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AQUATIC PLANTS

"A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise."

-- Aldo Leopold, Wisconsin conservationist and author

5-1 INTRODUCTION

The state of Wisconsin, through Section 23.24 of the Wisconsin Statutes, encourages the development of aquatic plant management (APM) plans to promote the long-term sustainability of lakes. An approved APM plan is also a prerequisite for obtaining various state grants and permit approvals, including those related to controlling nuisance weed growth through mechanical harvesting and lake-wide herbicide applications.

Submersed aquatic plants seen growing just below the surface in Lake Ripley's shallow South Bay.

This chapter is designed to guide the District in its efforts to control nuisance weed growth while protecting beneficial plant communities that contribute to good water quality and optimal habitat conditions. A 2007 Lake District opinion survey revealed that respondents generally perceived aquatic weed growth to be slightly excessive in certain areas of the lake, but with wide-ranging opinions on the subject. The survey results also showed strong preferences for maintaining a healthy aquatic plant community and an abundance of fish and wildlife habitat.

This chapter is further intended to document past and present plant conditions, identify trends, and outline the most cost-effective strategies for addressing plant-related challenges and opportunities. It is meant to provide a framework for future management action, with the flexibility to adjust to inter-annual variability in the aquatic plant community.

5-2 VALUE AND ROLE OF AQUATIC PLANTS

A thriving and diverse native plant community is the foundation of a healthy and high-functioning lake ecosystem. Aquatic plants are vital for maintaining ideal water quality and habitat conditions. Plants keep algae in check by influencing nutrient dynamics, cover and stabilize lake-bottom sediment, protect against shoreline erosion, oxygenate the water during photosynthesis, provide cover and spawning sites for fish, create shelter for zooplankton (algae grazers), and serve as food sources for waterfowl and other wildlife.

The relative abundance, distribution and types of rooted aquatic plants (also called macrophytes) can be used as an indicator of lake quality. Ideally, healthy lakes will have at least moderate levels of native plant growth that is characterized by high species diversity. Evidence of lake-wide degradation or localized disturbance can include too much or too little aquatic vegetation, or if the plant community becomes increasingly dominated by non-native, invasive “weeds.” Disturbances can come in many forms, including polluted runoff and sedimentation, propeller damage from motor boats, sun-blocking algal blooms, and the over-harvesting or eradication of beneficial plant beds.

An absence of vegetation and associated habitat can lead to declines in native fish and wildlife, while favoring more tolerant “rough fish” like carp. It can also lead to increased algal blooms and higher turbidity, resulting in a loss of water clarity that is likely to further suppress plant growth. This higher algal growth and turbidity is generally the result of multiple factors, including the increased re-suspension of unanchored lake-bottom sediment, and a reduction in vegetative-induced trapping and settling of suspended particulate matter. However, it is important to note that rooted plants (macrophytes) derive most of their phosphorus requirements from the sediment, whereas algae (phytoplankton) absorb phosphorus from the surrounding waters. Therefore, macrophytes and phytoplankton do not compete for nutrients through their normal growth cycles as much as might be expected.[1]

A different set of problems occurs when non-indigenous aquatic weeds gain dominance and become overly abundant. This situation can create single-species monocultures of low habitat value, impede recreational use of the water, stunt fish growth, and contribute to dramatic fluctuations in dissolved oxygen levels that can stress aquatic life. Aside from depleting the water of life-sustaining oxygen, the decomposition of excessive plant biomass can, in turn, contribute to late-season algal blooms. The algae thrive on the release of nutrients that were previously tied up in the living plant tissues. It is well accepted that maintaining native plant beds is an effective line of defense against the spread of non-native, nuisance species.

