An Aquatic Vegetation Survey of Carstens Lake

Manitowoc County, Wisconsin

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1.0 INTRODUCTION

Photo 1. Carstens Lake, Manitowoc County, WI

Carstens Lake is a 21-acre seepage lake located in southeastern Manitowoc County. It is a characteristically eutrophic system with elevated nutrient concentrations and low water clarity. The Manitowoc County Lakes Association and riparian property owners expressed concerns regarding increasing aquatic plant growth, specifically Eurasian water milfoil (*Myriophyllum spicatum*) within littoral areas of Carstens Lake.

In response to these concerns, Onterra ecologists conducted an aquatic plant point-intercept survey as described by the Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010 to characterize spatial distribution and abundance of submersed aquatic plants within Carstens Lake in July 2010.

The data collected during this survey indicates that the native species coontail (*Ceratophyllum demersum*) is the dominant plant within the plant community and has increased in occurrence by over 50% since a survey conducted in 2005. Eurasian water milfoil was the second-most frequently encountered species and actually decreased slightly in occurrence since 2005. It appears that the excessive aquatic plant growth hindering recreational activities and navigation is primarily caused by coontail. This report includes a detailed description of the 2010 survey methods, data analysis, as well as aquatic plant management recommendations.

2.0 AQUATIC PLANTS

Aquatic Plant Sampling Methodology and Data Analysis

Aquatic plants are an important element in every healthy aquatic ecosystem. Changes in these ecosystems are often first seen in the plant community. Whether these changes are positive, like variable water levels or negative, like increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways; there may be a loss of one or more species, certain life forms, such as emergents or floating-leaf communities may disappear from certain areas of the waterbody, or there may be a shift in plant dominance between species. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide very useful information for management decisions.

The aquatic plant survey that was completed on Carstens Lake assessed both native and non-native species in the system. A comprehensive survey of aquatic macrophytes was conducted to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. Specifically, the study was conducted in response to concerns brought about by the Manitowoc County Lakes Assocation regarding an increase in aquatic plant growth, primarily Eurasian water milfoil. The point-intercept method as described Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010 was used to complete this study in late July 2010. Based upon guidance from the WDNR, a point spacing of 30 meters was used resulting in 95 points.

At each point-intercept location within the littoral zone, information regarding the depth, substrate type (muck, sand, or rock), and the plant species sampled along with their relative abundance on the sampling rake was recorded. A pole-mounted rake was used to collect the plant samples, depth, and sediment information at point locations of 10 feet or less. A rake head tied to a rope (rope rake) was used at sites greater than 10 feet. At locations sampled with a rope rake, depth information was collected with the onboard sonar unit and information regarding substrate type was not collected due to the inability of the sampler to *feel* the bottom.

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the species that were found within the lake, both exotic and native. The list also contains the life-form of each plant found, its scientific name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in life-forms that are present, can be an early indicator of changes in the health of the ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of this project, plant samples were collected from plots laid out on a grid that covered the entire system. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, two types of data are displayed: littoral frequency of occurrence and relative frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are less than the maximum depth of plant growth (littoral zone). Littoral frequency is displayed as a percentage.

Relative frequency of occurrence uses the littoral frequency for occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

In the end, this analysis indicates the species that dominate the plant community within the lake. Shifts in dominant plants over time may indicate disturbances in the ecosystem. For instance, low water levels over several years may increase the occurrence of emergent species while decreasing the occurrence of floating-leaf species. Introductions of invasive exotic species may result in major shifts as they crowd out native plants within the system.

Species Diversity

Species diversity is probably the most misused value in ecology because it is often confused with species richness. Species richness is simply the number of species found within a system or community. Although these values are related, they are far from the same because diversity also takes into account how evenly the species are distributed within the system. A lake with 25 species may not be more diverse than a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

An aquatic system with high species diversity is much more stable than a system with a low diversity. This is analogous to a diverse financial portfolio in that a diverse aquatic plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. For example, a lake with a diverse plant community is much better suited to compete against exotic infestation than a lake with a lower diversity.

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed or pristine system. The higher the floristic quality, the closer the lake is to an undisturbed system. FQA is an excellent tool for comparing individual waterbodies and the same waterbody over time. In this section, the floristic quality of Carstens Lake will be compared to similar waterbodies within the same Wisconsin ecoregion and the entire state of Wisconsin (Figure 1).

Figure 1. Location of Carstens Lake within the ecoregions of Wisconsin. After Nichols 1999.

The floristic quality is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the waterbody; for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values are useful in assessing an aquatic ecosystem's plant community; however, the best assessment of the plant community's health is determined when the two values are used to calculate the floristic quality.

Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states.

