AQUATIC PLANT MANAGEMENT PLAN

FOR

LAKE MONONA
Lower Rock River Basin

DANE COUNTY, WISCONSIN

Turville Bay with American lotus

December 2011

OFFICE OF LAKES AND WATERSHEDS
DANE COUNTY LAND AND WATER RESOURCES DEPARTMENT
1 FEN OAK COURT, ROOM 234
MADISON, WI 53718

Prepared by
Agrecol Environmental Consulting, LLC
(Dave Marshall)

And

Dane County Land & Water Resources
Department Staff
(Sue Jones, Jim Leverance, Darren Marsh, and Michelle Richardson)

Edited by
Sue Jones

Cover photo by Dave Marshall

Survey Crew:
Dave Marshall, Richard Wedepohl, Jon Standridge, Kara Naramore, Jim Leverance, Helen Larson, Wendy Weisensel, Dave Grey

Preparation of this plan was funded in part by a Wisconsin Department of Natural Resources Lake Planning Grant

This plan was approved by the Wisconsin Department of Natural Resources in December 2011

Summary

An aquatic plant survey was performed during the summer of 2008 on Lake Monona. A total of 754 sites were sampled across the lake. Two hundred-eighty of the sites were located within Monona Bay. Results of the point intercept survey indicated that Eurasian watermilfoil (EWM) and coontail were the most frequently collected rooted plants in 2008, a consistent pattern in recent decades. Coontail was the most dominant plant in Monona Bay and reflected a pronounced EWM decline within the bay in 2008. Species richness of rooted plants was much higher in primary lake basin (12) than in Monona Bay (5). While species richness did not increase compared to surveys performed from 1990 to 1992, a few species were found that had not been identified in decades. American lotus had not been collected since 1961 and stiff water crowfoot had not been collected since 1929 in the larger basin. In 2006 City of Madison staff collected stiff water crowfoot and small pondweed in Monona Bay. Both American lotus and stiff water crowfoot were found in Turville Bay, an area previously identified as "natural area" and proposed "Sensitive Area." Turville Bay is recommended as a Sensitive Area designation under Wisconsin Administrative Code NR 107.05(3-i). Species that were not found in 2008 but were found in 1990-92 were flat-stem pondweed and northern water milfoil. The later species typically hybridizes with EWM and often renders field identification nearly impossible. The north shore of Monona Bay is also recommended as a Sensitive Area.

Public comment on the draft plan was solicited on the Dane County Office of Lakes and Watersheds website, and publicized using various forms of electronic communication.

Recommendations

1. Conduct large-scale mechanical harvesting in areas where EWM grows in dense monotypic stands. Goals for managing EWM are to improve boating access and fish habitat, and to expand native rooted plant species.
2. Prohibit chemical herbicide treatments in Sensitive Areas (see Figures 11 and 12) except in areas where monotypic stands of EWM occur and goals should include

improving fish habitat and expanding native rooted plants. Sensitive Areas are relatively undeveloped areas supporting coarse woody debris; floating-leaf plants including American lotus (*Nelumbo lutea*) and white water lily (*Nymphaea odorata*); and submersed native plant species including clasping-leaf pondweed (*Potamogeton richardsonii*), sago pondweed (*Struckenia pectinatus*), leafy pondweed (*Potamogeton foliosus*), water stargrass (*Heteranthera dubia*), and wild celery (*Vallisneria Americana*).

3. Chemical herbicide treatments should focus on the selective control of Eurasian watermilfoil – EWM (*Myriophyllum spicatum*) since several native pondweeds and other valuable native species have increased in the lake. Research on experimental early season chemical control and other techniques should continue.
4. Consider options for reducing motorboat impacts to floating-leaf plants (American lotus and white water lily) in Turville Bay.
5. Consider expanding floating-leaf plant beds and introducing high value species (historically found in the lake) within sheltered bays.
6. Dane County's mechanical harvesting crews should continue to take steps to prevent the spread of exotic invaders across Dane County lakes. These steps include removing any visible plants, mud, debris, water, fish or animals from the machinery and thoroughly washing the equipment. The fact sheet in Appendix A is included in the harvesting crews' operations manual.

Introduction

As required in Wisconsin Administrative Code NR 109.04(d), the purpose of this plan is to guide mechanical harvesting activities and the effective management of aquatic plants in Lake Monona. This plan also updates a previous aquatic plant management plan prepared in 1993 (Winkelman and Lathrop). Dane County periodically operates mechanical harvesters in Lake Monona to reduce dense beds of exotic EWM and exotic curly-leaf pondweed – CLP (*Potamogeton crispus*). Native coontail (*Ceratophyllum demersum*) beds are targeted when densities undermine recreational uses. Dense stands of these "weedy" plants have undermined boating access and other recreational uses in the lake. Harvesting efforts have been designed to enhance important lake management functions.

Aquatic plant beds in Lake Monona have changed significantly since the nineteenth century. The combination of declining water quality, invasions of non-native carp (*Cyprinus carpio*) and weedy plants (EWM and CLP), shoreline development, herbicide treatments and heavy motorboat traffic have altered the plant communities in the lake (Nichols and Lathrop 1994). Since Lake Monona is the most urbanized lake of the Yahara chain of lakes, shoreline development has likely been a greater factor than in the other lakes, particularly as historic wetlands were drained. As a result, several high value native species had not been collected in decades while other native species have declined substantially from the lake. Lake Monona has supported the lowest species richness in the Yahara Chain of Lakes, a likely symptom of urbanization and historic wastewater discharges. More detailed discussions on the trends and environmental impacts on aquatic plants in Lake Monona can be found in *Cultural Impacts on Macrophytes in the Yahara Lakes Since the Late 1800s (*Nichols and Lathrop 1994) and *Aquatic Plants in Lake Monona: Their Status and Implications for Management* (1993).

The primary goals in preparing this plan were to establish long-term realistic objectives for managing nuisance exotic plant species while protecting valuable native species and their important habitat functions. While the goal was not to create a comprehensive lake management plan, aquatic plant community relationships with other aspects of lake and watershed management cannot be ignored.

Goals

Because Eurasian watermilfoil has dominated the littoral zone for several decades, the goals for managing Lake Monona aquatic plants are to (1) improve recreational access in the lake, (2) identify and protect Sensitive Areas defined under Wisconsin Administration NR 107.05(3-i) and (3) restore documented declines and possible of high value species [NR 107.08(4)] in the lake including clasping-leaf pondweed (*Potamogeton richardsonii*), horned pondweed (*Zannichelia palustris*), wild celery (*Vallisneria*

Americana) and sago pondweed (*Struckenia pectinatus*). Other important native plants that have declined in Lake Monona and also require protection include flat-stem pondweed (*P. zosteriformis*) yellow water lily (*Nuphar*), white water lily (*Nymphaea tuberosa*), American lotus (*Nelumbo lutea*), *Chara*, slender naiad (*Najas flexilis*), leafy pondweed (*Potamogeton foliosus*), and water stargrass (*Heteranthera dubia*).

Background Information

Lake Monona (3,270 acres) is the second largest lake in the Yahara Chain and second in line below Lake Mendota (Figure 1). The lake has a maximum depth of 74 feet and shoreline length of 13.2 miles. This deep lake was formed by a moraine damming the pre-glacial Yahara River (Day et al. 1985). Excluding the land area that drains into Lake Mendota, the direct watershed area surrounding Lake Monona is 45.7 square miles and is primarily an urban landscape. Lake Monona typically displays more advanced eutrophic symptoms (primarily algal blooms and reduced water clarity) than Lake Mendota and reflects in part more numerous historic municipal and industrial wastewater effluents that were discharged to the lake and more extensive urbanization (Dane County Regional Planning Commission 1979). Adapted from the former authors, Table 1 lists the chronology of historic point source discharges into Lake Monona. Point source discharges had been diverted from the lake by 1950, yet internal loading from these historic sources and continued urban runoff continue to influence water quality in the lake. Lake Monona is somewhat less eutrophic than either Lake Waubesa or Lake Kegonsa because it is deeper and less likely to de-stratify during the summer growing season (Lathrop 1990).

Figure 1: Lake Monona and Monona Bay location within Dane County

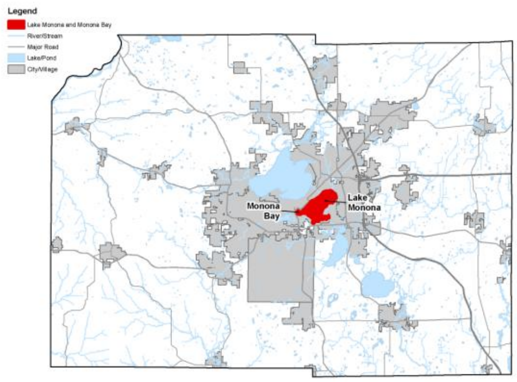


Table 1: History of point source effluents that discharged to Lake Monona

Time Period	**Wastewater Treatment Method**	**Documented Environmental Concerns**
1820 - 1886	Privies, cesspools, private sewers, brewery discharges.	Algal blooms reported.
1886 - 1898	Public sewers without treatment.	
1898 - 1902	1st sewage treatment plant (STP), ineffective.	
1902 - 1914	Turneaure STP constructed and reached capacity reached by 1906.	Lake users reported decreased aquatic nuisances.
1914 - 1926	Burke STP, primary settling and trickling filters built.	Survey of offensive odors on lake, Burke plant considered ineffective. Extensive copper sulfate treatments begin to control algae.
1926 - 1936	First unit of Nine Springs STP built to relieve Burke STP overloading	Madison Metropolitan Sewerage District formed to address wastewater treatment issues. Clearer water and more rooted plants linked to algal treatments.
1936	Burke STP closed	
1942 - 1946	Burke STP reactivated to serve military base	Objectionable odors linked to decomposing algae.
1947 - 1950	Burke STP reactivated during installation of east side interceptor, numerous untreated industrial discharges identified.	
1950	All municipal discharges diverted to Nine Springs STP	Heavy applications begin of now banned sodium arsenite to manage “weeds”.

The long-term effects of eutrophication, habitat destruction and herbicide applications have been altering aquatic plant communities in the lake for decades. Beginning in the early 1900’s, Lake Monona was considered densely vegetated with both Turville Bay and Squaw Bay supporting abundant growths of water lilies and American lotus (Nichols and Lathrop 1994). Dredging and filling destroyed shallow littoral areas and wetlands around the lake while declines in water clarity reduced the maximum depth for growth. Management of Monona Bay represented a unique arrangement that would have otherwise violated the Public Trust Doctrine. A 1908 lease agreement between shoreline owners and the Madison Park and Pleasure Drive (transferred to the City of Madison in 1937) allowed extensive dredging and filling large areas of the littoral zone (Winkelman and Lathrop 1993). In the early 1900’s, the maximum depth of aquatic plant growth in Lake Monona was approximately 10 feet but declined to less than 6 feet by 1951 (Nichols and Lathrop 1994). More recently, rooting depths for aquatic plants had increased to about 13 feet, reflecting improved water clarity. Coinciding with the trend of declining water clarity, which continued through the 1960s, and other factors mentioned above was the decline of wild celery, muskgrass, flatstem pondweed, water crowfoot, sago pondweed, spatterdock, white water lily, American lotus and other species.