5-3 EXTENT OF PLANT GROWTH

Aquatic plant abundance and plant-community composition are affected by a host of environmental variables. These include the depth and clarity of water and the type of lakebed substrate. Plant growth is most prevalent in shallow lakes with nutrient-rich bottom sediments and extensive littoral zones. The littoral zone is the shallow, biologically-productive portion of a lake that is able to support rooted plant growth (see Figure 40). The depth at which sunlight is able to penetrate the water column in quantities necessary to promote photosynthesis determines the extent of the littoral zone. Clear and uniformly shallow lakes will have the most extensive littoral areas. However, deeper lakes that have irregular shorelines with lots of small bays and narrow channels may also support expansive littoral zones.

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[1] Loucks, O.L. 1981. The littoral zone as a wetland and its contribution to water quality. In Selected proceedings of the Midwest conference on wetland values and management, ed. B. Richardson, pp. 125-138. St. Paul, MN: Minnesota Water Planning Board.

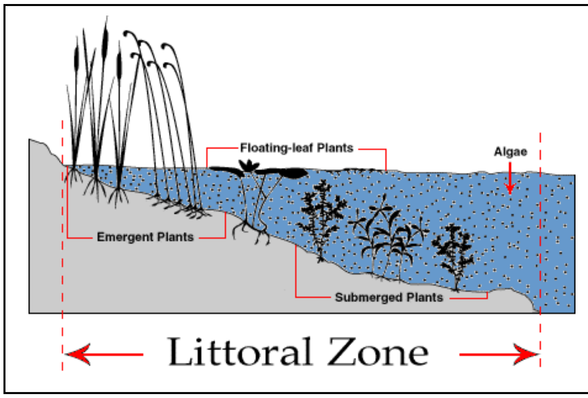
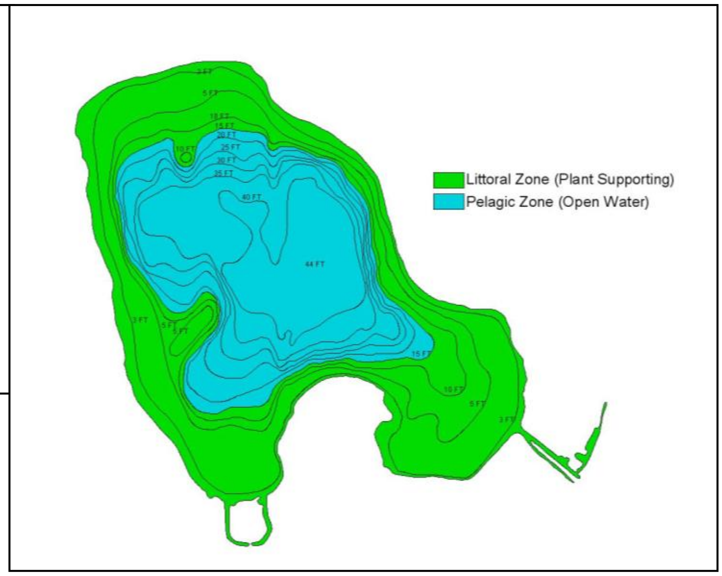


Figure 1: Lake Ripley's Littoral Zone



Lake Ripley's summer (July-August) water clarity has ranged from 2.5 to 9.5 feet during the 1973-2007 period of record, with an average summer mean clarity of 5.9 feet. Sunlight can typically penetrate the water column to a depth of 1.7 times the Secchi depth (called the photic zone). Rooted aquatic plant growth usually occurs in areas where the lake bottom intersects the photic zone, which can vary each year depending on prevailing water clarity conditions. Lake Ripley has a littoral zone that generally extends down to about 15 feet, covering about 54% of the lake in terms of surface area.

Lake Ripley's littoral areas support a variety of flora and fauna, including some rare, threatened and endangered species. Some of these species were discovered during a 1994 survey, and include the giant carrion beetle (*Nicrophorus americanus*), least darter (*Etheostoma microperca*), lake chubsucker (*Erimyzon sucetta*), cuckoo flower (*Cardamine pratensis*), pugnose shiner (*Notropis anogenus*) and blanding's turtle (*Emydoidea blandingi*).[2] Shoreline development, stormwater pollution, and habitat loss threaten such sensitive species. These species rely on good water quality, functioning wetlands and a diverse aquatic plant community for their survival.