Exotic Plants

Because of their tendency to upset the natural balance of an aquatic ecosystem, exotic species are paid particular attention to during the aquatic plant surveys. Two exotics, curly-leaf pondweed and Eurasian water milfoil are the primary targets of this extra attention.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 2). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes and rivers via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

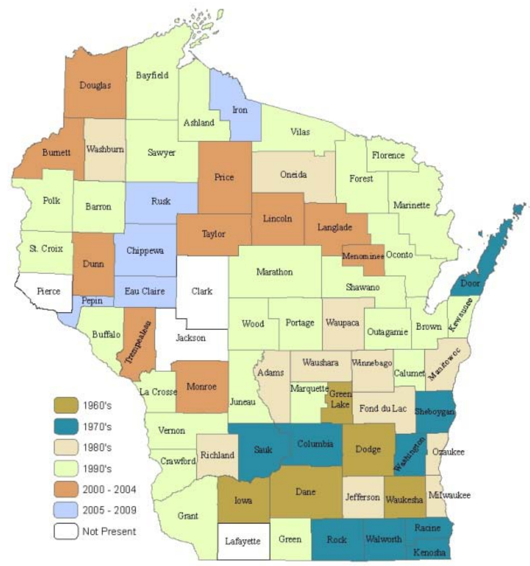

Figure 2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2009 mapped by Onterra.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle giving it a competitive advantage over our native plants. Curly – leaf pondweed begins growing almost immediately after ice-out and by mid-June is at peak biomass. While it is growing, each plant produces many turions (asexual reproductive shoots) along its stem. By mid-July most of the plants have senesced, or died-back, leaving the turions in the sediment. The turions lie dormant until fall when they germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in early May, giving the plant a significant jump on native vegetation. Like Eurasian water-milfoil, curly-leaf pondweed can become so abundant that it hampers recreational activities within the waterbody. Furthermore, its mid-summer die back can cause algal blooms spurred from the nutrients released during the plant's decomposition.

Aquatic Plant Point-intercept Survey Results

The aquatic plant point-intercept survey was conducted on Carstens Lake on July 30, 2010 by Onterra in response to concerns brought by the Manitowoc County Lakes Association and riparian property owners regarding increased growth of aquatic plants, primarily Eurasian water milfoil, throughout littoral areas of the lake. During the 2010 survey, 10 aquatic plant species were located in Carstens Lake (Table 1), including two non-native species: Eurasian water milfoil and curly-leaf pondweed. Approximately 90% of the point-intercept locations that fell within the maximum depth of plant growth (11 feet) contained aquatic vegetation. Figure 3 shows that aquatic vegetation is most abundant between 4 and 7 feet, but is relatively evenly distributed throughout the rest of the littoral area.

Table 1. Aquatic plant species located on Carstens Lake during July point-intercept survey.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2005	2010
E	*Typha latifolia*	Broad-leaved cattail	1		X
FL	*Nuphar variegata*	Spatterdock	6	X	X
	Nymphaea odorata	White water lily	6	X	X
FL/E	*Sparganium eurycarpum*	Common bur-reed	5		X
Submergent	*Ceratophyllum demersum*	Coontail	3	X	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	X	X
	Potamogeton crispus	Curly-leaf pondweed	Exotic		I
	Potamogeton foliosus	Leafy pondweed	6		X
FF	*Lemna turionifera*	Turion duckweed	9	X	X
	Wolffia sp.	Watermeal sp.	N/A		X

E = Emergent
FL = Floating Leaf
FL/E = Floating Leaf and Emergent
FF = Free Floating
X = present; I = Incidental

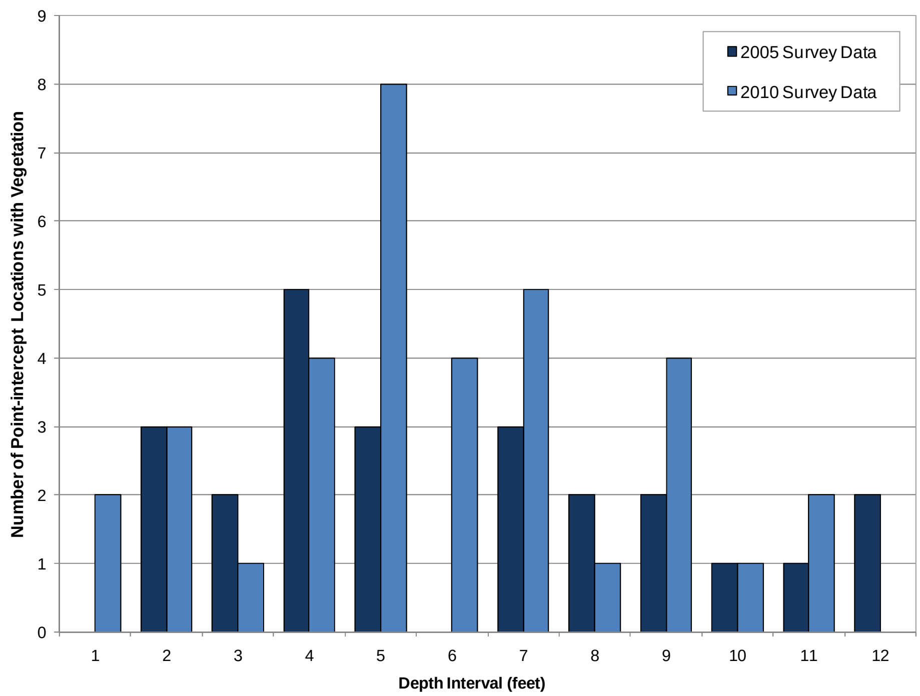

Figure 3. Carstens Lake aquatic plant distribution across littoral depths. Created using data from July 2010 survey.

In Carstens Lake, coontail was the most frequently encountered species, followed by Eurasian water milfoil, white water lily, and spatterdock (Figure 4). Coontail lacks true roots, often making its locations within a lake subject to water movement. Because of this, coontail has the capacity to aggregate and form dense mats at the surface as it becomes entangled in rooted plants, rocks, and other debris. Able to tolerate low-light conditions and acquire the majority of its nutrients directly from the water column, it thrives in high-nutrient (eutrophic) systems and often reaches nuisance levels affecting recreation and/or navigation. Carstens Lake has high nutrient concentrations and relatively low water clarity; ideal conditions for excessive coontail growth.