During the period when municipal and industrial wastewater effluents entered Lake Monona, severe water quality problems in the form of Cyanobacteria blooms were treated with extensive copper sulfate applications. Between 1925 and 1960, over 1,545,000 pounds of copper sulfate were applied to control odors associated with planktonic algae in Lake Monona (Dane County Regional Planning Commission 1979). The chemically suppressed algae resulted in clearer water at times when copper sulfate application rates were high. In 1935, the maximum depth of the littoral zone reached 18 feet during chemically induced clear water conditions. However, the total area of rooted plant growth was limited since nearshore areas were treated with sodium arsenite, a chemical that was banned in 1964. The long-term legacy of inorganic herbicides use was the significant accumulation of both arsenic and copper in deep-water lake sediments. In 1958, organic herbicides were first introduced for rooted plant control including now banned 2, 4, 5-TP. To this date, chemical herbicides treatments are more extensive in Lake Monona than in the other Yahara Lakes. Chemical treatments focus on selective control of EWM and filamentous algae in the nearshore areas while the outer littoral zones are managed with mechanical harvesters.

In addition to declining water quality and extensive chemical treatments, other factors that lead to native plant declines include exotic invasions of common carp, EWM and to a much lesser extent CLP. Carp were introduced into Lake Monona between 1897 and 1893. Direct impacts of carp include uprooting and roiling the bottom sediments during feeding and spawning. EWM appeared to have a pronounced impact as native plant declines coincided with rapid expansion of the exotic plant by 1966 (Nichols and Lathrop 1994). Because they begin their growth early in the year, both EWM and CLP can create dense canopies before native species emerge from winter dormancy. For approximately a decade after its introduction, EWM became well established in Lake Monona and remained very abundant until the first noted decline in 1976. Since then, periodic declines and resurgence of EWM have occurred in Lake Monona and in the other Yahara lakes, a typical sequence found for EWM and other exotic plant invasions (Nichols 1994, Smith and Barko 1992). Compared with EWM, CLP growth trends have been insignificant and had minor impacts on native plants in Lake Monona

EWM has undermined boating, fishing, water skiing, and swimming in Lake Monona. This is a common pattern found throughout the United States when EWM enters a lake (Nichols 1994, Smith and Barko 1990). In addition to human use impairments, the ecological side effects of dense stands of EWM and other weedy plants on fisheries have been extensively evaluated (Engel 1987, Dibble et al. 1996, Olson et al. 1998, Savino and Stein 1982, Trebitz et al. 1997). Dense EWM beds have been linked with slow fish growth rates in some lakes. However the effects of EWM on panfish and predator growth rates in Lake Monona are not significant. Growth rates and production of a variety of sportfishes in Lake Monona have been considered excellent for decades. In Lake Mendota, EWM may have contributed to the disappearance of nongame fishes including banded killifish (*Fundulus diaphanus*), blackstripe topminnow (*Fundulus* *notatus*) blackchin shiner (*Notropis heterodon*), blacknose shiner (*Notropis heterolepis*), pugnose shiner (*Notropis anogenus*), and tadpole madtom (*Noturus gyrinis*) (Lyons 1996). Other factors such as shoreline development and piers may have also affected these species due to their strong affinity for nearshore aquatic plant habitat (Garrison et al. 2005, Bryan and Scarnecchia 1992, Becker 1983, Gaumitz 2005, Marshall and Lyons 2008). Heavy motorboat traffic has also been linked to declining aquatic plant habitat in lakes (Asplund and Cook 1997).

In addition to the nongame fish declines noted above, Lake Monona supports diverse warmwater fisheries including coolwater cisco (*Coregonus artedii*), a member of the trout and salmon family (Salmonidae). The fish species list also includes lake sturgeon (*Acipenser fulvescens*), longnose gar (*Lepisosteus osseus*), bowfin (*Amia calva*), northern pike (*Esox lucius*), musky (*Esox masquinongy*), common carp (*Cyprinus carpio*), golden shiner (*Notemigonus crysoleucas*), emerald shiner (*Notropis atherinoides*), common shiner (*Notropis cornutus*), bluntnose minnow (*Pimephales notatus*), fathead minnow (*Pimephales promelas*), white sucker (*Catostomus commersoni*), bigmouth buffalo (*Ictiobus cyprinellus*), black bullhead (*Ameiurus melas*), yellow bullhead (*Ameiurus melas*), brown bullhead (*Ameiurus nebulosus*), channel catfish (*Ictalurus punctatus*), burbot (*Lota lota*), brook silverside (*Labedesthes sicculus*), white bass (*Morone chrysops*), yellow bass (*Morone mississipiensis*), rock bass (*Ambloplites rupestris*), green sunfish (*Lepomis cyanellus*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), white crappie (*Pomoxis annularis*), black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), logperch (*Percina caprodes*), Iowa darter (*Etheostoma exile*), johnny darter (*Etheostoma nigrum*), walleye (*Stizostediun vitreum*), freshwater drum (*Aplodinotus grunniens*) and mottled sculpin (*Cottus bairdi*) – (Day et al. 1985).

High mercury in lake sediments from historic wastewater discharges is a concern due to bioaccumulation of methyl-mercury in fish and the fish consumption advisory. While mercury in sediments are at higher levels most lakes in the state, mercury levels in fish have consistently been lower than those found in many other lakes with lower alkalinities and higher rates of anaerobic bacterial conversion of inorganic mercury to methyl-mercury. Lakes with lower alkalinities (closer to neutral or below 7 on the pH scale) are typically found in northern Wisconsin. They are often referred to as northern shield lakes. These lakes are found in soils that have low amounts of calcium and magnesium, which results in lower alkalinities. Most mercury found in these northern lakes is a result of mercury contribution from rain and snow. Anaerobic (low or no oxygen) conditions then facilitate the process of methylation of mercury, or changing its form to one that can readily enter the food chain.

Recent Chemical and Harvesting Aquatic Plant Management Records

Dane County's mechanical harvesting program typically runs from mid-May to mid-August each summer. Harvesting is not conducted in water less than three feet deep. Harvesting staff at times will operate the machines in waters shallower than three feet, but only to scoop up floating plants. The cutting head of the harvesters are lifted up so as to avoid disturbing sediment during these floating plant collection times. Priority harvesting includes emergency flood relief, boat navigation and public access areas such as beaches and boat landings. Harvested plants are composted. Figure 2 contains the annual tonnage of aquatic plants harvested from Lake Monona from 1989 to 2008. Figure 3 indicates harvesting tonnages from Monona Bay from 1989 to 2006. Harvesting efforts typically focus on EWM but also include dense coontail beds. Figure 4 is a map of priority harvesting areas within Lake Monona. Background on establishment of harvesting priorities is found at www.countyofdane.com/lwrd/parks/aquatic_plant_harvesting.aspx.

