where bare ground is preferred. **Glyphosate** is an example of a broad spectrum aquatic herbicide. **Diquat, Endothall, and fluridone** are used as broad spectrum aquatic herbicides, but can also be used selectively under certain circumstances. While glyphosate, diquat and endothall are considered broad spectrum herbicides, they can also be considered selective in that they only kill the plants that they contact. Thus, you can use them to selectively kill an individual plant or plants in a limited area such as a swimming zone. If used for CLP, an early season broad spectrum herbicide can target the CLP as most other plants are dormant.

Selective herbicides

Selective herbicides are those that are used to control certain plants, but not others. A good example of selective aquatic herbicide is 2,4-D, which can be used to control water hyacinth with minimum impact on eel grass. Herbicide selectivity is based upon the relative susceptibility or response of a plant to an herbicide. Many related physical and biological factors can contribute to a plant's susceptibility to an herbicide. Physical factors that contribute to selectivity include herbicide placement, formulation, and rate of application. Biological factors that affect herbicide selectivity include physiological factors, morphological factors, and stage of plant growth.

Environmental Considerations

Aquatic communities consist of aquatic plants including macrophytes (large plants) and phytoplankton (free floating algae), invertebrate animals (such as insects and clams), fish, birds, and mammals (such as muskrats, otters, and manatees). All of these organisms are interrelated in the community. Organisms in the community require a certain set of physical and chemical conditions to exist such as nutrient requirements, oxygen, light, and space. Aquatic weed control operations can affect one or more of the organisms in the community that can in turn affect other organisms or it can affect water chemistry that in turn affects organisms. The effects of aquatic plant control on the aquatic community can be separated into direct effects of the herbicides or indirect effects.

General descriptions of the breakdown of commonly used aquatic herbicides are included below.[8]

Copper compounds

Copper is a naturally occurring element that is essential at low concentrations for plant growth. It does not break down in the environment, but it forms insoluble compounds with other elements and is bound to charged particles in the water. It rapidly disappears from water after application as an herbicide. Because it is not broken down, it can accumulate in bottom sediments after repeated high application rates. Accumulation rarely reaches levels that are toxic to organisms or significantly above background concentrations in the sediment.

2,4-D

2,4-D photo-degrades on leaf surfaces after applied to leaves and is broken down by microbial degradation in water and sediments. Complete decomposition usually takes about 3 weeks in water and can be as short as 1 week. 2,4-D breaks down into naturally occurring compounds.

Diquat

When applied to enclosed ponds for submersed weed control, diquat is rarely found longer than 10 days after application and is often below detection 3 days after application. The most important reason for the rapid disappearance of diquat from water is that it is rapidly taken up by aquatic vegetation and binds tightly to particles in the water and bottom sediments. When bound to certain types of clay particles diquat is not biologically available. When it is bound to organic matter, it can be slowly degraded by microorganisms. When diquat is applied foliarly it is degraded to some

[8] These descriptions are taken from Hoyer/Canfield: Aquatic Plant Management. North American Lake Management Society. 1997.

extent on the leaf surfaces by photodegradation, and because it is bound in the plant tissue a proportion is probably degraded by microorganisms as the plant tissue decays.

Endothall
Like 2,4-D, endothall is rapidly and completely broken down into naturally occurring compounds by microorganisms. The by-products of endothall dissipation are carbon dioxide and water. Complete breakdown usually occurs in about 2 weeks in water, and 1 week in bottom sediments. This will be the chemical of choice for early season CLP treatments.

Fluridone
Dissipation of fluridone from water occurs mainly by photodegradation. Metabolism by tolerant organisms and microbial breakdown also occurs, and microbial breakdown is probably the most important method of breakdown in bottom sediments. The rate of breakdown of fluridone is variable and may be related to time of application. Applications made in the fall or winter when the sun's rays are less direct and days are shorter result in longer half-lives. Fluridone usually disappears from pond water after about 3 months but can remain up to 9 months. It may remain in bottom sediment between 4 months and 1 year.

Glyphosate
Glyphosate is not applied directly to water for weed control, but when it does enter the water it is bound tightly to dissolved and suspended particles and to bottom sediments and becomes inactive. Glyphosate is broken down into carbon dioxide, water, nitrogen, and phosphorus over a period of several months.

Algaecide treatments for filamentous algae
Copper-based compounds are generally used to treat filamentous algae. Common chemicals used are copper sulfate and Cutrine Plus, a chelated copper algaecide.

Herbicide use to manage invasive species of concern

Curly leaf pondweed
The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies three herbicides for control of curly leaf pondweed: Diquat, Endothall, and Fluridone. Fluridone requires exposure of 30 to 60 days making it infeasible to target a discreet area in a lake system. The other herbicides act more rapidly. Herbicide labels provide water use restriction following treatment. Diquat (Reward) has the following use restrictions: drinking water 1-3 days, swimming and fish consumption 0 days. Endothall (Aquathol K) has the following use restrictions: drinking water 7 – 25 days, swimming 0 days, fish consumption 3 days.

Early season herbicide treatment:[9]

Studies have demonstrated that curly leaf can be controlled with Aquathol K (a formulation of Endothall) in 55 - 60 degree F water, and that treatments of curly leaf this early in its life cycle can prevent turion formation. Staff from the Minnesota Department of Natural Resources and the U.S Army Engineer Research and Development Center are conducting further trials of this method.

Because the dosage is at lower rates than dosage recommended on the label, a greater herbicide residence time is necessary. To prevent drift of herbicide and allow greater contact time, application in shallow bays is likely to be most effective. Herbicide applied to a narrow band of vegetation along the shoreline is likely to drift, rapidly decrease in concentration, and be rendered ineffective.[10] More recent application rates that have shown effective reduction range from 1.5-2.0 ppm.