During the 2010 survey, coontail was observed matting on the surface throughout the entire littoral area of the lake (Photo 2). It is unrealistic to quantitatively define the term “nuisance,” as this designation is subjective by nature. However, the WDNR Science Services researchers indicate that nuisance levels of a given aquatic plant species likely occur when the littoral frequency of occurrence exceeds 35% (Alison Mikulyuk, personal comm.). In 2010, coontail within Carstens Lake had a littoral frequency of approximately 90%; well above this somewhat arbitrary nuisance level benchmark (Figure 4). The over abundance of coontail within Carstens Lake is not unexpected given the environmental state of the lake (high nutrient concentrations and low water clarity), and likely gives coontail a competitive advantage over other aquatic plant species that are not as tolerable of eutrophic conditions.

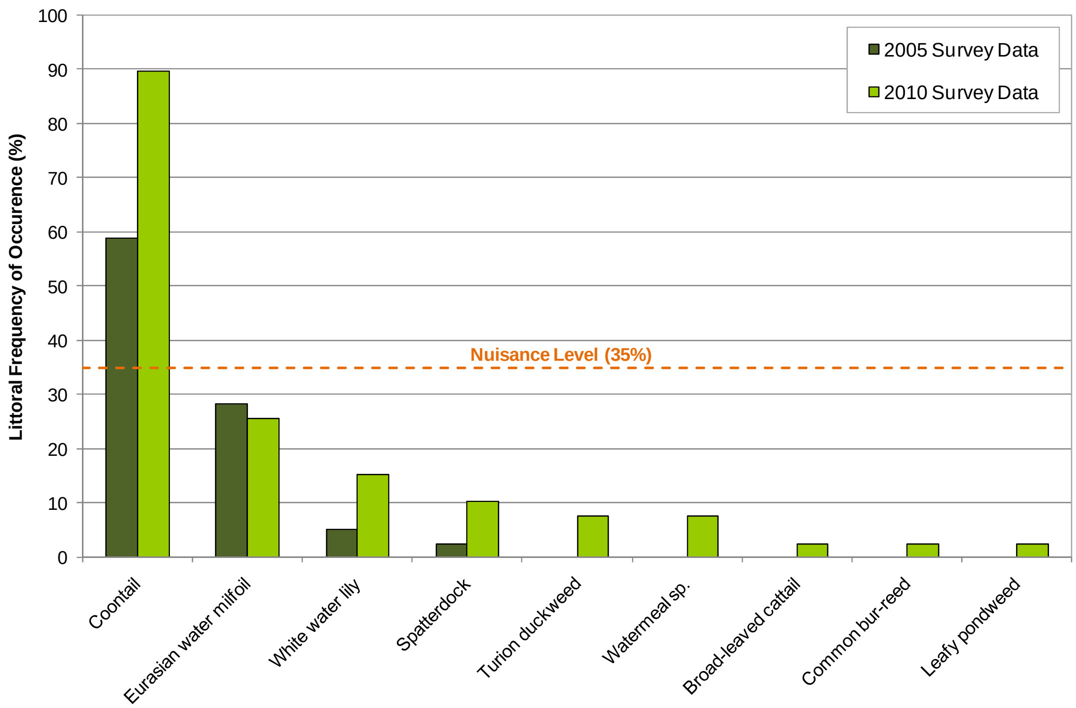

Figure 4. Carstens Lake aquatic plant littoral occurrence analysis. Created using data from July 2010 survey.

Photo 2. Excessive coontail growth on Carstens Lake. Left**:** Onterra ecologist with a rake-full of coontail. Right: Surface matting coontail covered in algae within the littoral zone of Carstens Lake. Photographs from 2010 survey.

Table 2 displays the results of statistical analysis (Chi-square analysis) applied to the 2005 and 2010 plant occurrence data, and shows that coontail increased in occurrence by over 50% during this period. The analysis indicates that this increase is "statistically significant," meaning that it is highly improbable that the increase in occurrence of coontail from 2005 to 2010 is due to random chance. However, no single factor can be attributed to this increase as many factors such as climate (temperature, precipitation, etc.,) are creating conditions favorable for abundant coontail growth. Fluctuations and cycles in aquatic plant species' occurrences are to be expected over time with climatic and other environmental variations. The coontail population in Carstens Lake may decline again at some point in the future, but will likely continue to hinder recreational activities.