5-4 OVERVIEW OF PLANT COMMUNITY

Lake Ripley can be described as a shallow lake when viewed in the context of its littoral area. As mentioned earlier, rooted aquatic plant growth is generally found in 0-15-ft. water depths, covering over half the lake's surface area. The most recent aquatic plant inventory, completed in 2006, documented 31 different species of plants found growing in and around the lake. Most of these species are native and provide excellent habitat for fish and other aquatic life.

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[2] Wisconsin Department of Natural Resources, and Lake Ripley Management District. 1994. Lake Ripley Water Resources Appraisal.

Examples of high value plants include water lilies, bulrushes and native pondweeds. The major concentrations of aquatic plants are found covering the bottom of both bays, with species like pondweeds (*Potamogeton* sp.), water celery (*Vallisneria americana*), muskgrass (*Chara vulgaris*) and spiny naiad (*Najas marina*) found distributed throughout the lake. In addition to rooted plants, there are also free-floating duckweed, filamentous algae and planktonic algae in the lake.

Eurasian watermilfoil (*Myriophyllum spicatum*), which is common in Lake Ripley, is one of two nuisance species found in the lake that are not native to Wisconsin. The other is curly-leaf pondweed (*Potamogeton crispus*), but this species continues to represent a small fraction of the overall plant community. It is unknown how or when these common lake weeds were first introduced to Lake Ripley. They were first documented in 1976 when the lake's first comprehensive plant inventory was conducted. General problems related to plant growth, however, were reported as early as 1961.[3] Under the right conditions, non-native weeds can pose a problem by out-competing native plants and forming monotypic stands of dense vegetation. Such prolific growth can eventually reduce biological diversity and restrict recreational use of the water.

The infestation and rapid proliferation of Eurasian watermilfoil was among the initial driving forces behind the establishment of the Lake Ripley Management District in 1991. Two years earlier, peak milfoil growth reduced the lake's useable surface area by roughly 40%, contributing to user conflicts and increasing the potential for boating hazards within the remaining 60%.[4] Since 1991, the prevalence of Eurasian watermilfoil in the lake has declined precipitously. This trend is likely the combined result of an ongoing mechanical harvesting program, continued efforts to reduce sediment and nutrient loading into the lake, slow-no-wake protections that limit lakebed disturbances, and the cyclical nature of invading milfoil populations.

5-5 RESULTS OF PAST INVENTORIES

Comprehensive inventories of Lake Ripley's aquatic plant community were conducted in 1976, 1989, 1991, 1996, 2001 and 2006. The 1989-2001 inventories involved sampling along the same 15 transects, with the 2001 inventory incorporating an additional eight transects in an attempt to better characterize the plant community. The original 1976 inventory was based upon significantly different transects and sampling methodology, making it less suitable for year-to-year comparisons. The most recent 2006 inventory employed the point-intercept method, representing the latest sampling methodology utilized by the Wisconsin DNR. The only other documented aquatic plant survey of Lake Ripley was performed in 1953, but it cannot be considered comprehensive since only six dominant species were studied.

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[3] Burris, John E. 1971. A Study of Man's Effects on Lake Ripley. University of Wisconsin-Madison. Zoology 518 Report.
[4] Wisconsin Department of Natural Resources. 1990. Aquatic Plant Control Reconnaissance Report for Lake Ripley.

Findings from prior inventories were used to develop aquatic plant management plans in 1992 and 2001. These earlier plans were used to assess the health of the aquatic plant community, evaluate long-term trends, and set forth recommendations for future management. The 1992 plan was authored by the Wisconsin DNR.[5] It was used for several years to help guide mechanical weed-harvesting activities, and was significantly expanded and updated by the District in 2001.[6] The current plan builds upon these earlier efforts, namely by incorporating findings and analysis from the 2006 inventory.