Figure 2: Lake Monona mechanical harvesting summary

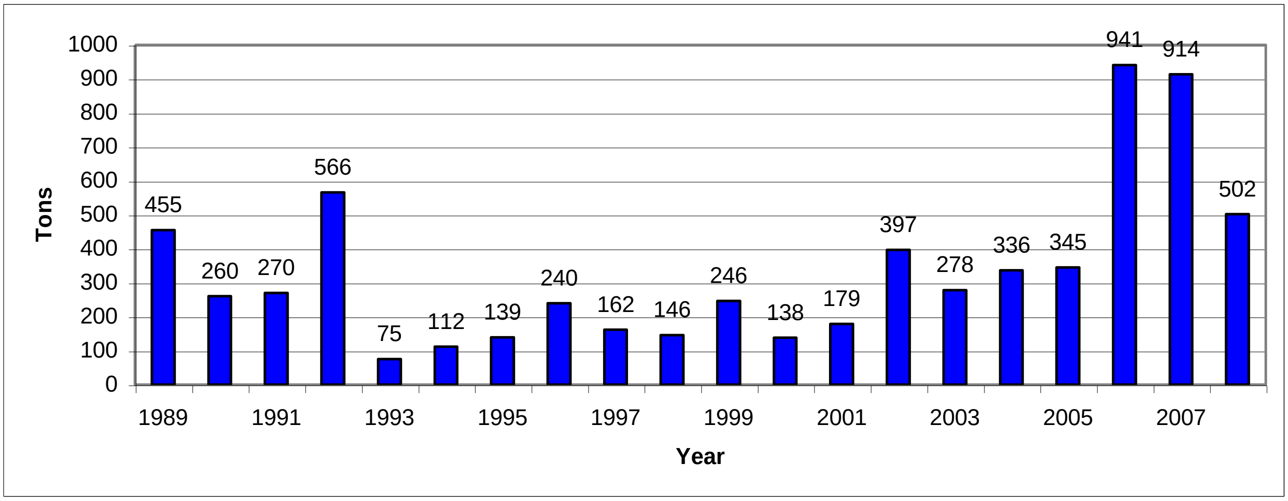


Figure 3: Monona Bay mechanical harvesting summary

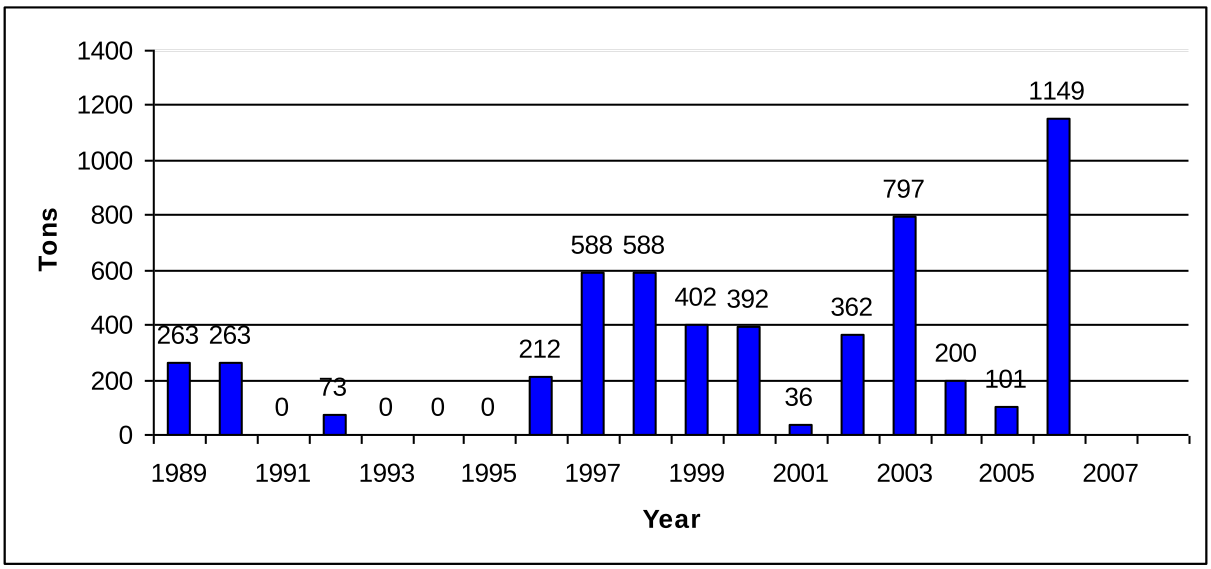
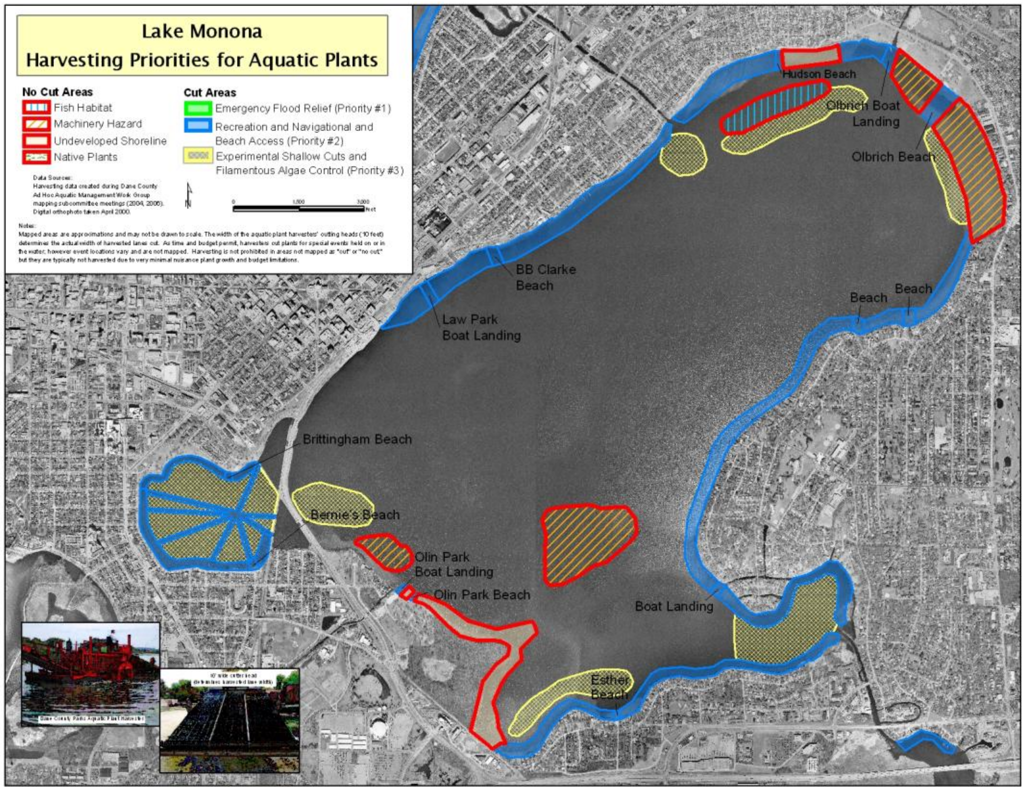
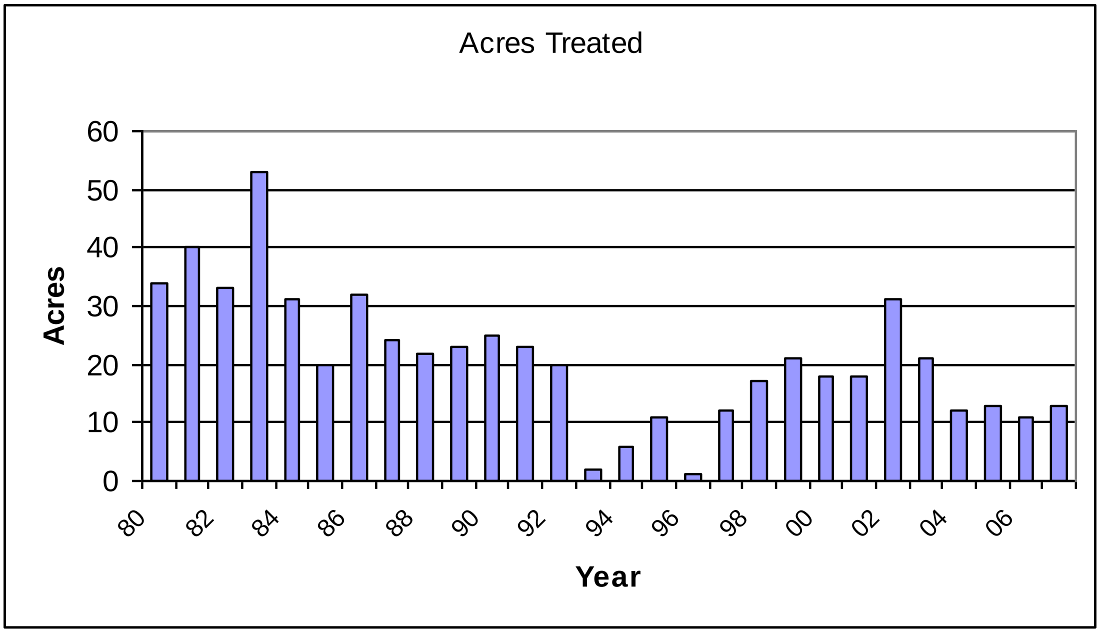


Figure 4: Lake Monona mechanical harvesting priority areas for aquatic plants



While Dane County operates mechanical harvesting equipment in water deeper than three feet, a number of the private riparian property owners collectively hire one or more certified chemical applicators each year for nuisance plant control in shallower waters. These chemical herbicide applications are for individual property owners and include areas adjacent to their docks. Chemical applications have been a controversial issue for managing aquatic plants in the Yahara lakes since the 1970s, primarily due to concerns over potential unknown ecological and health effects. Potential adverse impacts of chemical applications include damage to non-target organisms and change to ecosystem functions. In general, chemical applications have been fairly consistent over the last few decades and treatment areas have been relatively modest in relation to the total littoral zone in the lake. One concern has been that herbicide treatments focus on near shore plant communities where most of the native plants occur. Figure 5 lists total littoral zone acres treated annually for EWM and filamentous algae from 1980 to 2007.

Figure 5: Acres chemically treated in Lake Monona by private entities



2008 Aquatic Plant Survey Update

Methods

Jen Hauxwell, a research scientist with the Wisconsin Department of Natural Resources (WDNR) Bureau of Integrated Science Services, developed the point intercept sampling protocol. The point intercept method involves a large number of sampling sites that are distributed equidistantly across a lake. In each lake, sampling determines the maximum depth of rooted plant growth and greater depths are ultimately ignored. GPS units were used to locate the sites and double-headed rakes were used to collect aquatic plants. Two forms of sampling rakes were used. The pole rake was used for sampling aquatic plants up to 15 ft (4.6 m) and rope rake was used to sample deeper areas. Density ratings from 1-3 were determined by the amount of plant material in the two-headed rake. Plants that were observed near the boat but were not collected in the rake were also noted. Samples of each species found in a lake were collected, pressed and submitted as voucher specimens to the UW Madison Herbarium. Secchi measurements were collected during each sampling day and these were transformed to Trophic State Index values (TSI). The

TSI is a lake water quality index ranging from 0 to 100. Values greater than 50 indicate eutrophic or high fertility.

Statistical analysis included the following:

- Frequency of occurrence within vegetated sites (number of times a species was found divided by the total number of vegetated sites).
- Relative frequency of plant species collected (describes each species contributing a certain percentage of the whole aquatic plant community).
- The Simpson Diversity Index is a nonparametric estimator of community heterogeneity. The Simpson Diversity Index range is from 0 to 1 with lower diversity reflected in scores closer to 1.

Detailed statistical results appear in Appendix B. Appendix F contains detailed plant survey results.

WDNR provided the sampling grids and Excel spreadsheet software for data entry and analysis. A more detailed sampling description can be found in Baseline Monitoring of Aquatic Macrophytes (Hauxwell 2006).

Results and Discussion

The point intercept survey was conducted on July 23, 24, 27, 28 and August 4 and 8, 2008 within the main Lake Monona basin. Secchi depths ranged from 3.2 feet (TSI = 60) and 5.5 feet (TSI = 53) and reflected heavy to moderate Cyanobacteria blooms. Aquatic plants were sampled at a total of 474 GPS points across the lake. The maps in Appendices C and D display plant distributions in Lake Monona and Monona Bay. Appendix E summarizes fish and waterfowl values of native plants in Lake Monona. Results of the 2008 plant survey included that plants were found at a maximum depth of 14 feet and was comparable with early 1990s surveys (Figure 6 – adapted from Winkelman and Lathrop 1993). Total species richness was similar during the two sampling periods. However, a few species that were found in 2008 had not been found in decades while the 2008 survey missed a few species that were found in 1992. Stiff water crowfoot was collected in Turville Bay and had not been identified in Lake Monona since 1929. American lotus was also found in Turville Bay and had not been documented since

1961. The new collection of these species reflects the relatively natural condition of the bay. Species that were sampled during the 1992 survey but not found in 2008 were flatstem pondweed and northern water milfoil. The latter species often hybridizes with EWM and is nearly impossible to identify without genetic testing. Simpson Diversity Index was relatively low at 0.55. Values closer to 1 indicate greater aquatic plant community diversity.

Table 2 lists aquatic plant species collected 1990-92 and 2008. Adapted from Winkelman and Lathrop (1993), Figure 7 compares relative frequencies for EWM, coontail, CLP and sago pondweed. While relative frequencies varied for individual species, the dominant species in all sampling years were the four species mentioned above. EWM was the dominant rooted plant in all years except 1990 when coontail was collected in slightly greater frequency. Relative frequency data for all species collected in 2008 are displayed in Figure 8, including filamentous algae and duckweed. Previous surveys excluded these two plant groups but filamentous algae were frequently collected in 1992 rake-head samples. While EWM was the dominant species in 2008, rake density values were lower in mechanically harvested channels throughout the lake. In areas not harvested, density ratings were often 2-3 versus 1-2 in mechanically harvested areas.

Figure 6: Depth of maximum rooted plant growth in Lake Monona.

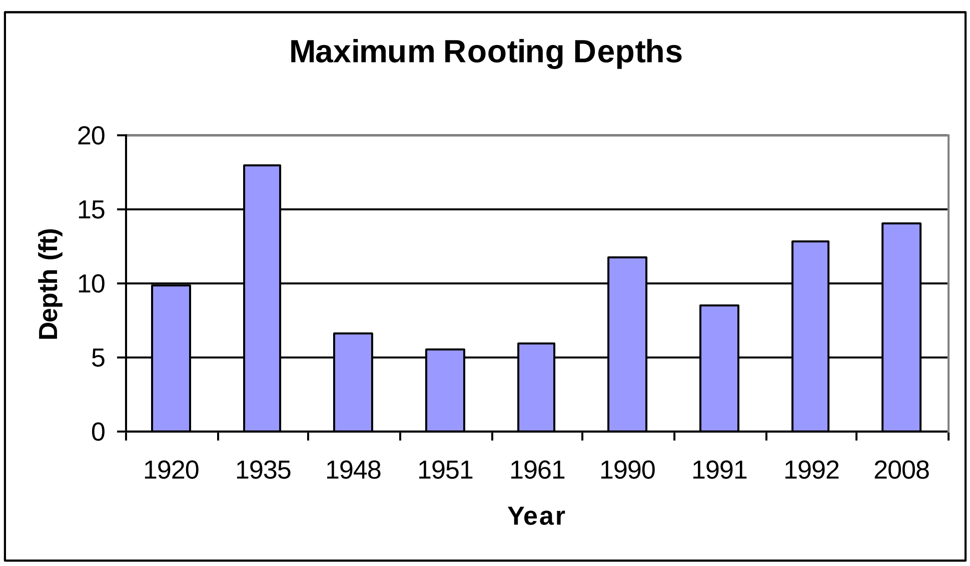


Table 2: Lake Monona Aquatic Plant Species List, 1990-92 and 2008 (Adapted from Winkelman and Lathrop 1993).