Plant Management History

The Lake Wapogasset/Bear Trap Lake Sanitary District and the Lake Wapogasset/Bear Trap Lake Association have not embarked in any plant management practices prior to 2009 that has any reliable record. There have been extensive treatments of aquatic macrophytes over the years, but this was mainly with private riparian owners. There is an extensive file for these two lakes that dates back many decades. There has been no evaluation of effectiveness during those times and therefore there is no available data for comparison.

Starting in 2009, the Lake Wapogasset/Bear Trap Lake Sanitary District began sponsoring the treatment of CLP in two treatment sites that were used as test sites. These sites are shown on the map in figures 25 and 26. This treatment was to determine if herbicide treatment was a viable option for reduction of CLP in the two lakes. Treatment continued from 2009 through 2012, which totaled four years. The treatment was somewhat effective two of the four years and not effective at all the other two years (see Appendix G-CLP treatment analysis for years 2009-2012). The herbicide treatment was ceased in 2013 since this method was not consistently effective. The herbicide application rate was lower the first three years of treatment (1.0 ppm) and could be part of the reason the treatment was not effective. The rate of 1.5 ppm was used the last year of treatment, but was not effective either.

9 Research in Minnesota Control of Curly Leaf Pondweed. Wendy Crowell, Minnesota Department of Natural Resources. Spring 2002.

10 Personal communication, Frank Koshere. Wisconsin DNR. March 2005.

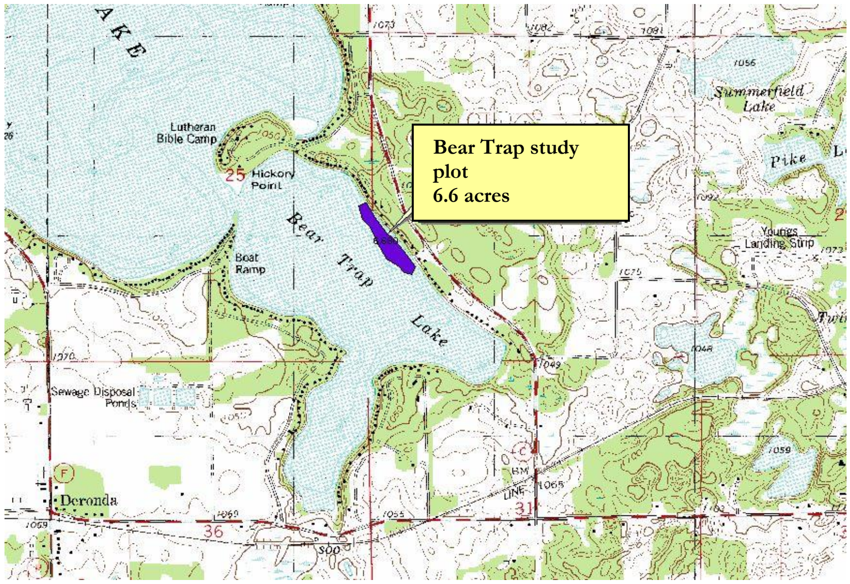

Figure 25: Treatment area (study plot) for year one (May 2009) Bear Trap Lake.

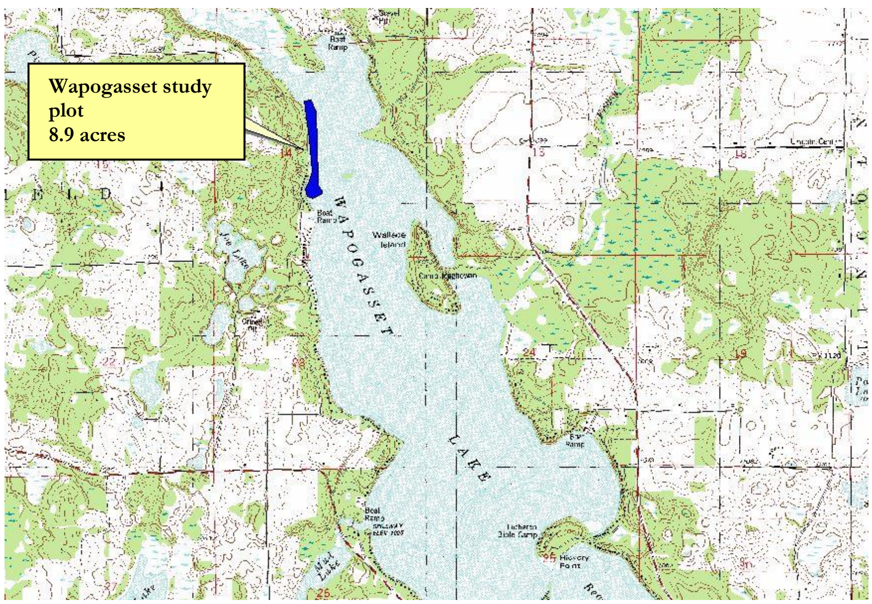

Figure 26: Treatment area (study plot) for year 1 (May 2009) on Lake Wapogasset.

In 2011, the potential impact CLP has on the phosphorus load was explored. The biomass of CLP was estimated by sampling numerous CLP beds and determining the mean dry mass per acre. In addition, the phosphorus content was determined in mg of P per gram of CLP biomass. These values were then used to determine the amount of phosphorus that could be released by all of the CLP growing then senescing from the acreage of any given year. Since the values of potential phosphorus loading from CLP in July were significant, the District was interested in reducing CLP for the purpose of nutrient reduction.