						Chi-square Analysis	
Scientific Name	**Common Name**	**2005 FOO**	**2010 FOO**	**Percent Change**	**Direction**	**Statistically Different**	**p-value**
Ceratophyllum demersum	Coontail	59.0	89.7	52.2	▲	Yes	0.0019
Myriophyllum spicatum	Eurasian water milfoil	28.2	25.6	-9.1	▼	No	0.7985
Nymphaea odorata	White water lily	5.1	15.4	200.0	▲	No	0.1355
Nuphar variegata	Spatterdock	2.6	10.3	300.0	▲	No	0.1655
Lemna turionifera	Turion duckweed	0.0	7.7	100.0	▲	No	0.0773
Wolffia spp.	Watermeal sp.	0.0	7.7	100.0	▲	No	0.0773
Potamogeton foliosus	Leafy pondweed	0.0	2.6	100.0	▲	No	0.3142
Sparganium eurycarpum	Common bur-reed	0.0	2.6	100.0	▲	No	0.3142
Typha latifolia	Broad-leaved cattail	0.0	2.6	100.0	▲	No	0.3142

FOO = Frequency of Occurrence
▲ or ▼ = Significant Change (Chi-square; α = 0.05)
▲ or ▼ = Insignificant Change (Chi-square; α = 0.05)

Eurasian water milfoil, first documented in Carstens Lake in 1993, was the second-most frequently encountered species during the 2010 survey, and was found scattered throughout the entire littoral area (Map #). Despite concerns by the Manitowoc County Lakes Association that Eurasian water milfoil had increased in Carstens Lake, the Chi-square analysis revealed that there is no statistical difference in Eurasian water milfoil occurrence from 2005 and 2010 (Table 2). Though there is a fair amount of Eurasian water milfoil in Carstens Lake, the excessive plant growth impeding recreational activities is primarily caused by coontail. However, as discussed previously, fluctuations in species' occurrences do occur and Eurasian water milfoil may gain a competitive advantage and increase, for example, if conditions are less favorable for coontail.

In 2010, all species observed except for Eurasian water milfoil increased in their littoral frequency of occurrence, and overall, 90% of the point-intercept locations within the littoral zone contained aquatic plants in 2010 compared to 61% in 2005. Figure 3 displays the relative frequencies of occurrence (proportions) of plant species from the 2005 and 2010 surveys. Even though coontail has increased in littoral occurrence by over 50%, its proportion within the plant community only changed slightly from 2005 to 2010 (Figure 5). Due to an increase in occurrence of all other observed species except Eurasian water milfoil, its proportion within the plant community decreased in 2010 (Figure 3). This does not mean that there is significantly less Eurasian water milfoil in Carstens Lake; rather there is a greater amount of native vegetation relative to the amount Eurasian water milfoil in 2010 than in 2005.

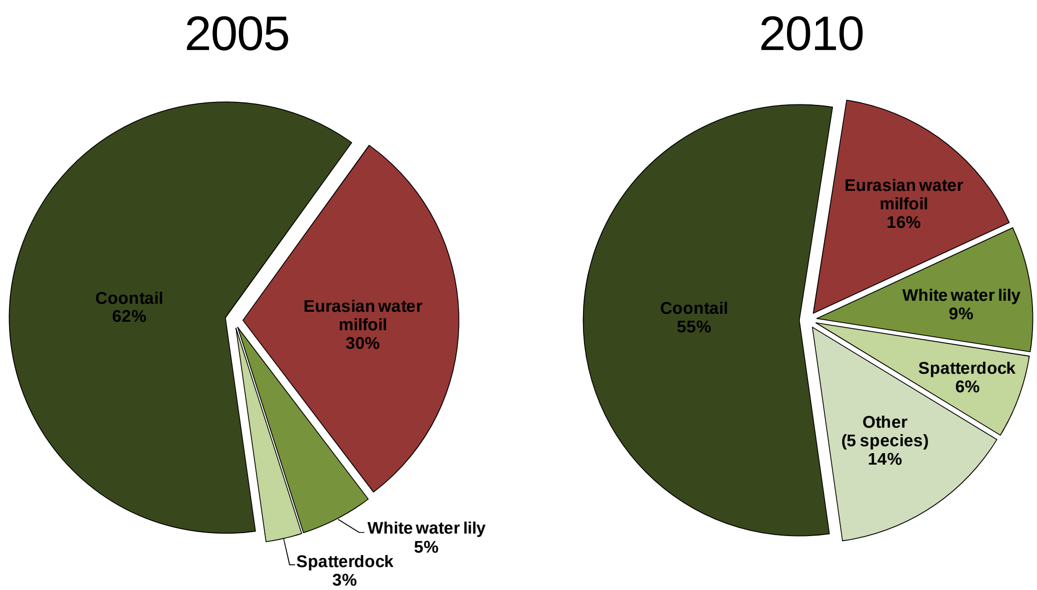

Figure 5. Carstens Lake aquatic plant relative frequency of occurrence analysis. Created using data from 2005 and 2010 aquatic plant surveys.

Carstens Lake contains a low number of native aquatic plant species, or has low species richness. Figure 6 shows that in both 2005 and 2010 the number of native plant species fell below both the Southeast Lakes Ecoregion and Wisconsin State medians. The lake also has low species diversity, with Simpson's diversity measures of 0.52 in 2005 and 0.66 in 2010. As mentioned earlier, how evenly the species are distributed throughout the system also influences the diversity. These values indicate that the plant species within the plant community of Carstens Lake are not evenly distributed and are dominated by a single or few species; in this instance, coontail dominates the plant community.

Eighty percent of the point-intercept locations contained mucky substrate while 20% contained sand (Map 2). Similar to terrestrial plants, most aquatic plant species favor this soft, nutrient-rich sediment. The combination of this substrate and high nutrient concentrations within the water column of Carstens Lake fuels vigorous aquatic plant growth. Map 3 displays the total-rake fullness ratings from the 2010 point-intercept survey. Not surprisingly, 94% of the point-intercept sampling locations that contained aquatic vegetation had the highest rake-fullness rating of 3.