Species	**1990-92**	**2008**
Coontail	x	x
Elodea	x	x
CLP	x	x
Flatstem pondweed	x	
Leafy pondweed	x	x
Clasping-leaf pondweed	x	x
Sago pondweed	x	x
Wild celery	x	x
N. water milfoil	x	
EWM	x	x
Water stargrass	x	x
Water crowfoot		x
White water lily	x	x*
American lotus		x

*White water lilies were observed but not sampled in Monona Bay.

Figure 7: Relative frequencies for EWM, coontail, CLP and sago pondweed (adapted from Winkelman and Lathrop 1993). Filamentous algae and duckweed are not represented. Other native species are represented in areas where the bars do not reach 100%.

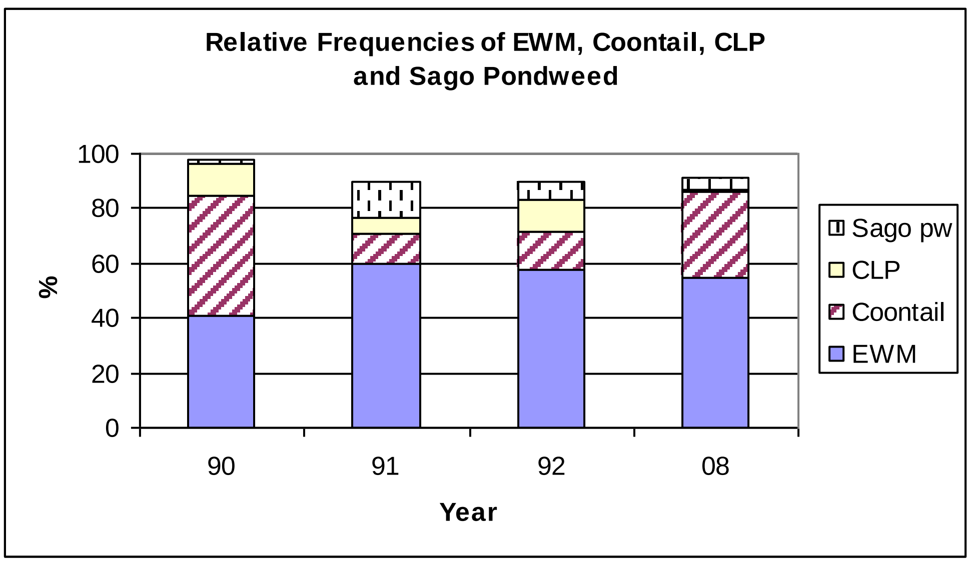
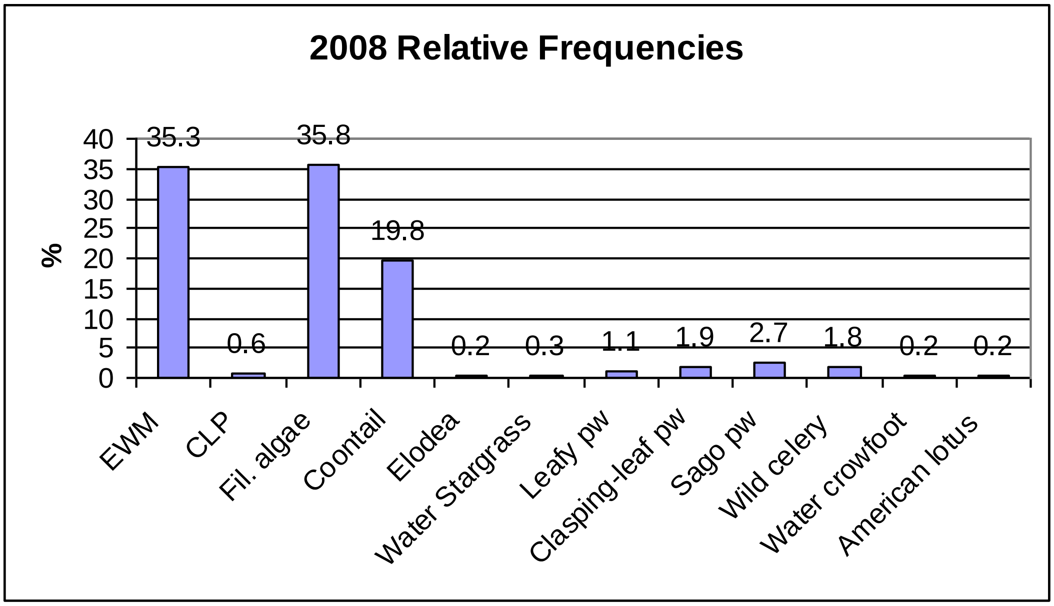


Figure 8: Relative frequencies for all plants sampled in 2008



As mentioned earlier, Monona Bay is a highly modified area of Lake Monona, both chemically and physically. Species richness was much lower in Monona Bay compared to the rest of the lake, with only four rooted plant species in Monona Bay versus 12 species elsewhere in the lake. Yet in 2006, the City of Madison (Genesis Steinhorst) conducted a point intercept survey on Monona Bay and found nine rooted plant species. The species list included stiff water crowfoot and small pondweed. Small pondweed had not been sampled in the larger basin over the last few decades. In general, aquatic plants sampled in 2008 represented significant declines in rake fullness (1 in 2008 and 2 in 2006), diversity (5 total species in 2008 and 10 total species in 2006) and frequency of occurrence within vegetated sites (34.3 % in 2008 and 98.5 % in 2006). It is uncertain if the floodwater in 2008 was a factor in the plant community-wide decline, including EWM. High water early in the 2008 season may have raised water levels above the normal maximum rooting depths. Higher water levels may have contributed to typically lower water clarity within the bay, since the maximum rooting depth in both years was 12 feet versus 14 feet in the larger basin. Water clarity in the bay was also significantly lower in 2008. In the north and south triangles, secchi measurements were 4.7 feet (TSI = 55) and 3.5 feet (TSI = 59) respectively. In the larger area of Monona Bay, secchi measurements were even lower at 2.5 feet (TSI = 64) and 2 feet (TSI = 67). The EWM relative frequency and frequency of occurrence were much lower than coontail in 2008, suggesting a significant EWM decline (Figures 9 and 10). Survey periods may be another factor. The 2006 survey was performed in June when CLP is typically at peak growth while the 2008 survey was performed in August when CLP typically declines. A small white water lily bed was observed near sampling points 20 and 33. Figure 9 displays relative frequency results for point intercept surveys in 2006 and 2008. Figure 10 displays frequency of occurrence values within vegetated sites for both sampling years and displays significant changes. Figures 11 and 12 display proposed sensitive areas (Wisconsin Administrative Code NR 107.05(3-i)) in Lake Monona and Monona Bay.

Figure 9: Relative frequencies of plants sampled in Monona Bay, 2006 (Genesis Steinhorst) and 2008.

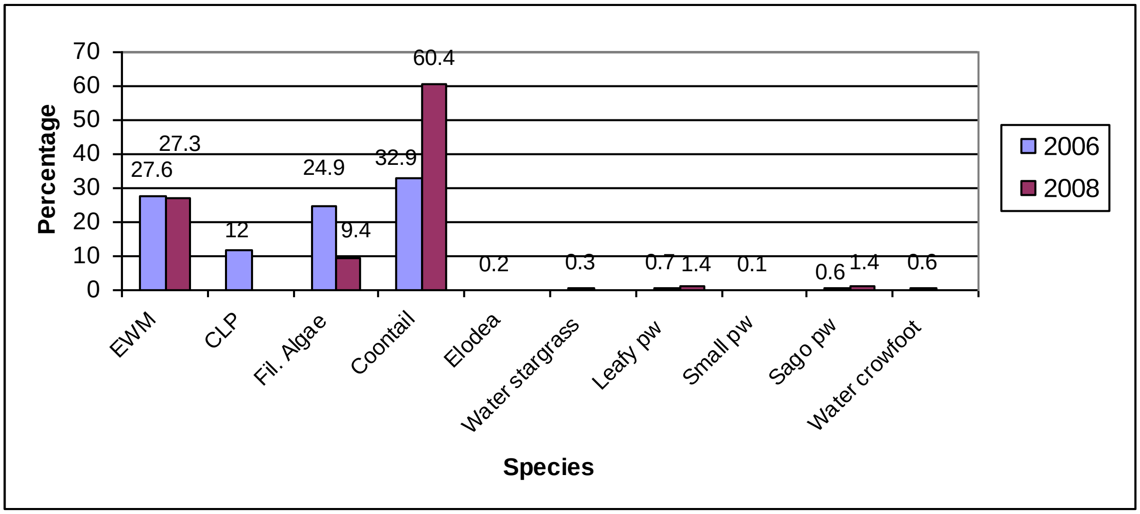


Figure 10: Frequency of occurrence for dominant plants within Monona Bay vegetated sites, 2006 (Genesis Steinhorst) and 2008.

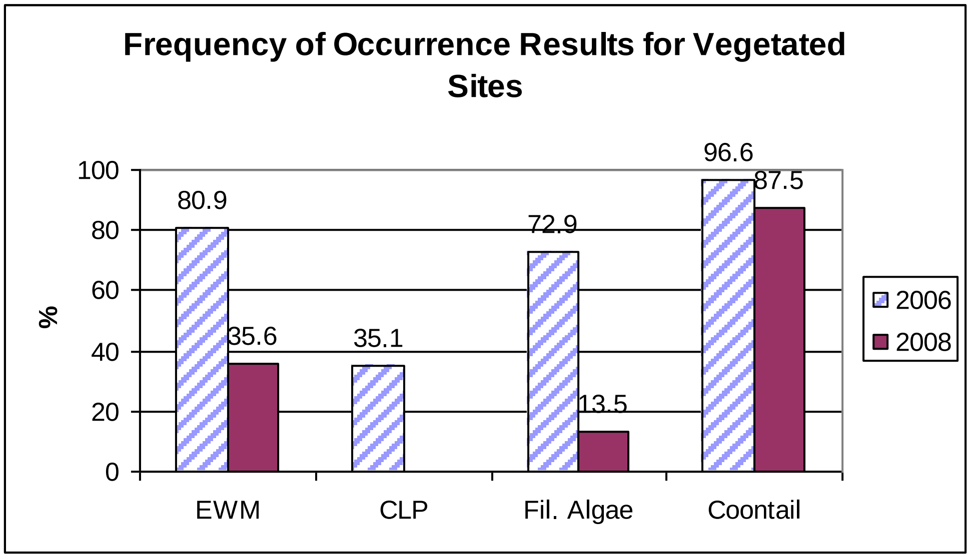


Figure 11: Proposed Lake Monona sensitive areas

Figure 12: Proposed Monona Bay sensitive areas

Aquatic Plant Management Alternatives

While the primary emphasis of this plan is to protect important aquatic plant habitats and control nuisance EWM growths with mechanical harvesting equipment, additional management tools are available to individual property owners. Chemical treatments are regulated under Wisconsin Administrative Code NR 107. Figure 5 demonstrates the recent trends in herbicide applications.