Since the herbicide treatments have not been consistently effective, the discussion of harvesting CLP was initiated. To determine if harvesting the CLP would help with nutrient loading, the amounts that could be potentially removed were analyzed in 2013. The beds of CLP that were determined to be good candidates for harvesting were delineated. Good candidates were very dense, monotypic beds with the CLP plants reaching the surface at or near peak growth. The mean depth of the beds were determined and the amount of CLP that could be harvested down 5 feet in each bed was estimated. The minimum depth of three feet is needed to harvest and was also considered[9]. These values have led to the further exploration of harvesting CLP as a control method for nutrient reduction and harvesting is discussed in greater detail later in this plan (p.75).

[9] Alex Smith, Wisconsin DNR. Personal comment in APMP review, 2013.

Management Recommendations

The following are goals that the aquatic plant management committee developed based upon review of all data presented and public input from the public survey analysis. These goals are also based upon re-evaluation of the Aquatic Plant Management Plan developed in 2009.

Goals:

1. Preserve a healthy and diverse community of native plants.
2. Stop the introduction of new invasive species into Bear Trap Lake and Lake Wapogasset and maintain a rapid response plan to address any new AIS introductions that may occur.
3. Reduce curly leaf pondweed (*Potamogeton crispus*) coverage and biomass in Bear Trap Lake and Lake Wapogasset.
4. Restore developed shorelines to native habitat.
5. Educate lake residents, non-resident lake users about lake ecology, and water quality issues.

Objectives and actions

In order to reach the goals of the aquatic plant management plan, objectives have been outlined. These objectives are specific methods and/or criteria to reach the stated goals. Each objective will be described in further detail in the management section. Action items will articulate the methods and details used to reach the objectives.

Goal 1: Preserve a healthy and diverse native plant community.

Objective 1.1-Management schemes will limit impact on native plants.

The native plant community is very important to the lake ecosystem. As a result, any management of plants, especially invasive species such as curly-leaf pondweed (present at this time) and Eurasian water milfoil (not present at this time) must use management practices that will preserve native plants. Management such as herbicide treatments should be limited to early season (water temperatures less than 60 degrees F) and should target the invasive species only. Management practices should avoid adversely affecting floating vegetation such as water lily, and avoid sensitive areas. The 2014 macrophyte survey showed a significant decrease in native plants compared to 2007. The reason for this is unknown, but it is important to preserve the important native plant community.

Action: Provide information about native plants and aquatic invasive species (AIS) in newsletters.

Previous CLP management had minimal impact on native plants. No other management was conducted, including native plant reduction in areas that have become a potential navigation problem. Any future management that may affect the native plant community will be done be keep the degradation of native plant species to a minimum and will be a point of emphasis.

Objective 1.2-Encourage preservation of native plant stands, including wild rice in/near the Balsam Branch.

Education is the key component for preservation of native plant stands. This includes providing information about their importance. Residents should be encouraged to maintain native plants in front of their properties and limit their removal whenever possible. Communication avenues are outlined under goal 5. If native plants are a nuisance for recreation such as swimming and boating, a **minimum** amount may be removed to mitigate the problem. This is outlined in objective 1.4.

Both Lake Wapogasset and Bear Trap Lake have a history of excess nutrients and nuisance algae blooms. Native plants can contribute to better water clarity by absorbing nutrients from the bottom sediment as well as directly from the water column. Coontail (*Ceratophyllum demersum)* is a plant that is abundant in both lakes. This plant is known to absorb large amounts of phosphorus during growth, but can release that phosphorus back when it dies (Lombardo et al, 2003). Therefore, maintaining a healthy population of this and other native plants could help maintain or improve water clarity and water quality. Also the 2014 survey showed a substantial reduction in plant coverage compared to the 2007 survey. This coverage should be monitored as preservation is important.

Action: Management will not be in areas of wild rice and rice will be monitored every three years to evaluate any changes.

Due to wild rice being present in the north where the Balsam Branch enters Lake Wapogasset, no management of native plants will occur here, even if the density becomes very high. Management of AIS will be carefully evaluated so as to not adversely affect the rice. In addition, wild rice presence and its location will be monitored and evaluated on a three year basis. This will allow any indication of the distribution changes of this desirable plant. Wild rice was much more common and dense in the 2014 survey. The Balsam Branch has dense wild rice, with sparse rice coverage at the outlet into Lake Wapogasset. This area will be avoided in any plant management practices.

Objective 1.3-Evaluate native plant communities with whole lake point intercept survey.

Action: The native plant community will be evaluated using the full lake point intercept (PI) survey conducted summer 2014. Full lake PI surveys will be completed every 5 years if management to reduce any plants is used and 7 years if no management to reduce any plants is used. The next full lake survey will occur in either 2019 or 2021.

A point intercept survey was completed in June/July 2014 and is the basis for the plant community data in this plan. The next point intercept survey is scheduled for 2019 or 2021 depending on management practices.

Objective 1.4-Create (30 ft maximum width) navigation channels in dense plant beds that occur in the north end of Lake Wapogasset.

During the last 4 years (2010-2014), there have been concerns expressed from residents living on the north end of Lake Wapogasset that the plants are impeding navigation and aesthetics. The problem has been monitored and the plants are continuing to grow in dense beds. These plants include the invasive *Potamogeton crispus* (curly leaf pondweed) and a few natives dominated by *Ceratophyllum demersum* (coontail) Understanding that the native plants are very important and help reduce excess nutrients, cutting small navigation channels in key areas may be needed for individual riparian owners or their vicinity. Also, this may help facilitate a higher diversity of plants by reducing density of coontail.

The PI survey in 2014 showed only the very northwest portion of the north end bay in Lake Wapogasset with dense coontail. This was lower in density and coverage than in previous years and therefore important to evaluate annually as residents express concerns. The southern-most bay (see figure 27) may also have navigation issues, but no concerns have been raised. Both of the reduced navigation locations are within or adjacent to sensitive areas.