The following is an abbreviated summary of inventory findings from prior years. Statistical summaries from each inventory are presented for 14 aquatic plant species. Statistical measures for each species consist of frequency of occurrence, average density, relative frequency of occurrence, and importance value. Each of these measures is defined below.

Frequency of occurrence is the number of occurrences of a species divided by the number of sampling points within the defined littoral zone. It is the percentage of times a particular species occurred within areas capable of supporting plant growth. This measure is used to describe how widely distributed a particular species is found throughout the lake's littoral zone.

Relative frequency of occurrence is derived by dividing a particular species' frequency of occurrence by the sum total frequency of all species inventoried. The sum of the relative frequencies is equal to 100% when all documented species are included. This measure provides an indication of how the plants occur throughout the lake in relation to each other.

Average density is the sum of the density ratings for a species divided by the number of sampling points where vegetation was found. Density ratings are based on a 1-4 rake-fullness scale for the 1989-2001 transect surveys, and a 1-3 rake-fullness scale for the 2006 point-intercept survey. This measure provides an indication of how abundant the growth of a particular plant is throughout the lake.

Importance value is the product of the relative frequency and the average density, and is expressed as a percentage. This measure provides an indication of the dominance of a species within a community, and is based on both frequency and density values. It also somewhat addresses the challenge of comparing plants that have different physical statures.

1953

A limited survey was performed to monitor seasonal changes of six dominant species, consisting of muskgrass (*Chara contraria*), bushy pondweed (*Najas flexilis*), Illinois pondweed (*Potamogeton illinoensis*), sago pondweed (*Potamogeton pectinatus*), water celery (*Vallisneria americana*), and Fries' pondweed (*Potamogeton friesii*). Summary results are not presented due to the limited scope and narrow focus of this early survey.

[5] Wisconsin Department of Natural Resources. 1992. Lake Ripley Aquatic Plant Management Plan.
[6] Lake Ripley Management District. 2002. Lake Ripley Aquatic Plant Inventory and Management Plan.

1976

The first comprehensive plant survey was conducted on Lake Ripley. A total of 11 species of aquatic plants were reported, including two unidentified *Potamogeton* and *Naiad* species. Muskgrass (*Chara vulgaris*) and water celery (*Vallisneria americana*) were the dominant species reported. Eurasian watermilfoil (*Myriophyllum spicatum*), coontail (*Ceratophyllum demersum*) and sago pondweed (*Potamogeton pectinatus*) were also frequently observed in the aquatic plant community at this time. Table 18 presents a list of plant species and statistical relationships from the 1976 inventory.

Table 1: 1976 plant inventory findings

Species	Frequency of Occurrence (%)	Average Density (1-4 scale)	Relative Frequency	Importance Value
Ceratophyllum demersum (coontail)	20.6	- -	9.6	- -
Chara vulgaris (musk grass)	69.1	- -	32.2	- -
Elodea candensis (waterweed)	2.9	- -	1.4	- -
Heteranthera dubia (water star grass)	0.0	- -	0.0	- -
Myriophyllum spicatum (Eurasian watermilfoil)	27.9	- -	13.0	- -
Najas flexilis (bushy pondweed)	0.0	- -	0.0	- -
Najas marina (spiny naiad)	0.0	- -	0.0	- -
Potamogeton gramineus (variable pondweed)	0.0	- -	0.0	- -
Potamogeton crispus (curly-leaf pondweed)	1.5	- -	0.7	- -
Potamogeton pectinatus (Sago pondweed)	17.6	- -	8.2	- -
Potamogeton natans (floating-leaf pondweed)	14.7	- -	6.8	- -
Potamogeton zosteriformis (flat-stem pondweed)	0.0	- -	0.0	- -
Utricularia sp. (bladderwort)	8.8	- -	4.1	- -
Vallisneria americana (water celery)	36.8	- -	17.1	- -

1989

This survey reported 12 species of aquatic plants. Eurasian watermilfoil (*Myriophyllum spicatum*) was by far the most abundant and frequently observed plant, with Illinois pondweed (*Potamogeton illinoensis*), small pondweed (*Potamogeton pusillis*) and spiny naiad (*Najas marina*) also commonly represented. Eurasian watermilfoil was observed throughout the lake and at all depths sampled. Plant growth was generally present down to a depth of about 15 feet, with no growth reported from depths in excess of 18 feet. Subsequent surveys revealed similar findings in relation to the depth of plant growth. Table 19 presents a list of plant species and statistical relationships from the 1989 inventory.