Under NR 109.06 (a-1), a riparian owner is not required to obtain a permit for manual plant harvesting from WDNR if the removal involves invasive species or removal of native species is limited to a single area with a maximum width of no more than 30 feet measured along the shoreline.

Dredging is generally not considered to be a practical option due to high costs. Limited dredging efforts have been publicly-funded for selected boat ramps and river channel access. Dredging as a form of aquatic plant management would require a Chapter 30 permit from WDNR. Historic dredging has already resulted in significant losses and modifications of littoral areas.

Another alternative is the use of aquatic weevils. Weevils have been demonstrated to control EWM in laboratory and enclosure studies (Mazzei et al. 1999, Sheldon and Creed 1995). A EWM decline in Fish Lake occurred in 1994, coinciding with evidence of weevil damage (Lillie 2000), however EWM rebounded a few years later and high densities continue in the presence of the insect. More detailed discussions on aquatic plant management alternatives can be found in Cooke et al. (2005) and Petty (2005).

Specific Alternatives for Lake Monona

1) **No treatment**: Rejecting all types of aquatic plant management does not appear realistic, given the extent of EWM coverage and heavy recreational needs across the lake.
2) **Biological control**: This method does not appear realistic at this time. Research findings suggest that weevils are difficult and expensive to establish in a lake and effectiveness has been mixed. Research will no doubt continue to assess biological controls. If a method proves viable as a possible control method, it will be evaluated as a potential control method for Lake Monona or other Yahara Lakes.
3) **Chemical control:** Herbicide use should be restricted to agents selective at controlling EWM. 2, 4-D is the likely agent given the partial selectivity for controlling EWM. However, several valuable native plants including water lilies can be damaged from 2, 4-D so WDNR permit applications should be carefully screened to avoid loss of already declining native plants. Whole-lake chemical applications in Lake Monona are not feasible given its enormous size. The U.S. Army Corps of Engineers (COE) is working on using herbicides to control exotic plants while not adversely impacting and/or enhancing native plants. Dane County will continue to coordinate research efforts to assess early season chemical treatments in parts of Turville Bay.
4) **Manual - hand removal**: Manually removing plants around piers and swimming areas is a viable option. However, property owners should be educated about the importance of high value native species so that their efforts should focus on

weedy exotics such as EWM. Sensitive Areas should be avoided and all plants that are cut should be removed.

5) **Mechanical harvesting**: Given the extent of EWM throughout Lake Mendota, mechanical harvesting provides effective temporary access through the dense monotypic beds as well as providing habitat improvements. Sensitive Areas should be avoided to prevent loss of floating-leaf plants, particularly where American lotus grows in Turville Bay.
6) **Physical controls**: Hydraulic dredging can be an option for removing the nutrient rich sediments within designated navigation channels. This method has the greatest potential for long-term control but can be initially expensive. Whole lake dredging is unrealistic given the vast littoral areas affected by EWM. Fabrics are another physical control method but rarely used by property owners because of the labor of installation and maintenance. During local demonstrations at Tenney Locks, problems arose due to gas collection under the fabric and attached filamentous algae growth. Drawdown is infrequently used in Wisconsin for aquatic plant management and would not likely affect the weedy stands of EWM and coontail beyond the nearshore areas. Nearshore valuable native plants could be negatively affected by a drawdown and water replacement may be an issue during a drought cycle.
7) **WDNR management options for Wisconsin lakes can be found at this website**: www.danewaters.com/pdf/2006/management_options_aq_plants.pdf

References

Asplund, T.A. and C.M. Cook. 1997. Effects of motor boats on submersed aquatic macrophytes. Lake and Reserv. Mgmt. 13:1-12.

Borman, S., R. Korth and J. Temte. 1997. Through the looking glass: a field guide to aquatic plants. Wisconsin Department of Natural Resources Pub FH-207-97.

Bryan, M.D. and D.L. Scarnecchia. 1992. Species richness, composition, and abundance of fish larvae and juveniles inhabiting natural and developed shorelines of a glacial Iowa lake. Environmental Biology of Fishes 35:329-341.

Cooke, D.G., E.B.Welch, S.A. Peterson and P.R. Newroth. 2005. Restoration and management of lakes and reservoirs. Third edition. Taylor and Francis/CRC Press. 616p.

Dane County Regional Planning Commission. 1979. Dane County Water Quality Plan: Appendix B.

Day, E.A., G.P. Grzebieneak, K.M. Osterby, C.L. Brynildson. 1985. Surface water resources of Dane County. Wisconsin Department of Natural Resources lake and stream classification project. Second edition. p. 15-17.

Dibble, E.D., K. J. Killgore and S.L. Harrel. 1996. Assessment of fish-plant interactions. American Fisheries Society Symposium 16:357-372.

Engel, S. 1987. The restructuring of littoral zones. Lake Reserv. Manage. 3: 235-242.

Fassett, N.C. 1975. A manual of aquatic plants. The University of Wisconsin Press.

Garrison, P.J., D.W. Marshall, L. Stremick-Thompson, P.L. Cicero and P.D. Dearlove. 2005. Effects of pier shading on littoral zone habitat and communities in Lakes Ripley and Rock, Jefferson County, Wisconsin. PUB-SS-1006.

Gaumitz, L. 2005. Shoreline sentinels. Wisconsin Natural Resources. 29:22-28.

Janecek, J.A. 1988. Literature review on fishes interactions with aquatic macrophytes with special reference to the Upper Mississippi River System. U.S. Fish and Wildlife Service. Upper Mississippi River Conservation Committee. Rock Island, Illinois.

Lathrop, R.C. 1990. Response of Lake Mendota (Wisconsin USA) to decreased phosphorus loadings and the effect on downstream lakes. Verh. Internat. Verein. Limnol. 24:457-463.

Lyons, J. 1989. Changes in the abundance of small littoral zone fishes in Lake Mendota, Wisconsin. Can. J. Zool. 67:2910-2916.

Nichols, S.A. and R.C. Lathrop. Cultural impacts on macrophytes in the Yahara lakes since the late 1880s. Aquat. Bot. 47:225-247.

Nichols, S.A. 1994. Evaluation of invasions and declines of submersed macrophytes for the Upper Great Lakes Region. Aquat. Bot. 41:225-252.

Nichols, S.A. and J.G. Vennie. 1991. Attributes of Wisconsin Lake Plants. Wisconsin Geological and Natural History Survey. Information Circular 73.

Savino, J.F. and R.A. Stein. 1982. Predator-prey interaction between largemouth bass and bluegills as influenced by simulated, submersed vegetation. Transactions of the American Fisheries Society. 111: 255-265.

Smith, C.S. and J.W. Barko. 1992. Submersed macrophyte invasions and declines. Waterways Experiment Station, US Army Corps of Engineers, Aquatic Plant Control Research Program Bulletin A-92-1, Vicksburg, MS.

Smith, C.S. and J.W. Barko. 1990. Ecology of Eurasian watermilfoil. J. Aquat. Plant Manage. 28:55-64.
Steinhorst, G. 2008. Personal communication regarding 2006 Monona Bay sampling.
Trebitz, A., S. Carpenter, P. Cunningham, B. Johnson, R. Lillie, D. Marshall, T. Martin, R. Narf, T. Pellett, S. Stewart, C. Storlie and J. Unmuth. 1997. A model of bluegill-largemouth bass interactions in relation to aquatic vegetation and its management. Ecological Modeling. 94: 139-156.
Wisconsin Department of Natural Resources. 1990. Environmental Assessment – Aquatic Plant Management (NR 107) Program. 3rd Edition. 213 p.

GLOSSARY

Alleopathy Chemical suppression of a plant on another plant species.

Biomanipulation A technique involving using predatory fish to reduce the number of fish that feed on zooplankton.

Chlorophyll a The photosynthetic pigment in plant life. Concentrations in lake water are related to the planktonic algal growth and fertility.

Columnaris Bacterial infection of fish that especially occurs when they are stressed. The disease is highly contagious to fish and typically enters through gills, mouth or small skin wounds.

Cyanobacteria Blue-green algae: a group of algae that are often associated with nuisance lake blooms. Certain species can produce toxins that can cause illness and even death in animals and humans. Blue-green algae can fix nitrogen from the atmosphere and thus are often found when phosphorus levels in water are high.

Emergent plants Species with leaves that extend above the water surface and are usually found in shallow water.

Eutrophication The process of increasing lake fertility, often accelerated by humans (cultural eutrophication).

Eutrophic Description for a very productive and fertile lake.

Floating-leaf plants Rooted plants with leaves that float on the water surface such as water lilies and native several pondweeds.

Filamentous algae Algae that forms filaments or mats which attach to the bottom sediments, rooted plants, piers, etc.

Hectare A unit of measure which is equivalent to 2.47 acres.

Herptiles	A broad group of cold blooded animals including turtles and amphibians.
Hypereutrophic	A very nutrient enriched lake characterized by severe and dominant algal blooms are very poor water quality.
Hypolimnion	The deeper stratified layer in a lake that typically remains cold and isolated from the atmosphere.
Hypolimnetic	See hypolimnion.
Intolerant	Species sensitive to degraded habitat and water quality.
Limnologist	A specialist in the study of freshwater ponds and lakes.
Littoral Zone	Shallow areas of a lake where most of the rooted aquatic plants are found.
Macrophytes	Rooted plants typically found growing the littoral zone of lakes. They produce oxygen and provide food and cover for lake organisms.
Mesotrophic	Intermediate description for lake fertility between Eutrophic (very fertile) and Oligotrophic (infertile) waters.
Monotypic	Dominance of a single plant species.
Oligotrophic	Lakes that are relatively infertile with low levels of plankton and rooted plants.
Pelagic	The open water zone of a lake outside of the littoral zone.
Phytoplankton	Free-floating algae that form the base of lake food webs.
Planktivores	Fish that typically feed on zooplankton.
Point Source	Wastewater or source of pollution with a defined discharge point such as a discharge pipe.
Secchi disc	An eight-inch diameter disc with four alternating quadrants of black and white. It is lowered into a lake on a rope and used to measure light penetration. Lakes are infertile (oligotrophic) if the depth you can see the disc are great. Lakes are fertile (eutrophic) if the disc disappears quickly.
Species Richness	An indicator of species diversity.

Thermocline Metalimnion or transitional zone between the epilimnion (upper part) and the hypolimnion (bottom). This portion of a lake is where the temperature changes most rapidly and in most waters is found around 20 feet or deeper.

Trophic State Index An empirical water quality scale for lakes based on total phosphorus, secchi and chlorophyll-a.

Turions The over-wintering bud produced by aquatic plants.

Two story fisheries Management of trout and warm water sport fishes in lakes that typically sustain adequate dissolved oxygen in the hyplimnion.