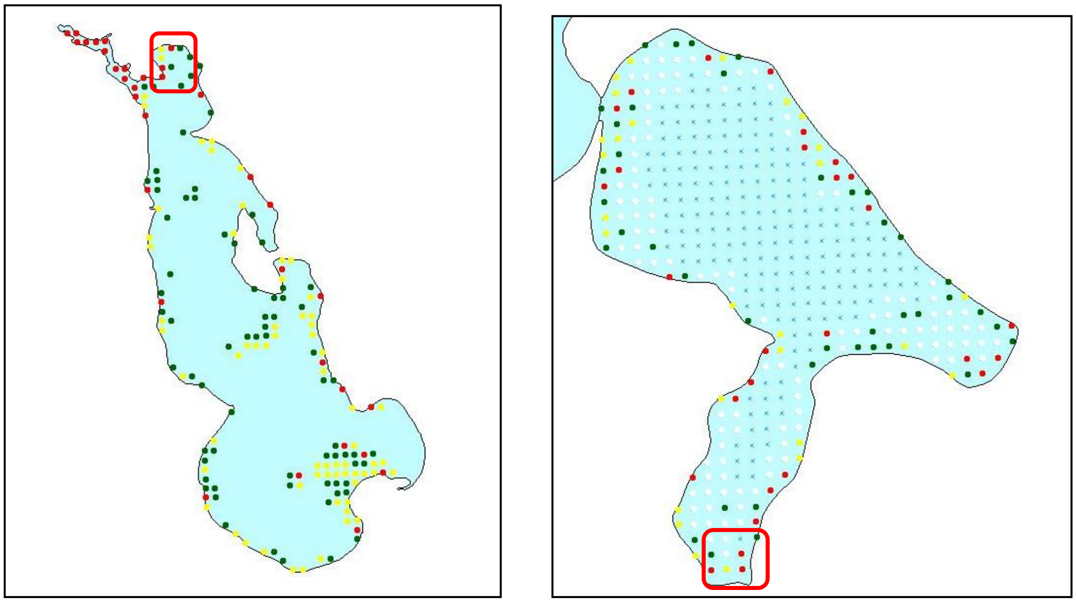

Figure 27: Area on each lake that potentially has density of plants that inhibit navigation.

Action: Use mechanical harvesting of native plants to create small (30ft maximum in width) navigation channels in dense plants beds on the north end of Lake Wapogasset. These areas will need to meet specific criteria as outlined in criteria below.

The following criteria will be used to determine if corridor creation is needed:

Procedure for Individual Corridor Permitting and Monitoring[10]

Verify/refute nuisance conditions and/or navigation impairment

- Landowners will document conditions with photographs and submit request for review by the APM Lead or designee.
- Landowner requests Sanitary District APM Lead review of their property prior to submitting a permit application to DNR.
- The APM Lead visits site, reviews documentation and provides a written opinion of navigation impairment i.e., is herbicide treatment or harvesting warranted?
- Describe practical alternatives to herbicide use or harvesting that were considered. These might include:
  - -Hand removal/hand raking of aquatic plants
  - -Extending dock to greater depth
  - -Altering the route to and from the dock
  - -Use of another type of watercraft or motor, i.e., is the type of watercraft

[10] Landowner can clear 30 foot wide corridor by hand without a permit from the Wisconsin DNR.

used common to other sites with similar conditions on this lake?

- Landowner/Sanitary District applies for permit to WDNR including photographic documentation, identification of plants causing navigation problems, and Sanitary District evaluation.
- WDNR will contact Sanitary District and owner with a notice to proceed with harvest or denial of harvest application.

Goal 2: Stop the introduction of new aquatic invasive species into Bear Trap Lake and Lake Wapogasset and develop a rapid response plan to address introductions that may occur.

Objective 2.1-Continue the Clean Boats/Clean Waters Program at landings on Wapogasset and Bear Trap Lakes.

Lake Wapogasset/Bear Trap Lake Association volunteers have been trained in the Clean Boats/Clean Waters program. This program will continue and possibly be expanded. The expansion should include the following options:

Action:

1. Station volunteers or hired personnel at key boat landings during high use times such as opening of fishing season, July 4th, etc.
2. Station volunteers or hired personal at boat landings on weekends and high use weekdays.
3. Hire trained individuals to occupy boat landings for significant portions of spring/summer months.

Regardless of options used, the boat landings will be monitored a minimum total of 200 hours for all landings combined. Option three has been implemented for the past 2 years and is planned to continue in the future.

Objective 2.2-Use trained volunteers to establish an AIS monitoring program.

Curly leaf pondweed is present in Lake Wapogasset and Bear Trap Lake, aquatic forget-me-not (not considered invasive) and narrow-leaved cattail (potentially invasive). Eurasian water milfoil is not present at this time. In order to reduce the chance of introducing this and other invasive species and prevent the spread of existing aquatic invasive species in the lakes, a good monitoring program is important. A volunteer group has been trained in the identification of key aquatic invasive species. The group will continue to monitor the lakes monthly in pre-determined locations. This protocol is contained in the appendix.

It is recommended that the areas mapped in Figure 28 continue to be emphasized for monitoring purposes. These areas are a minimum and therefore can be expanded. Sample points have been generated for each area to provide for pre-determined sample points. A rake sample will be taken at each sample point. Only invasive species will be monitored and recorded (emphasis on Eurasian water milfoil). If there is a species sampled that is a potential invasive, the plant will be vouchered in a plastic bag forwarded to an aquatic plant specialist (Polk County Land and Water Conservation Dept, Wisconsin DNR, or private consultant with expertise).

Monitoring kits have been constructed which include a viewing scope, a roped double tined rake, and plant ID plates.

Action: Volunteer monitoring groups will monitor for AIS every two weeks. The monitors will be trained in the identification of common AIS and the use of the monitor kits. The volunteers will be on a two week rotation.