Data collected from the aquatic plant surveys indicate that the average conservatism values from the 2005 and 2010 surveys also fall below both the ecoregion and state medians (Figure 6). This indicates that when compared to other lakes within the region and state, the plant community of Carstens Lake is of lower quality and indicative of a disturbed system. As discussed previously, in lakes with high nutrient inputs, like Carstens Lake, the species that are best adapted to access these nutrients directly from the water, like coontail, out-compete other species for space and light. Thus, the plant community within Carstens Lake is comprised of species that are more tolerant to environmental disturbance.

The Floristic Quality Index (FQI) was calculated for both the 2005 and 2010 plants surveys using the species richness and average conservatism values (equation shown below). Given the low species richness and low conservatism values, it is expected that Carstens Lake should have a low FQI value as well. The FQI values for 2005 and 2010 were well below ecoregion and state medians, further illustrating the poor state of the lake's plant community (Figure 6).

$$\text{FQI} = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

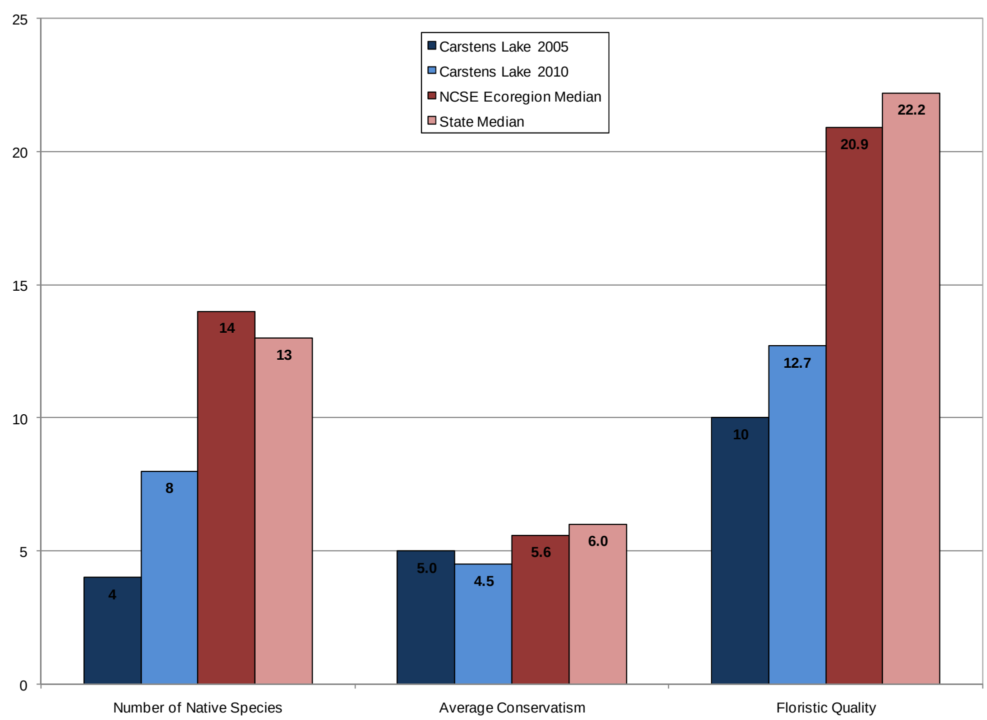

Figure 6. Carstens Lake floristic quality assessment. Created using data from July 2010 survey.

3.0 SUMMARY AND CONCLUSIONS

As stated in the Carstens Lake Management Plan (2000) and Treatment Feasibility Study (2003), an incredible amount of phosphorus exists in the lake, both as inputs through the lake's tributaries and through internal nutrient loading. These phosphorus sources fuel the incredible biomass of aquatic plants observed in Carstens Lake. Abundance of aquatic plants at this level can negatively impact the ecosystem by causing anoxic (without oxygen) conditions that result from the decomposition of plant and algal material during the winter months. Occasional winter fish kills have been observed on Carstens Lake resulting from this phenomenon and in cooperation with the Manitowoc County Lakes Association and the Manitowoc County Soil and Water Conservation Department, aeration systems have been installed to supply oxygen to the lake during the winter months.

Abundant aquatic vegetation can also greatly impede recreational activities on a lake. Carstens Lake stakeholders believe that aquatic vegetation has been increasing on the lake, which ultimately initiated the surveys reported on within this document. Knowing that the lake contains Eurasian water milfoil and being aware of the devastating impacts this non-native species can have over time likely lead to their conclusion that the issues they faced were due to Eurasian water milfoil. However, comparative analysis of the current survey with a survey conducted in 2005 indicates that Eurasian water milfoil occurrences have remained relatively constant. It appears that an increase in the lake's native species, particularly coontail, is causing the conditions that are concerning the lake stakeholders.

The commonly non-rooted coontail forms dense canopies in most areas of the lake and causes the nuisance conditions observed. The matted surface is a perfect area for filamentous algae to thrive as well as free-floating plant species such as duckweeds. All of this adds up to a great amount of water surface area that is non-navigable and likely alters the underlying water's dissolved oxygen levels and pH.

At this time, targeting Eurasian water milfoil will not alleviate the concerns brought forth by Carstens Lake stakeholders and therefore is not justified. If the goal of the Carstens Lake stakeholders is to facilitate access to open water areas of the lake, three possibilities exist: 1) manually remove the plants, 2) contract to have the plants cut and removed through mechanical harvesting, and 3) apply herbicides to kill the plants.