Table 2: 1989 plant inventory findings

Species	Frequency of Occurrence (%)	Average Density (1-4 scale)	Relative Frequency	Importance Value
Ceratophyllum demersum (coontail)	5.0	3.0	2.5	8
Chara vulgaris (musk grass)	11.7	1.3	5.8	8
Elodea candensis (waterweed)	0.0	- -	0.0	- -
Heteranthera dubia (water star grass)	0.0	- -	0.0	- -
Myriophyllum spicatum (Eurasian watermilfoil)	75.0	2.8	37.5	105
Najas flexilis (bushy pondweed)	11.7	1.1	5.8	7

Najas marina (spiny naiad)	18.3	1.0	9.2	18
Potamogeton gramineus (variable pondweed)	3.3	1.0	1.7	2
Potamogeton crispus (curly-leaf pondweed)	1.7	1.0	0.8	8
Potamogeton pectinatus (Sago pondweed)	5.0	1.0	2.5	7
Potamogeton natans (floating-leaf pondweed)	13.3	1.1	6.7	8
Potamogeton zosteriformis (flat-stem pondweed)	0.0	- -	0.0	- -
Utricularia sp. (bladderwort)	0.0	- -	0.0	- -
Vallisneria americana (water celery)	11.7	1.6	5.8	9

1991

Eleven (11) aquatic plant species were documented in the survey, including one unidentified *Potamogeton* species. Eurasian watermilfoil (*Myriophyllum spicatum*) was again the most abundant and frequently observed plant, followed by spiny naiad (*Najas marina*), coontail (*Ceratophyllum demersum*), muskgrass (*Chara vulgaris*) and sago pondweed (*Potamogeton pectinatus*). Eurasian watermilfoil was less prevalent compared to the 1989 survey, although the weed continued to be reported at all depths sampled. Table 20 presents a list of plant species and statistical relationships from the 1991 inventory.

Table 3: 1991 plant inventory findings

Species	Frequency of Occurrence (%)	Average Density (1-4 scale)	Relative Frequency	Importance Value
Ceratophyllum demersum (coontail)	21.1	2.5	11.9	30
Chara vulgaris (musk grass)	20.0	2.3	11.3	26
Elodea candensis (waterweed)	2.2	1.0	1.3	1
Heteranthera dubia (water star grass)	0.0	- -	0.0	- -
Myriophyllum spicatum (Eurasian watermilfoil)	53.3	3.0	30.0	89
Najas flexilis (bushy pondweed)	13.3	2.6	5.0	13
Najas marina (spiny naiad)	41.1	2.5	23.1	58
Potamogeton gramineus (variable pondweed)	0.0	- -	0.0	- -
Potamogeton crispus (curly-leaf pondweed)	0.0	- -	0.0	- -
Potamogeton pectinatus (Sago pondweed)	13.3	2.3	7.5	18
Potamogeton natans (floating-leaf pondweed)	0.0	- -	0.0	- -
Potamogeton zosteriformis (flat-stem pondweed)	0.0	- -	0.0	- -
Utricularia sp. (bladderwort)	2.2	1.5	1.3	2
Vallisneria americana (water celery)	7.8	1.6	4.4	7

1996

A total of 12 aquatic plant species were documented in the survey, including one unidentified *Potamogeton* species. Eurasian watermilfoil (*Myriophyllum spicatum*) continued to be among the more dominant species, but remained less widespread compared to earlier surveys. Other dominant species included spiny naiad (*Najas marina*), muskgrass (*Chara vulgaris*), coontail (*Ceratophyllum demersum*) and sago pondweed (*Potamogeton pectinatus*). Greater uniformity of plant growth was observed among the several dominant species in relation to prior surveys. Table 21 presents a list of plant species and statistical relationships from the 1996 inventory.