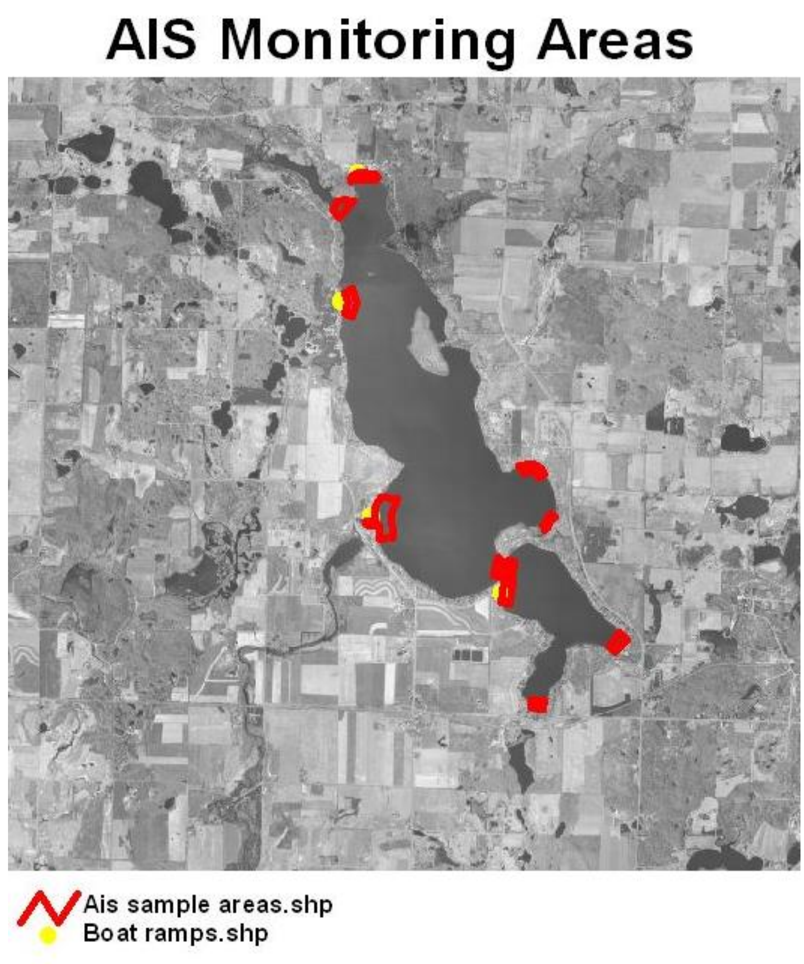

Figure 28: Proposed monitoring locations for AIS.

Objective 2.3-Develop and educate stakeholders about a rapid response plan.

Should other aquatic invasive species be located (or thought to be) in Lake Wapogasset and/or Bear Trap Lake, a rapid response plan will be followed. This rapid response will include: (see Appendix G for detailed file)

1. Verification of AIS by Polk County Water Quality Specialist and the Wisconsin DNR.
2. Evaluation of degree of infestation and strategic planning by Polk County Water Quality Specialist (pioneer plants removed, herbicide treatments, etc.).
3. Creation of a rapid response file that contains a copy of the rapid response grant application, the rapid response protocol, and contact information for the Wisconsin DNR.

Action: A rapid response plan will be on file with the Sanitary District and will communicate the response process with the volunteer monitors. A budget item of $3000 will be reserved annually to cover potential, immediate response costs.

Goal 3: Reduce curly leaf pondweed (*Potamogeton crispus*) coverage and biomass in Lake Wapogasset and Bear Trap Lake.

CLP has reached nuisance levels in many areas of both lakes. A point intercept analysis of CLP was conducted on both lakes and was found to be the most dominant plant in Lake Wapogasset and the second most dominant plant in Bear Trap Lake (when comparing early survey for CLP to the data in the main survey in July). Many of the areas had monotypic, high density beds. These beds can reduce navigation and recreational activities in the lake during the month of June, into early July. In addition, the CLP can contribute a large phosphorus load during the decomposition of the dead plants in July.

Objective 3.1-Reduce CLP beds that reach the nuisance level threshold and reduce recreational use and increase the probability of CLP being carried to other lakes (near boat landings), which is described as follows:

a. Mean density greater than “2” (from DNR protocol)
b. Aerial coverage greater than 200 square feet.
c. Plants at or near the surface at peak height.
d. Plants impede any navigation at peak growth.
e. Beds are monotypic: >75% of bed density is CLP

Attempts of reduction of CLP with herbicides have failed. The desire to reduce CLP continues and therefore alternative methods have been evaluated. The plant committee has determined that mechanical harvesting would be the best option for CLP reduction in both lakes.

Action: Mechanically harvest the maximum amount of CLP to reduce phosphorus loading through CLP biomass removal. Any bed that is dominated by CLP and is close enough to the surface to harvest and has a water depth allowable for harvester use (see maps) will be harvested.

CLP is growing extensively and is so dense in areas, it appears to affect navigation, aesthetics and other uses. Furthermore, there is dense CLP growth at the landing on the north end of Lake Wapogasset, adjacent to the Sunrise Beach landing, and straight out from the Bear Trap Lake landing. This CLP growth could be affecting the use of these landings and also increases the chance for CLP to be attached to boats, motors and/or trailers and get transported to other lakes. The dense CLP at these landings is a concern for these reasons.

Objective 3.2-Reduce nutrient loading by 80 kg (Lake Wapogasset) and 13 kg (Bear Trap Lake) in July through CLP reduction with mechanical removal of all harvestable CLP beds.

Both lakes have excessive nutrients. Since the alum treatment was not successful in 1999, interested parties are hesitant to do a subsequent treatment. Other nutrient management attempts, such as purchasing agriculture land to take out of production, have failed to come to fruition. As a result, use of CLP management for nutrient purposes is a desirable practice as there is potential positive effect and can be done under the Wisconsin DNR AIS guidelines. The committee hopes the nutrient reduction will result in later and less intense algae blooms.