Manual removal techniques are allowable to all riparians and do not require a permit if the area of plant removal is no more than 30 feet wide and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within that 30 feet. While not applicable to Carstens Lake, please note that a permit is needed in all instances if wild rice is to be removed.

Mechanical harvesting is frequently used in some lakes in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. A typical mechanical harvesting plan would consist of creating navigation lanes (20-30 feet wide) that would allow riparians to have access to deeper parts of the system. Contracting a harvesting firm to conduct these actions carry significant costs and may not be feasible for a lake the size of Carstens. And while new technology has emerged, the equipment required for such activities still is quite large and bulky and tends to be quite difficult to use on small lakes without exceptional access locations.

Similar to mechanical harvesting, contracting a firm to apply an herbicide in navigation lanes (20-30 feet wide) to kill the plants within these areas is also an option. Because the target plants are two hearty dicot species (Eurasian water milfoil, coontail), herbicide application could be quite expensive due to the herbicide and concentrations required to kill the plants. While chemical use can have immediate results, there are numerous disadvantages including the following: unknown ecological risks, the plant biomass is not removed from the waterbody, but instead the plant tissue is left to decay; high per-acre cost; and the use of herbicides is often controversial among stakeholders.

If manual removal techniques are able to alleviate the nuisance conditions, they should be utilized first and foremost. However, if this method proves incapable of reducing the nuisance conditions on the lake, a defined plan of management would need to be developed that outlines the goals and locations that mechanical harvesting or herbicide application methods are implemented. This plan would require approval of the WDNR.

The last option not explored above is to do nothing. While this may seem least unfavorable to many riparians, the truth is that the conditions that have favored coontail over the past few years may change and the associated conditions may subside on their own.

4.0 LITERATURE CITED

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Nichols, S.A. 1999. Floristic quality assessment of Wisconsin lake plant communities with example applications. Journal of Lake and Reservoir Management 15(2): 133-141

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NES Ecological Services. 2003. Carstens Lake Alum Treatment Feasability Study. WDNR Project Number LPL-773-02 & LPL-774-02.

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Feet

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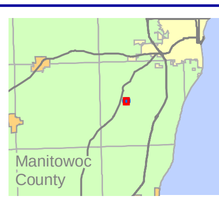
Sources:
Roads and Hydro: WDNR
Aquatic Plant Survey: Onterra, 2010
Map Date: 01/07/2011
Carstens_EWM_PB_Summer10



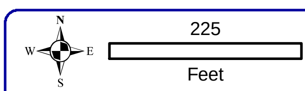
Extent of large map shown in red.

Legend

EWM Survey Results

- Highly Scattered
- Scattered
- Dominant *(None Found)*
- Highly Dominant *(None Found)*
- Surface Matting *(None Found)*

Map 3
Carstens Lake
Manitowoc County, Wisconsin
2010 EWM Survey Results



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Sources:
Roads and Hydro: WDNR
Aquatic Plant Survey: Onterra, 2010
Map Date: 01/07/2011
Carstens_TotalRakeFullness_2010

Extent of large map shown in red.

Legend

Aquatic Vegetation Total Rake Fullness

- Rake Fullness = 1 (None)
- Rake Fullness = 2
- Rake Fullness = 3

Map 3
Carstens Lake
Manitowoc County, Wisconsin
2010 P-I Survey
Total Rake-Fullness

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Sources:
Roads and Hydro: WDNR
Aquatic Plant Survey: Onterra, 2010
Map Date: 01/07/2011
Carstens_Sediment_2010

Extent of large map shown in red.

Legend

Sediment Types

- + No Data (Too Deep or Unreachable)
- Sand
- Muck

Map 2
Carstens Lake
Manitowoc County, Wisconsin

Point-intercept Survey
Sediment Types

A

APPENDIX A

Aquatic Plant Survey Data from 2005 and 2010.

Point Number	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P), Visual (V)	Notes	Ceratophyllum demersum	Myriophyllum spicatum	Nuphar variegata,Spatterdock	Nymphaea odorata,White water lily
1	44.026121	-87.765828	12	S	P		1			
2	44.025851	-87.765839	15	S	P					
3	44.025582	-87.765849	10	S	P			1		
4	44.025312	-87.765859	3.5	M	P		1	2		1
5	44.025042	-87.765869	2	M	P		1	2		1
6	44.026384	-87.765444	9	S	P					
7	44.026114	-87.765454	11	S	P					
8	44.025844	-87.765465	15	S	R					
9	44.025574	-87.765475	20	S	R					
10	44.025304	-87.765485	15	S	P					
11	44.025034	-87.765495	12	S	P					
12	44.024765	-87.765505	11	S	P					
13	44.024495	-87.765515	13	S	P					
14	44.024225	-87.765525	16		R					
15	44.023955	-87.765536	20			DEEP				
16	44.023685	-87.765546	7	M	P		1	V		V
17	44.026646	-87.765060	3.5	M	P		1	1		