Appendix A

BOAT AND HARVESTER DISINFECTION AND VEGETATION REMOVAL LAWS

Dane County Lake Management Guidelines

We already have many exotic species in our waters, and while it may seem somewhat ridiculous to remove plants that are already a problem, and found in most if not all the county waters, the future most likely will find new problems being identified. Frequently, exotics become established because you do not realize that you even have one of these “new visitors” on your boat. It is now <u>State Law</u> to remove plant materials and water from watercrafts and equipment.

We follow the State Law Guidelines developed by the Wisconsin Department of Natural Resources (DNR). Their guidelines are consistent with nationally accepted set of prevention steps.

Following these guidelines is important for three reasons. It sets a good example to the public, it insures that we are not responsible for, or contributing to, the spread of aquatic exotics and due to recent legislative changes may also be against the law to transport or spread invasive species.

The following steps shall be taken every time a boat, equipment or gear is moved between waters to avoid transporting invasive species and/or pathogens.

- **Inspec**t and **remove** aquatic plants, animals, and mud from your boat, trailer, equipment and gear.
- **Drain** all water, if applicable, from your boat, motor, live well, bilge, transom wells, as well as from your equipment and gear, including but not limited to tracked vehicles, barges, silt or turbidity curtain, hoses, sheet pile and pumps.
- **Dispose** of unwanted aquatic plants and animals in an appropriate way. Try and place them where normal clean-up activities can occur or so as to not contribute to an unsightly condition.
- **Disinfect** – We will disinfect all harvesters and equipment whenever equipment leaves or enters the Yahara River Chain of Lakes or when moving from one waterbody to another waterbody outside the Yahara River Chain of Lakes. Disinfecting: Pressure wash and treat all surfaces with a bleach solution **-** using 0.5 oz of household bleach per gallon of water. At least a 10-minute contact time is recommended. Bleach contains chlorine and the following precautions should be taken.

****** Wear eye protection, rain gear and gloves if spraying.
****** Stay upwind of the spray.

Chlorine is corrosive to metal and rubber and toxic to fish at these concentrations so it needs to be well rinsed after the 10 minute contact time (sodium thiosulfate can also be used to neutralize chlorine – at three grams per gallon of water). Rinsing should be done so as to prevent runoff to a surface water.

The following guidance is directly from the DNR Manual Code (9183.1).

<u>Boats, trailers and live wells</u>
Remove organic material from boats, trailers, and live wells. Drain water from live wells, bilges and pumps. The outside and inside of the boat, trailer, live wells, bilges and pumps should be sprayed with the disinfection solution and left wet for the appropriate contact time. The inside of the live wells, bilges and pumps should be made to contact the solution for the appropriate contact time as well. Run pumps so they take in the disinfection solution and make sure that the solution comes in contact with all parts of the pump and hose. The boat, trailer, bilges, live well, and pumps should be rinsed with clean water or water from the next waterbody after the appropriate contact time. *Every effort should be made to keep the disinfection solution and rinse water out of surface waters.* Pull the boat and trailer off the ramp and onto a fairly level area and away from street drains to minimize potential runoff into surface waters.

Appendix B

2008 Summary Statistics for Lake Monona (excluding Monona Bay) and Monona Bay

SUMMARY STATS: Lake Monona (excluding Monona Bay)	
Total number of points sampled	474
Total number of sites with vegetation	273
Total number of sites shallower than maximum depth of plants	339
Frequency of occurrence at sites shallower than maximum depth of plants	80.53
Simpson Diversity Index	0.71
Maximum depth of plants (ft)	14.00
Number of sites sampled using rake on Rope (R)	12
Number of sites sampled using rake on Pole (P)	342
Average number of all species per site (shallower than max depth)	1.83
Average number of all species per site (veg. sites only)	2.27
Average number of native species per site (shallower than max depth)	0.52
Average number of native species per site (veg. sites only)	1.53
Species Richness	12
Species Richness (including visuals)	14

SUMMARY STATS: Monona Bay	
Total number of points sampled	280
Total number of sites with vegetation	96
Total number of sites shallower than maximum depth of plants	269
Frequency of occurrence at sites shallower than maximum depth of plants	35.69
Simpson Diversity Index	0.55
Maximum depth of plants (ft)	12.00
Number of sites sampled using rake on Rope (R)	0
Number of sites sampled using rake on Pole (P)	275
Average number of all species per site (shallower than max depth)	0.52
Average number of all species per site (veg. sites only)	1.45
Average number of native species per site (shallower than max depth)	0.33
Average number of native species per site (veg. sites only)	1.19
Species Richness	5
Species Richness (including visuals)	5

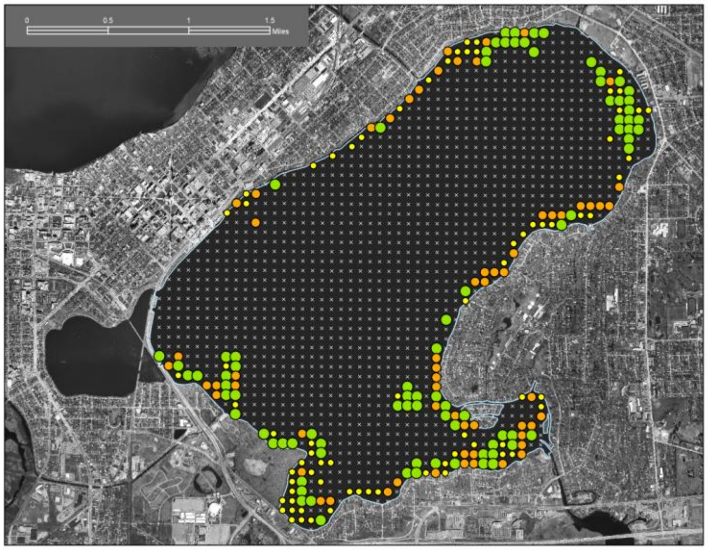
Appendix C. 2008 Lake Monona Aquatic Plant Distributions

Individual Plant Species Amounts

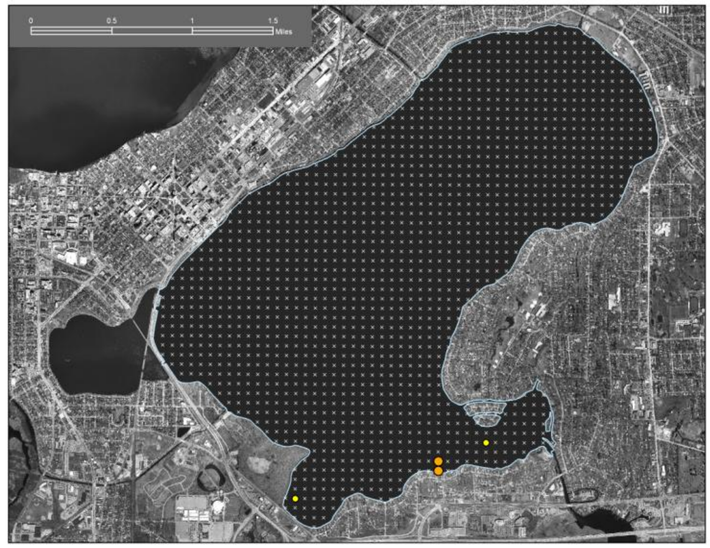
Amount Found / Rake
- overflowing, can't see top of rake head
- rake head ~1/2 full, between 1 & 2
- few plants on rake head
- × nothing found

perimeter of sampling points (provided by WDNR)

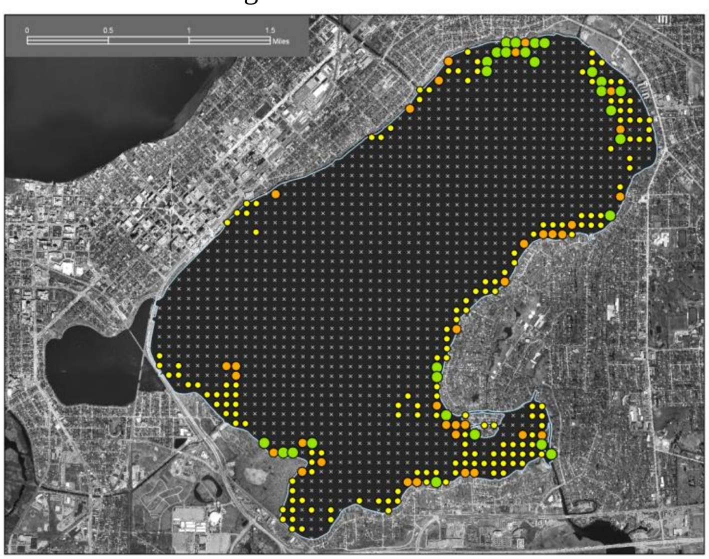
C1. Eurasian Water-milfoil



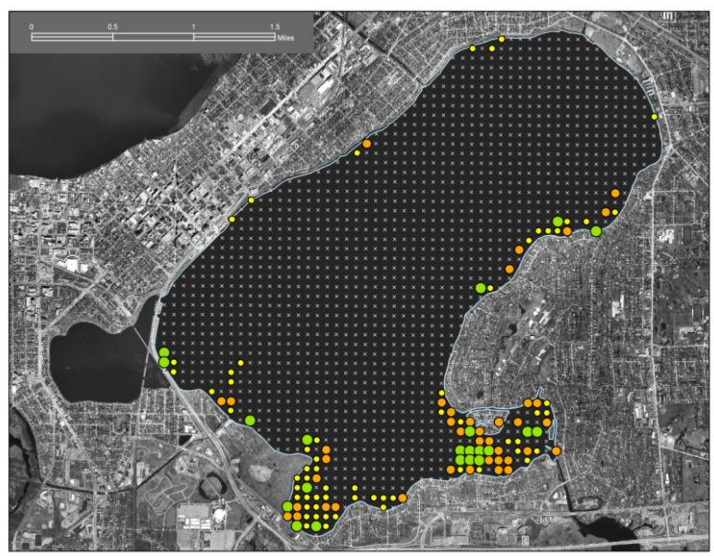
C2. Curly-leaf Pondweed



C3. Filamentous Algae



C4. Coontail



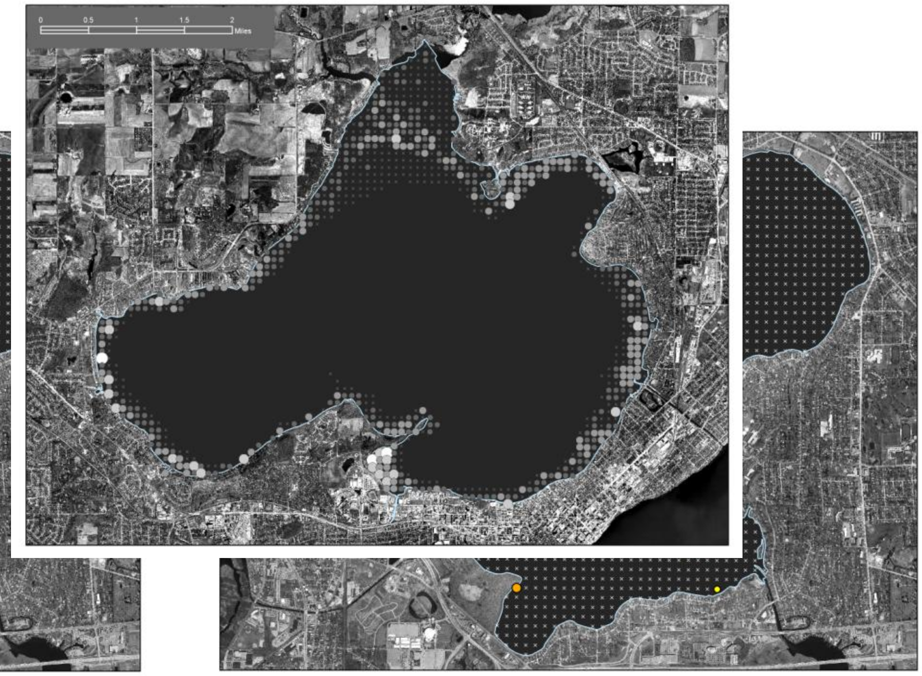
Appendix C. 2008 Lake Monona Aquatic Plant Distributions (cont.)