Table 4: 1996 plant inventory findings

Species	Frequency of Occurrence (%)	Average Density (1-4 scale)	Relative Frequency	Importance Value
Ceratophyllum demersum (coontail)	23.3	1.9	10.8	21
Chara vulgaris (musk grass)	25.6	2.2	11.9	26
Elodea candensis (waterweed)	1.1	1.0	0.5	1
Heteranthera dubia (water star grass)	0.0	- -	0.0	- -
Myriophyllum spicatum (Eurasian watermilfoil)	58.9	2.6	27.3	70
Najas flexilis (bushy pondweed)	12.2	2.2	5.7	12
Najas marina (spiny naiad)	51.1	2.3	23.7	54
Potamogeton gramineus (variable pondweed)	0.0	- -	0.0	- -
Potamogeton crispus (curly-leaf pondweed)	0.0	- -	0.0	- -
Potamogeton pectinatus (Sago pondweed)	20.0	2.0	9.3	19
Potamogeton natans (floating-leaf pondweed)	0.0	- -	0.0	- -
Potamogeton zosteriformis (flat-stem pondweed)	0.0	- -	0.0	- -
Utricularia sp. (bladderwort)	2.2	1.5	1.5	2
Vallisneria americana (water celery)	11.1	1.4	1.4	7

2001

Fifteen (15) species of aquatic plants were reported, including a large stand of water bulrush (*Scirpus subterminalis*) observed growing on the northeastern shore. Muskgrass (*Chara vulgaris*) was slightly more frequently observed in the samples compared to Eurasian watermilfoil (*Myriophyllum spicatum*). Spiny naiad (*Najas marina*), water celery (*Vallisneria americana*), sago pondweed (*Potamogeton pectinatus*) and bushy pondweed (*Najas flexilis*) were the next most frequently observed plants. Eurasian watermilfoil continued to be observed throughout the lake, but overall plant diversity and uniformity of growth continued to increase. Plant growth was mostly concentrated in those areas where water depth was less than 12 feet. Table 22 presents a list of plant species and statistical relationships from the 2001 inventory.

Table 5: 2001 plant inventory findings

Species	Frequency of Occurrence (%)	Average Density (1-4 scale)	Relative Frequency	Importance Value
Ceratophyllum demersum (coontail)	5.6	3.4	2.4	8
Chara vulgaris (musk grass)	50.0	3.0	21.5	66
Elodea candensis (waterweed)	3.3	1.3	1.4	2
Heteranthera dubia (water star grass)	3.3	3.0	1.4	4
Myriophyllum spicatum (Eurasian watermilfoil)	45.6	2.1	19.6	42
Najas flexilis (bushy pondweed)	14.4	1.9	6.2	12
Najas marina (spiny naiad)	38.9	2.4	16.7	41
Potamogeton gramineus (variable pondweed)	8.9	1.5	3.8	6
Potamogeton crispus (curly-leaf pondweed)	1.1	1.0	0.5	0
Potamogeton pectinatus (Sago pondweed)	22.2	2.0	9.6	19
Potamogeton natans (floating-leaf pondweed)	1.1	1.0	0.5	0
Potamogeton zosteriformis (flat-stem pondweed)	13.3	2.2	5.7	13
Utricularia sp. (bladderwort)	1.1	1.0	0.5	0
Vallisneria americana (water celery)	23.3	2.0	10.0	20