Point Number	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P), Visual (V)	Notes	Ceratophyllum demersum	Myriophyllum spicatum	Nuphar variegata,Spatterdock	Nymphaea odorata,White water lily
18	44.026377	-87.765070	10	S						
19	44.026107	-87.765080	14	S	P					
20	44.025837	-87.765091	16		R					
21	44.025567	-87.765101	20		R					
22	44.025297	-87.765111	21		R					
23	44.025027	-87.765121				DEEP				
24	44.024757	-87.765131	21		R					
25	44.024487	-87.765141	22		R					
26	44.024217	-87.765151				DEEP				
27	44.023948	-87.765162	23		R					
28	44.023678	-87.765172	7	M	P		1	1		
29	44.026909	-87.764676	4	M	P		1	2		
30	44.026639	-87.764686	11	S	P					
31	44.026369	-87.764696	13	S	P					
32	44.026099	-87.764706	15	S	P					
33	44.025829	-87.764716	15	S	P					
34	44.025560	-87.764727	17			DEEP				

Point Number	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P), Visual (V)	Notes	Ceratophyllum demersum	Myriophyllum spicatum	Nuphar variegata,Spatterdock	Nymphaea odorata,White water lily
35	44.025290	-87.764737	23			DEEP				
36	44.025020	-87.764747				DEEP				
37	44.024750	-87.764757	16		R					
38	44.024480	-87.764767	18		R					
39	44.024210	-87.764777	14	S	P					
40	44.023940	-87.764787	5	M	P		1	2	V	V
41	44.026902	-87.764302	12	M	P					
42	44.026632	-87.764312				DEEP				
43	44.026362	-87.764322				DEEP				
44	44.026092	-87.764332				DEEP				
45	44.025822	-87.764342				DEEP				
46	44.025552	-87.764353				DEEP				
47	44.025282	-87.764363				DEEP				
48	44.025012	-87.764373				DEEP				
49	44.024743	-87.764383	11	S	P					
50	44.024473	-87.764393	4	M	P		1	2	V	
51	44.024203	-87.764403				TERRESTRIAL				

Point Number	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P), Visual (V)	Notes	Ceratophyllum demersum	Myriophyllum spicatum	Nuphar variegata,Spatterdock	Nymphaea odorata,White water lily
52	44.026894	-87.763928	8	M	P		1			
53	44.026625	-87.763938	14		R					
54	44.026355	-87.763948				DEEP				
55	44.026085	-87.763958				DEEP				
56	44.025815	-87.763968				DEEP				
57	44.025545	-87.763978				DEEP				
58	44.025275	-87.763989				DEEP				
59	44.025005	-87.763999	9	M	P		1			
60	44.024735	-87.764009				TERRESTRIAL				
61	44.026617	-87.763564	9	S	P		1			
62	44.026347	-87.763574	21		R					
63	44.026077	-87.763584				DEEP				
64	44.025808	-87.763594				DEEP				
65	44.025538	-87.763604				DEEP				
66	44.025268	-87.763615	11	M	P					
67	44.024998	-87.763625	2	M	P		1	1	1	
68	44.026610	-87.763190	7.5	S	P					

Point Number	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P), Visual (V)	Notes	Ceratophyllum demersum	Myriophyllum spicatum	Nuphar variegata,Spatterdock	Nymphaea odorata,White water lily
69	44.026340	-87.763200				DEEP				
70	44.026070	-87.763210				DEEP				
71	44.025800	-87.763220				DEEP				
72	44.025530	-87.763230				DEEP				
73	44.025260	-87.763241	8	S	P		1			
74	44.026603	-87.762816	10	M	P					
75	44.026333	-87.762826				DEEP				
76	44.026063	-87.762836				DEEP				
77	44.025793	-87.762846				DEEP				
78	44.025523	-87.762856				DEEP				
79	44.025253	-87.762866	6.5	S	P		1			
80	44.026595	-87.762442	9	S	P					
81	44.026325	-87.762452				DEEP				
82	44.026055	-87.762462				DEEP				
83	44.025786	-87.762472				DEEP				
84	44.025516	-87.762482	12	S	P		V	V		
85	44.025246	-87.762492	3	M	P		1	2		

Point Number	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P), Visual (V)	Notes	Ceratophyllum demersum	Myriophyllum spicatum	Nuphar variegata,Spatterdock	Nymphaea odorata,White water lily
86	44.026588	-87.762068	5	M	P					
87	44.026318	-87.762078	12	M	P		1			
88	44.026048	-87.762088	13	M	P					
89	44.025778	-87.762098	11	S	P		1			
90	44.025508	-87.762108	9	S	P					
91	44.025238	-87.762118	2	M	P		1	V	V	
92	44.026311	-87.761704	3.5	M	P		1	1		
93	44.026041	-87.761714	5	M	P		1	V		
94	44.025771	-87.761724	5	M	P		1			
95	44.025501	-87.761734	2.5	M	P		1		V	

Point Number	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Notes	Ceratophyllum demersum	Myriophyllum spicatum	Nymphaea odorata	Nuphar variegata	Wolffia sp.	Lemna turionifera	Potamogeton foliosus	Sparganium eurycarpum	Typha latifolia
1	44.026121	-87.765828	9	M	P		3								
2	44.025851	-87.765839	17		R	No Vegetation									
3	44.025582	-87.765849	9	M	P		3								
4	44.025312	-87.765859	7	M	P		3	1							
5	44.025042	-87.765869	4	M	P		3		1			1			
6	44.026384	-87.765444	6	M	P		3					1			
7	44.026114	-87.765454	15			To Deep									
8	44.025844	-87.765465	21			To Deep									
9	44.025574	-87.765475	17			To Deep									
10	44.025304	-87.765485	13			To Deep									
11	44.025034	-87.765495	11		R	No Vegetation									
12	44.024765	-87.765505	11		R	No Vegetation									
13	44.024495	-87.765515	11		R	No Vegetation									
14	44.024225	-87.765525	19			To Deep									
15	44.023955	-87.765536	20			To Deep									
16	44.023685	-87.765546	5	M	P		3		1		1	1			
17	44.026646	-87.765060	4	M	P		3				1				
18	44.026377	-87.765070	11	M	P	No Vegetation									
19	44.026107	-87.765080				To Deep									