A CLP nutrient analysis was conducted in 2010 to evaluate the potential phosphorus load from CLP. The following tables summarize those findings and support significant phosphorus loading from CLP.

Analysis	Lake Wapogasset	Bear Trap Lake
Mean % dry mass	9.07%	8.89%
Mean Tissue phosphorus	3.3 mg P/g of CLP tissue	3.3 mg P/g of CLP tissue
Mean wet biomass of CLP	194.02 g CLP tissue/sample	174.65 g CLP tissue/sample
Mean dry biomass of CLP	17.6 g dry CLP tissue/sample	15.53 g dry CLP tissue/sample

Table 26: CLP nutrient data from CLP nutrient study.

Values	Lake Wapogasset	Bear Trap Lake
Area of CLP sampled (m^2)	225158	47882
Mean g of P/m^2	0.57	0.51
Kg of P from CLP	128.34	24.42
% total P budget	4.60%	5.70%

Table 27: Phosphorus loading from CLP based upon 2010 CLP map.

Since the nutrient release of CLP is high, mitigation of phosphorus through CLP reduction is a goal. The CLP beds were evaluated as to how much phosphorus could realistically be removed using mechanical harvesting as a method. During peak CLP growth in June 2013, all beds that were monotypic CLP and had growth at the surface were delineated. The mean depth of the bed was determined and the amount of CLP growth that could be removed was determined based upon those depths. It was assumed that a harvester could remove plants 5 feet below the surface, in up to three feet of water total depth. The table below summarizes those findings.

P removal Estimates	**Lake Wapogasset**	**Bear Trap Lake**
Acres of CLP (harvest)	58.66	9.12
weighted mean depth	6.87	6.27
% of harvest (5.5 ft)	80.06	87.72
g P/m2 (from 2010)	0.57	0.51
kg P harvestable	135.31	18.82
Estimated Kg P removed (harvest)	**108.33**	**16.51**
% of total P budget	3.88	3.85

Table 28: Summary of potential phosphorus removal through CLP harvesting.

Note: The model Bathtub, predicts that the sechhi disk reading could increase up to <u>0.3 meters</u> with the removal of the amount of phosphorus estimated from the 2013 harvest analysis.

Since the chemical treatment on the two test plots was unsuccessful, the use of chemical herbicide to reduce CLP for nutrient reduction is questionable as a main tool at this time. Mechanical harvest of CLP has been determined to be the best method available.

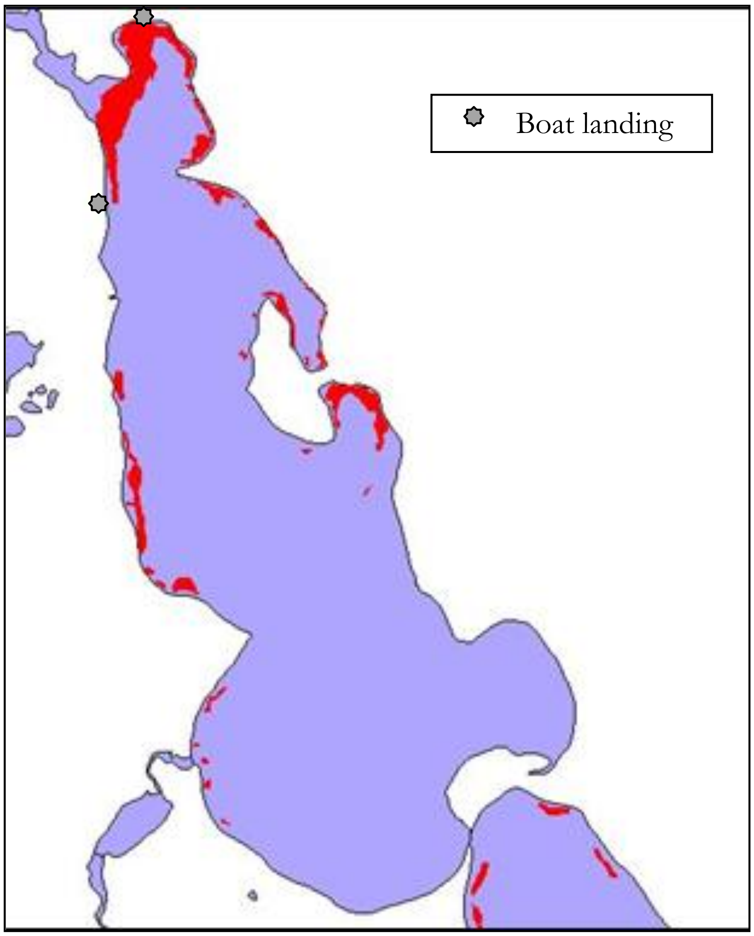

Figure 29: CLP mapped on Lake Wapogasset in 2013 that is considered dense enough and close enough to the surface to harvest adequate amounts of the beds (58.7 acres).