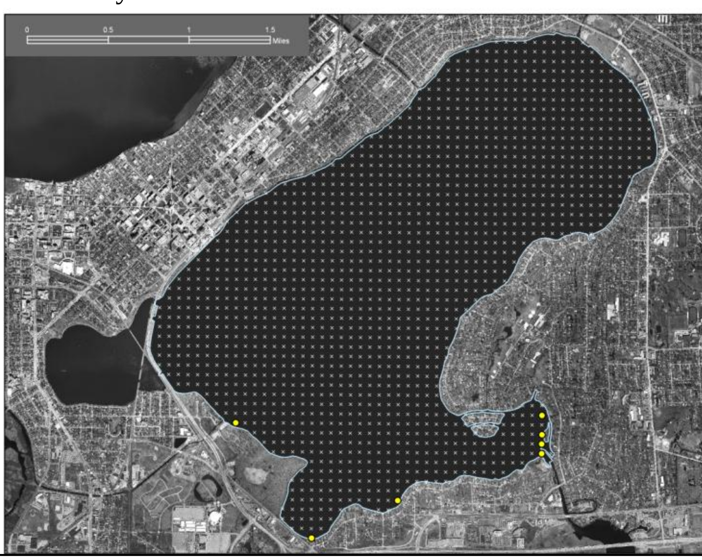
Individual Plant Species Amounts

Amount Found / Rake
- overflowing, can't see top of rake head
- rake head ~1/2 full, between 1 & 2
- few plants on rake head
- × nothing found

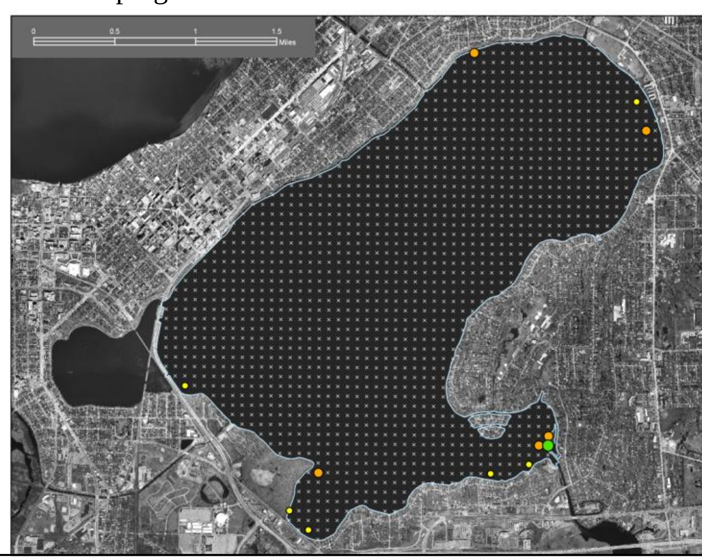
perimeter of sampling

Figure C5. Common Waterweed





C7. Leafy Pondweed



C8. Clasping-leaf Pondweed

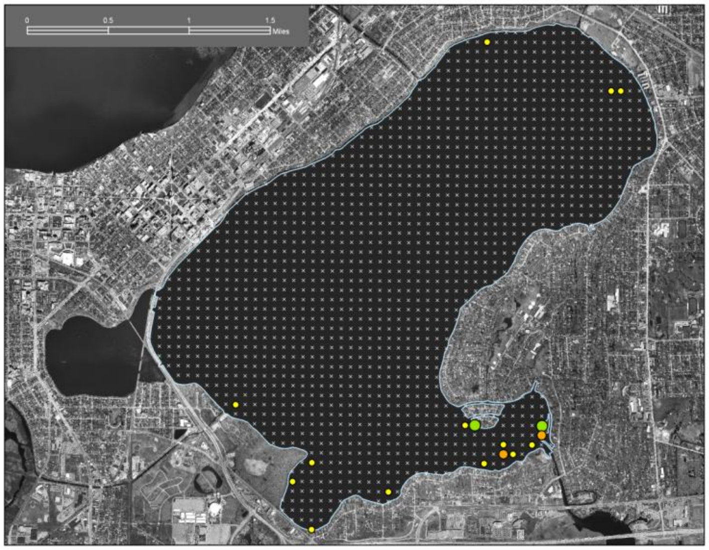
Appendix C. 2008 Lake Monona Aquatic Plant Distributions (cont.)

Individual Plant Species Amounts

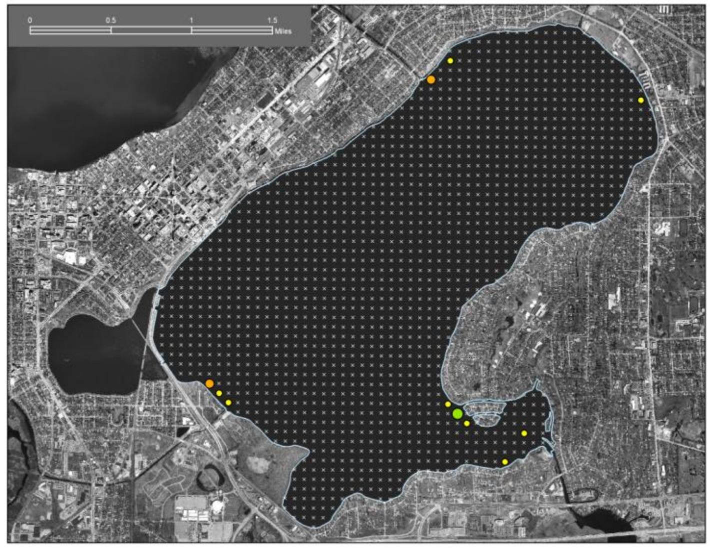
Amount Found / Rake
- overflowing, can't see top of rake head
- rake head ~1/2 full, between 1 & 2
- few plants on rake head
- × nothing found

perimeter of sampling points (provided by WDNR)

C9. Sago Pondweed



C10. Wild Celery



C11. Nelumbo

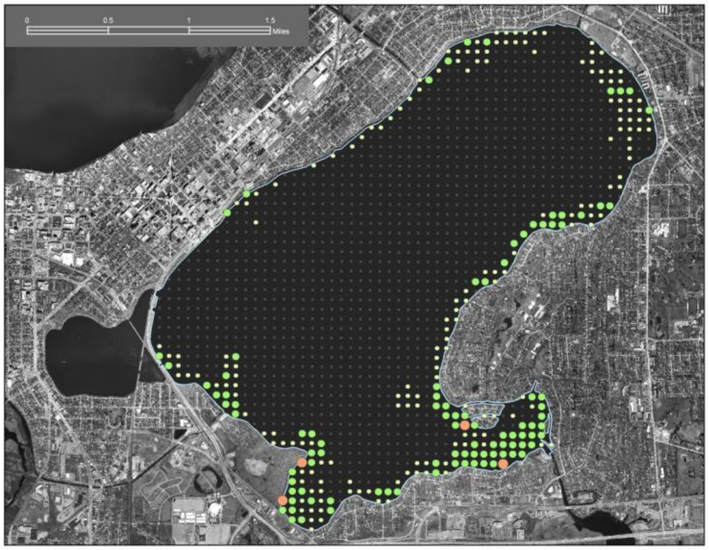
C12. Rannunculus

Appendix C. 2008 Lake Monona Aquatic Plant Distributions (cont.)

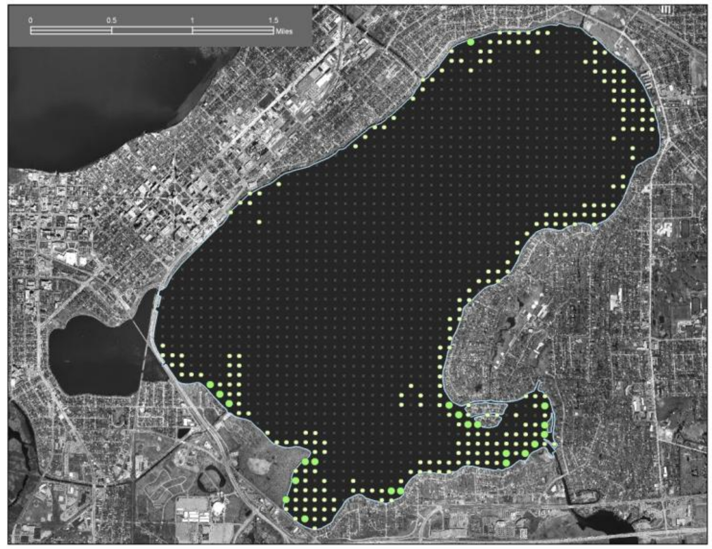
Total Number of Plant Species

Number of Species
- 5
- 3-4
- 1-2
- × 0

C13. Total Number of Species (includes exotics)



C14. Total Number of Species (no exotics)



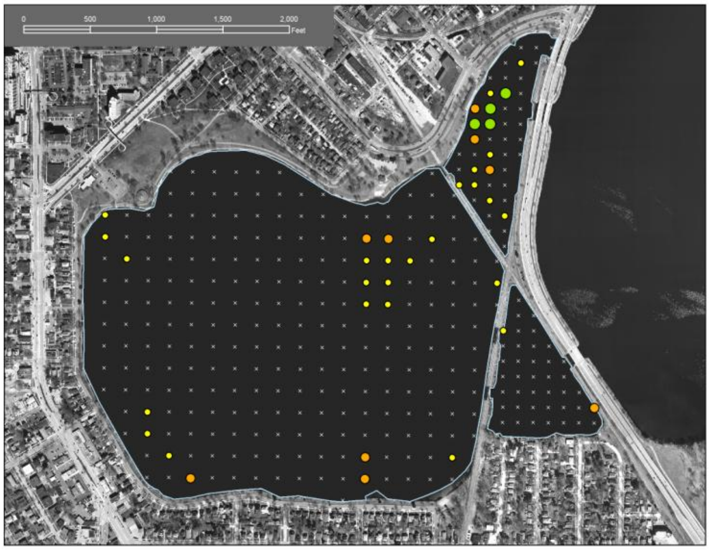
Appendix D. 2008 Monona Bay Aquatic Plant Distributions