Point Number	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Notes	Ceratophyllum demersum	Myriophyllum spicatum	Nymphaea odorata	Nuphar variegata	Wolffia sp.	Lemna turionifera	Potamogeton foliosus	Sparganium eurycarpum	Typha latifolia
20	44.025837	-87.765091				To Deep									
21	44.025567	-87.765101				To Deep									
22	44.025297	-87.765111				To Deep									
23	44.025027	-87.765121				To Deep									
24	44.024757	-87.765131				To Deep									
25	44.024487	-87.765141				To Deep									
26	44.024217	-87.765151				To Deep									
27	44.023948	-87.765162				To Deep									
28	44.023678	-87.765172	5	M	P		3	1							
29	44.026909	-87.764676	5	M	P		3								
30	44.026639	-87.764686				To Deep									
31	44.026369	-87.764696				To Deep									
32	44.026099	-87.764706				To Deep									
33	44.025829	-87.764716				To Deep									
34	44.025560	-87.764727				To Deep									
35	44.025290	-87.764737				To Deep									
36	44.025020	-87.764747				To Deep									
37	44.024750	-87.764757				To Deep									
38	44.024480	-87.764767				To Deep									

Point Number	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Notes	Ceratophyllum demersum	Myriophyllum spicatum	Nymphaea odorata	Nuphar variegata	Wolffia sp.	Lemna turionifera	Potamogeton foliosus	Sparganium eurycarpum	Typha latifolia
39	44.024210	-87.764777				To Deep									
40	44.023940	-87.764787	5	M	P		3		1						
41	44.026902	-87.764302	9	M	P		3								
42	44.026632	-87.764312				To Deep									
43	44.026362	-87.764322				To Deep									
44	44.026092	-87.764332				To Deep									
45	44.025822	-87.764342				To Deep									
46	44.025552	-87.764353				To Deep									
47	44.025282	-87.764363				To Deep									
48	44.025012	-87.764373				To Deep									
49	44.024743	-87.764383	6	M	P		3								
50	44.024473	-87.764393	4	M	P		3		1	1					
51	44.024203	-87.764403	1	S	P		3	1	1	1				1	1
52	44.026894	-87.763928	5	M	P		3	1							
53	44.026625	-87.763938	12		R	No Vegetation									
54	44.026355	-87.763948				To Deep									
55	44.026085	-87.763958				To Deep									
56	44.025815	-87.763968				To Deep									
57	44.025545	-87.763978				To Deep									

Point Number	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Notes	Ceratophyllum demersum	Myriophyllum spicatum	Nymphaea odorata	Nuphar variegata	Wolffia sp.	Lemna turionifera	Potamogeton foliosus	Sparganium eurycarpum	Typha latifolia
58	44.025275	-87.763989				To Deep									
59	44.025005	-87.763999	6	M	P		3								
60	44.024735	-87.764009	1	S	P		3		1				1		V
61	44.026617	-87.763564	8	M	P		2								
62	44.026347	-87.763574				To Deep									
63	44.026077	-87.763584				To Deep									
64	44.025808	-87.763594				To Deep									
65	44.025538	-87.763604				To Deep									
66	44.025268	-87.763615				To Deep									
67	44.024998	-87.763625	4	M	P		3								
68	44.026610	-87.763190	7	M	P		3								
69	44.026340	-87.763200				To Deep									
70	44.026070	-87.763210				To Deep									
71	44.025800	-87.763220				To Deep									
72	44.025530	-87.763230				To Deep									
73	44.025260	-87.763241	6	M	P		3								
74	44.026603	-87.762816	7	M	P		3								
75	44.026333	-87.762826				To Deep									
76	44.026063	-87.762836				To Deep									

Point Number	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Notes	Ceratophyllum demersum	Myriophyllum spicatum	Nymphaea odorata	Nuphar variegata	Wolffia sp.	Lemna turionifera	Potamogeton foliosus	Sparganium eurycarpum	Typha latifolia
77	44.025793	-87.762846				To Deep									
78	44.025523	-87.762856				To Deep									
79	44.025253	-87.762866	2	S	P		3	1		1					
80	44.026595	-87.762442	9	M	P		3								
81	44.026325	-87.762452				To Deep									
82	44.026055	-87.762462				To Deep									
83	44.025786	-87.762472				To Deep									
84	44.025516	-87.762482	12		R	No Vegetation									
85	44.025246	-87.762492	2	S	P		3	2							
86	44.026588	-87.762068	7	M	P		3								
87	44.026318	-87.762078	10	M	P		3								
88	44.026048	-87.762088	11	M	P		3								
89	44.025778	-87.762098	11	M	P		2								
90	44.025508	-87.762108	7	M	P		3								
91	44.025238	-87.762118	2	M	P		3	1							
92	44.026311	-87.761704	5	S	P		3	1			1				
93	44.026041	-87.761714	5	S	P		3	1							
94	44.025771	-87.761724	5	S	P		3			1					
95	44.025501	-87.761734	3	S	P		3	1							