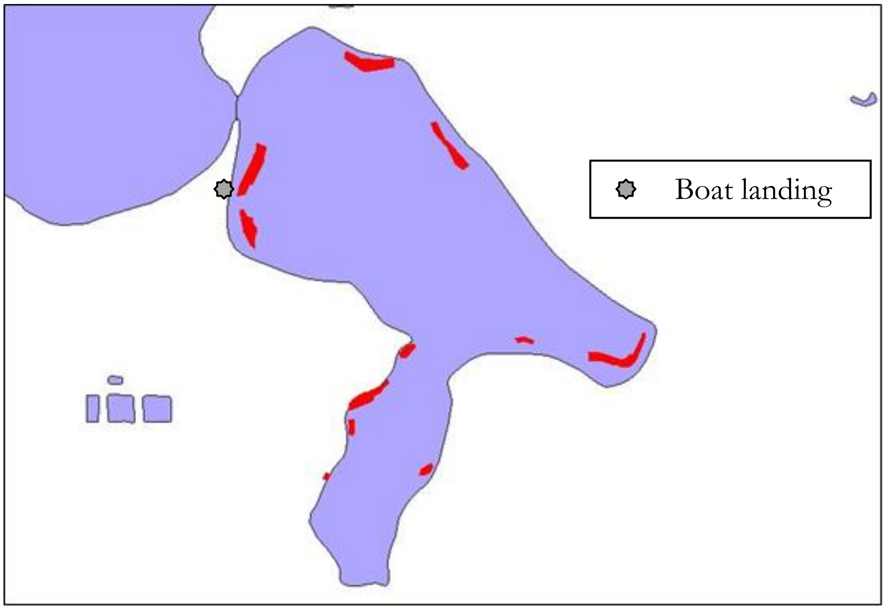

Figure 30: CLP mapped on Bear Trap Lake in 2013 that is considered dense enough and close enough to the surface to harvest adequate amounts of CLP from the bed (9.12 acres).

When mechanical harvest is utilized, the following criteria will be used:

1. The CLP beds to be harvested will be monitored as to CLP coverage. The CLP will make up >75% of the plant coverage in the bed at peak growth.
2. The quantity of the wet CLP removal will be estimated and the phosphorus removed will be estimated based on past data collected in tissue samples. The annual goal of a minimum of 80 kg removed will be evaluated based upon this data collected.
3. The secchi disk depth will be monitored weekly during July and the first three weeks in August. This will be archived for all 5 years and graphed for comparison. The goal is for an average increase of one foot for each of the August readings.
4. The harvested beds will be evaluated near peak growth after harvest with CLP density measured within the beds. A turion analysis will occur within each harvested area each October to evaluate any turion density changes.

Action: The amount of phosphorus removed will be estimated after harvest based upon biomass of CLP estimates. Weekly, deep hole surface total phosphorus samples will be analyzed in the last week of July and the first three weeks of August on an annual basis. Weekly secchi readings will be taken the last week in July and the first three weeks of August on an annual basis.

Objective 3.3-Reduce CLP aerial coverageby 80% and reduce mean density to <1, and turion density after reductions in all managed CLP beds (harvest).

- Aerial coverage will be reduced by 80%. This will be evaluated using the Wisconsin DNR pre and post treatment survey protocol for herbicide treatments. The area will be multiplied by the frequency of CLP at designated sample points and will show 80% less (or approximately 20% frequency). In mechanical harvest areas, the beginning and ending acreage will be evaluated to compare coverage before and after CLP is harvested. Coverage will be based on visible, near surface CLP growth.

- Mean density will be decreased to less than "1" through rake samples in the herbicide areas and less than "1" in surface samples of CLP in herbicide areas.

- An annual turion analysis will also be conducted within all herbicide treated areas and mechanical harvest areas. This will allow the measurement of turion density per square meter. Turion density can help indicate the potential for future growth. The goal for turion density after a 5 year harvesting regimen is a 50% reduction in overall turion density (from 2015 to 2019).

Action: Complete CLP biomass reduction estimates, pre and post-harvest surface density estimates, and turion density (post-harvest) to evaluate CLP reductions.

Goal 4: Restore developed shorelines to native habitats.

Objective 4.1-Educate landowners about the importance of native shoreline vegetation.

Lake Wapogasset and Bear Trap Lake have large residential land use areas. As a result, this can contribute large amounts of phosphorus into the lake, contributing to nuisance algae blooms and increased CLP growth. One very effective method to reduce this loading is the restoration of developed shorelines. Replacing turf grass and/or implementing infiltration areas (such as rain gardens) will reduce runoff and nutrient loading from their land.

Education activities for this will include newsletters (there are currently 7 per year), postings on the lake website and annual presentations at meetings for the Lake Association and Sanitary District.

Objective 4.2-Develop a partnership with Polk Land and Water Conservation Department to educate and plan shoreline restoration projects.

Both Lake Wapogasset and Bear Trap Lake have a great deal of developed shorelines and these properties most likely contribute large amounts of phosphorus into the lakes. The restoration of these areas could have a tremendous positive impact on lake water clarity.

The public survey indicated that 41% of the respondents are either very interested or somewhat interested in implementing a water quality improvement practice. Providing education will be the key to encouraging property owners to implement such a practice. Since there is no cost share money currently available, it would be difficult to establish a specific implementation goal. However, with the public commitment, educational materials, and collaboration of the Sanitary District and the Lake Association, and the Polk County Land and Water Conservation Department, some restorations will hopefully occur.

The Polk County Land and Water Conservation Department can provide planning assistance should residents consider a shoreline restoration.

Action: Provide one educational component each year to help facilitate shoreline restoration.

Objective 4.3-Evaluate funding sources to implement the shoreline restoration plan and secure funding for shoreline restoration if available.

Action: Work with PCLAR to evaluate potential future funding sources to make it as an optional program for interested parties.

Goal 5: Educate lake residents and non-resident lake users about lake ecology.

Lack of understanding about lake ecology is a concern for the committee. They would like to provide materials for educating lake residents and non-residents about the ecology of these lakes. It is believed that education and understanding of lake ecology is a limiting factor in protection of the lakes.

According to the public survey, respondents don't appear to have a complete understanding of native vs non-native plants and the significance of this distinction. As a result, education about the importance of preserving native species and eliminating invasive species is important.

Objective 5.1-Publish a lake association newsletter.

Newsletters are an effective method to communicate with residents and lake users or interested parties. The value of this communication is recognized and will result in numerous publications with important plant management issues/information.