Individual Plant Species Amounts

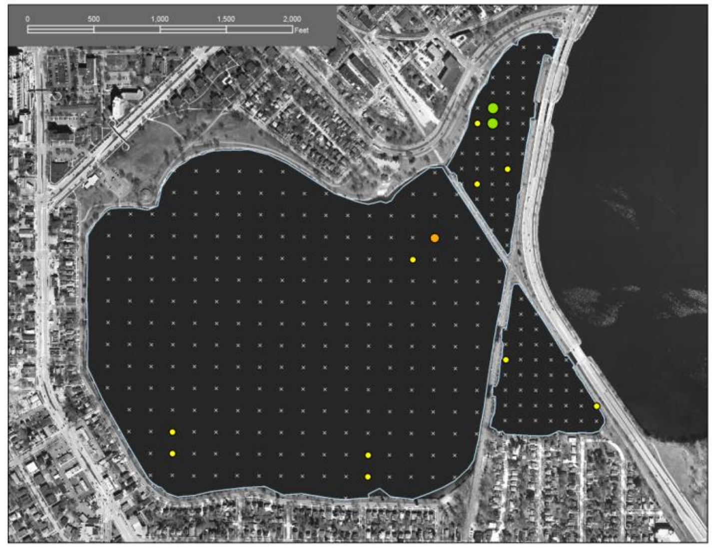
Amount Found / Rake
- overflowing, can't see top of rake head
- rake head ~1/2 full, between 1 & 2
- few plants on rake head
- x nothing found

perimeter of sampling points (provided by WDNR)

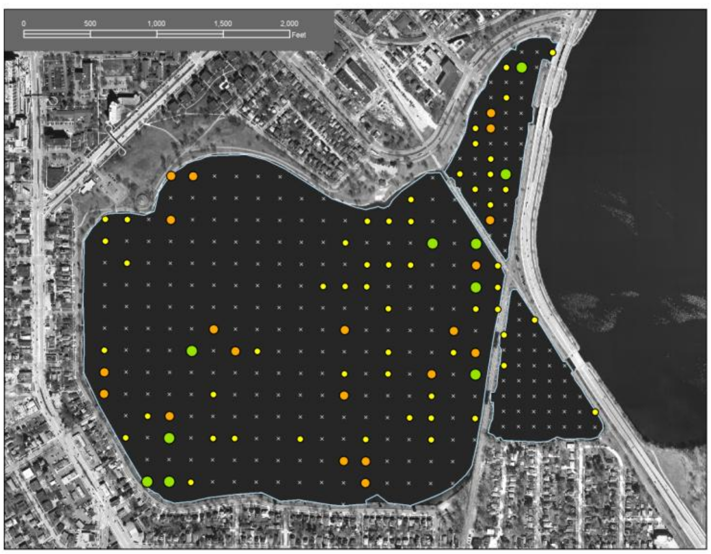
D1. Eurasian Water-milfoil



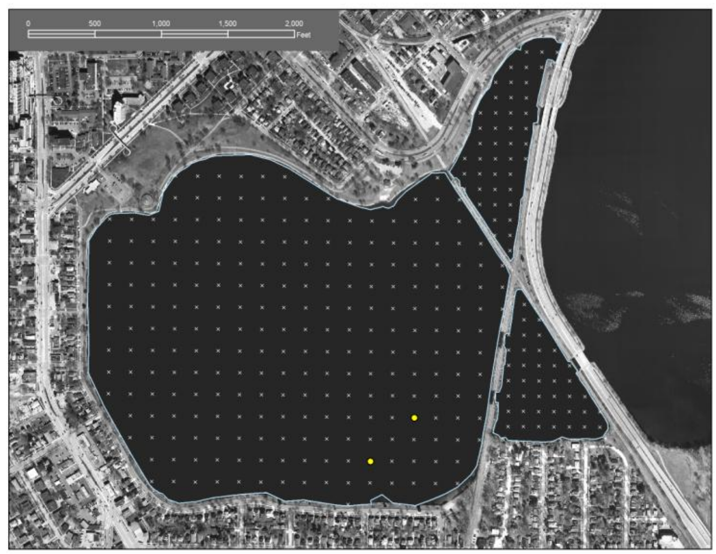
D2. Filamentous Algae



D3. Coontail



D4. Leafy Pondweed



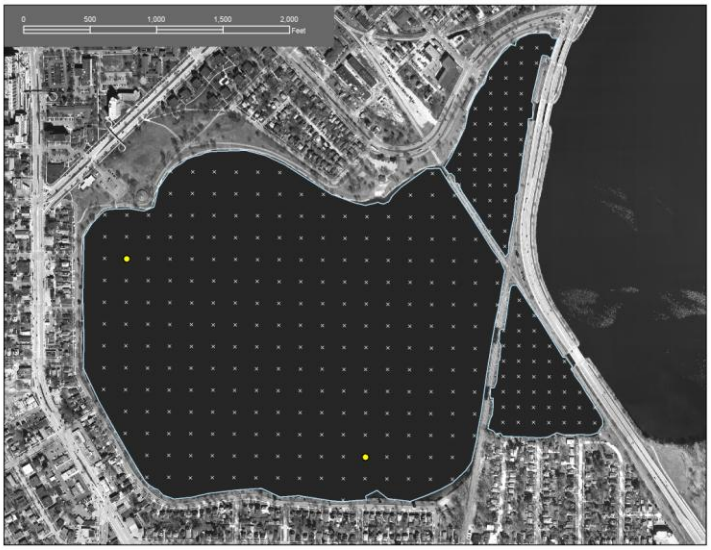
Appendix D. 2008 Monona Bay Aquatic Plant Distributions (cont.)

Individual Plant Species Amounts

Amount Found / Rake
- overflowing, can't see top of rake head
- rake head ~1/2 full, between 1 & 2
- few plants on rake head
- × nothing found

perimeter of sampling points (provided by WDNR)

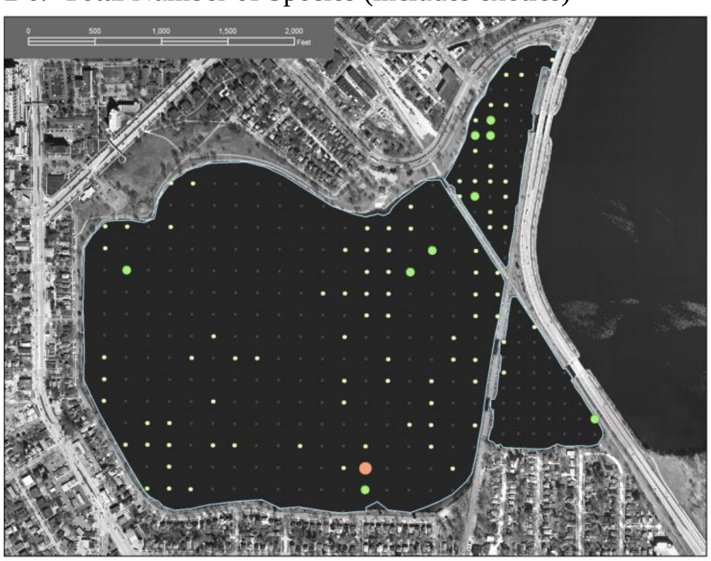
D5. Sago Pondweed



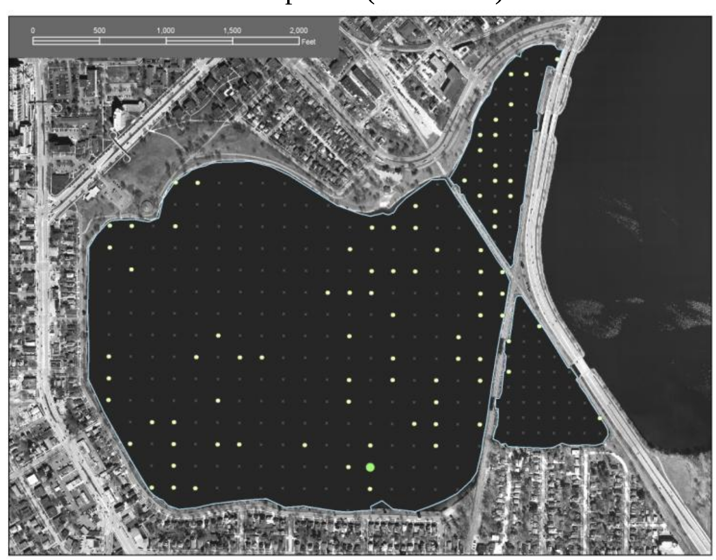
Total Number of Plant Species

Number of Species
- 5-6
- 3-4
- 1-2
- × 0

D6. Total Number of Species (includes exotics)



D7. Total Number of Species (no exotics)



Appendix E

Fish and Waterfowl Values of Desirable Native Plants in Lake Monona

Scientific Name	Common Name	Fish	Wildlife
Ceratophyllum demersum	Coontail	Food and cover	Food
Elodea canadensis	Elodea	Food and cover	Food
Heteranthera dubia	Water stargrass	Food and cover	Food
Lemna minor	Lesser Duckweed	Food and cover	Food
Myriophyllum sibiricum	Northern Watermilfoil	Food and cover	Food
Nelumbo lutea	American lotus	Food and cover	Food
Nymphaea odorata	White Water Lily	Food and cover	Food
Potamogetan foliosus	Leafy Pondweed	Food and cover	Food
Potamogeton pusillus	Small Pondweed	Food and cover	Food
Potamogetan richardsonii	Clasping-leaf Pondweed	Food and cover	Food
Potamogetan zosteriformes	Flat-stem Pondweed	Food and cover	Food
Ranunculus longirostris	Stiff water crowfoot	Food	Food
Struckenia pectinatus	Sago Pondweed	Food and cover	Food
Vallisneria americana	Wild celery	Food and cover	Food

Fish and Wildlife Values based on Borman et al. 1997, Nichols and Vennie 1991 and Janecek 1988.

Appendix F

Detailed 2008 APM Survey Results for Lake Monona and Monona Bay
Lake Monona (excluding Monona Bay)

Species	Freq. veg. sites (%)	Freq. shallower – max. root depth (%)	Rel. freq. (%)	Sites found	Ave. rake fullness	Visual sites
EWM	80.22	64.2	35.3	219	2	11
CLP	1.47	1.18	0.6	4	2	1
Fil. algae	81.31	65.49	35.8	222	1	3
Coontail	45.05	36.28	19.8	123	2	14
Elodea	0.37	0.29	0.2	1	1	
W. stargrass	0.73	0.59	0.3	2	2	
Small d.w.						18
Leafy .p.w.	2.56	2.06	1.1	12	2	5
Sago p.w.	6.23	5.01	2.7	17	1	10
Large d.w.						13
W. celery	4.03	3.24	1.8	11	1	2
A. lotus	0.37	0.29	0.2	1	2	1
s. w. crowfoot	0.37	0.29	0.2	1	1	

Monona Bay

Species	Freq. veg. sites (%)	Freq. shallower – max. root depth (%)	Rel. freq. (%)	Sites found	Ave. rake fullness	Visual sites
EWM	39.58	14.13	27.3	38	1	9
Fil. algae	13.54	4.83	9.4	13	1	
Coontail	87.5	31.23	60.4	84	2	2
Leafy p.w.	2.08	0.74	1.4	2	1	1
Sago p.w.	2.08	0.74	1.4	2	1	5