Action: Publish a newsletter seven times annually. The newsletter will be published on the Lake Association website and printed copies sent to all members.

A lake association newsletter is currently published 7 times annually. This will continue but a bigger commitment will be made to include information about lake ecology, lake issues, and management schemes. Each newsletter will contain an educational component.

Objective 5.2-Continue an updated Sanitary District website and past informational brochures on the website as well as the Lake Association website.

At the development of this plan a website had been started and posted on the web. The information available is presently being expanded.

Action: The websites will contain this plan as well as other documents important to the management of the lakes.

Action: Educate lake residents and non-resident lake users about the specific goals for nutrient reduction and enhanced lake use through mechanical removal of CLP (and the impact dense CLP is having on the ecosystem). This education will be an emphasized component at lake meetings and informational publications.

The Sanitary District will publish an annual plant management report each August. This report will discuss the management practices conducted during that spring and summer. This discussion will include areas managed and the results of that management. The web sites for the Sanitary District and the Lake Association are listed as follows:

Lake Wapogasset/Bear Trap Sanitary District- http://www.wapobear.com

Lake Wapogasset Bear Trap Association- http://www.wbtlakes.com

Implementation Plan

The objectives outlined in the management recommendations will be implemented over the course of the next five years. Table 17 summarizes the activity, time of implementation and the responsible parties involved. It is important the Sanitary District and the Lake Association work together to assure that these management objectives are implemented. It is also the responsibility of the two organizations to plan for funding the various activities.

Table 29: Implementation plan for objectives.

SD=sanitary district
LA=lake association
PCLWD=Polk County Land and Water Dept.
PLS=professional lake scienctist
V=volunteers

Activity	Timeline	Responsible Party	Estimated Cost	Comments/notes	Grant eligibility
Education about native plants and AIS	Annually through 2019.	SD and LA	$3500 annually for printing and distribution of newsletter.	This has occurred annually in Lake Scene	AIS education
Wild Rice monitoring and evaluation	2017 and 2019 or 2012 PI survey	PLS and V	Volunteers and $200 training fee OR consultant at approximately $600/eval.	Evaluated 2014 PI survey.	Lake Planning
Clean Boats/Clean Waters	Annually 2015-2019	LA and SD	$5500 per year + approx. 60 hrs volunteer	Has occurred annually 2011-14	AIS-CBCW
Monitoring AIS	Annually; biweekly with volunteer teams changing every two weeks.	LA/SD and V PLS and/or PCLWD is training needed.	Training of approximately $200 and volunteers conduct monitoring. Approximately 12 hours of volunteer time.	Training biannually or as needed.	AIS

Activity	Timeline	Responsible Party	Estimated Cost	Comments/notes	Grant eligibility
Update/maintain rapid response file and protocol	2015 and 2018	SD	Maintain a rapid response budget of $3000		AIS Rapid Response
Whole lake plant surveys	Spring/summer 2019 or 2021	PLS SD	Approximately $5000	Completed July 2014 5-7 years after this most recent survey.	AIS
Education on shoreline restoration	2016-17	LA and SD	Included in $3500 budget on education.		
Evaluation of CLP management success and turion analysis	Yearly pre and post treatment surveys. Yearly management reviews	PLS SD	Approx. $2500 annually. Will increase with increased acreage treated.		AIS for evaluation of herbicide nuisance areas only.
Evaluate nutrient reduction through phosphorus and secchi data	Last week in July, first three weeks in August 2015-2019.	SD/LA and V Possible assistance from PLS	8 volunteer hours $240 for added total phosphorus samples (State Lab of Hygeine).	Self help monitoring occurs on the lake, but would need to be expanded for these additional data	Lake Planning

Activity	Timeline	Responsible Party	Estimated Cost	Comments/notes	Grant eligibility
Evaluate harvester bids and select a dealer	2014-15	Sanitary District and LA	Donated time for meetings Two Bids: 159,680 and $167,650 (includes conveyor and trailer).	Renting was determined to not be an option due to availability, lack of flexibility, and AIS concerns.	
Harvester Purchase and implementation (including hiring and training harvester operator)	2015	SD/LA	Operator costs: $3000/summer Trucking cost: $3000/summer Maintenance/insurance:$2000	Plants may be composted on Sanitary District land and/or at a local plant nursery (depending on amount desired at nursery) There are three off-loading sites (Bear Trap landing, Sunrise Landing and Waterside landing which divide lake fairly evenly)	Wisconsin Waterways Commission Grant

Activity	Timeline	Responsible Party	Estimated Cost	Comments/notes	Grant eligibility
Reduction of CLP phosphorus loading through CLP mechanical harvest .	Annually during peak CLP growth 2015-2019.	SD/PLS	Approximately $8000/ summer.		
Harvest navigation corridors in north end of Lake Wapogasset	Annually on an “as needed basis”(see threshold procedure) 2015-2019	SD/ WI DNR	Approximately $100/30’X30’ area (based upon operation costs).		
Education on nutrient mitigation and lake use/access through use of harvesting CLP	Special mention made at 2015 annual meetings and publication in summer-2015 newsletter and segment placed in websites	SD/LA	4 volunteer hours		

Educational programming will be conducted throughout the next 5 years. The Lake Wapogasset/Bear Trap Lake Sanitary District along with the Lake Wapogasset/Bear Trap Lake Association have made a commitment to implementing components discussed in the goal 6 discussion. This will include shoreline restoration training.

In 2014, another point intercept whole lake aquatic plant survey was conducted. A qualified aquatic plant professional will complete future point intercept surveys. The Wisconsin DNR point intercept method will be used. The same sample grid that was used in 2007 and 2014 will be utilized in all future surveys. A chi-square analysis showing the significance of change will be conducted. In addition, all plants will be vouchered and verified with the Wisconsin DNR as required by regional lakes coordinator.

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