2006

This survey employed the point-intercept method in accordance with Wisconsin DNR's revised protocols. This represents a change from previous surveys where the Jessen and Lound transect-sampling technique was used.[7] By 2006, the reported number of aquatic plant species had jumped from a previous low of 11 to a high of 19. (This number increases to 31 species if visual observations from a follow-up boat survey are included). Muskgrass (*Chara vulgaris*) was found to be the most dominant species, followed by spiny naiad (*Najas marina*), sago pondweed (*Potamogeton pectinatus*) and coontail (*Ceratophyllum demersum*). Eurasian watermilfoil (*Myriophyllum spicatum*) continued to show signs of significant decline, and now represents a much smaller component of the overall plant community compared to earlier surveys. Plant growth remained fairly uniform among dominant species. While overall plant diversity appears to have increased, this finding may have been influenced by the change to a point-intercept sampling methodology. Plant growth was found in water depths down to 17 feet.

Tables 23-25 present plant species and statistical relationships from the 2006 inventory. Figure 41 depicts the sample locations where the non-native Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) were found. Finally, a 30-year comparative analysis for the 1976-2006 monitoring period is provided in Tables 26-29 and Figure 42 below. During the 30-year period of record, the trend toward an increasing number of documented plant species is not considered significant. These results may reflect inter-annual variability, differences in sampling technique, and the influence of seasonality in plant growth consequent to the time of year during which the surveys were conducted.

Table 6: 2006 plant inventory findings

Species	Frequency of Occurrence (%)	Average Density* (1-3 scale)	Relative Frequency	Importance Value
Ceratophyllum demersum (coontail)	12.2	1.4	6.9	9.7
Chara vulgaris (musk grass)	53.1	1.5	30.1	45.2
Elodea candensis (waterweed)	0.8	1.0	0.5	0.5
Heteranthera dubia (water star grass)	4.3	1.1	2.5	2.8
Myriophyllum spicatum (Eurasian watermilfoil)	6.8	1.3	3.8	4.9
Najas flexilis (bushy pondweed)	1.1	1.0	0.6	0.6
Najas marina (spiny naiad)	33.3	1.0	18.9	18.9
Potamogeton gramineus (variable pondweed)	0.0	--	0.0	--
Potamogeton crispus (curly-leaf pondweed)	1.4	1.2	0.8	1.0
Potamogeton pectinatus (Sago pondweed)	16.8	1.0	9.5	9.5
Potamogeton natans (floating-leaf pondweed)	0.0	--	0.0	--
Potamogeton zosteriformis (flat-stem pondweed)	0.0	--	0.0	--
Utricularia sp. (bladderwort)	0.0	--	0.0	--
Vallisneria americana (water celery)	3.0	1.0	1.7	1.7

* Average Densities and corresponding Importance Values are based on a 1-3 rake-fullness scale, versus a 1-4 scale used in prior inventories. This change is due to switching to the point-intercept method which uses a different scaling system.

[7] Jessen, Robert and Richard Lound. 1962. An Evaluation of a Survey Technique for Submerged Aquatic Plants. Minnesota Department of Conservation. Investigational Report No. 6.

Table 7: Statistical summary for all plant species documented in the 2006 inventory

Aquatic Plant	Number of Sites Found	FREQ[a] [0-17'] (%)	FREQ[b] [Veg. Sites] (%)	RFREQ[c] (%)	ADEN[d] (1-3 scale)	IV[e]	C[f]
Muskgrass *Chara* sp.	196	53.1	61.6	30.1	1.5	45.2	7
Spiny naiad *Najas marina*	123	33.3	38.7	18.9	1.0	18.9	NA
Sago Pondweed *Stuckenia pectinata*	62	16.8	19.5	9.5	1.0	9.5	3
Coontail *Ceratophyllum demersum*	45	12.2	14.2	6.9	1.4	9.7	3
Fries' pondweed *Potamogeton friesii*	27	7.3	8.5	4.1	1.1	4.5	8
*Eurasian Watermilfoil *Myriophyllum spicatum*	25	6.8	7.9	3.8	1.3	4.9	NA
Illinois Pondweed *Potamogeton illinoensis*	18	4.9	5.7	2.8	1.0	2.8	6
Unknown watermilfoil *Myriophyllum sp.(sibiricum/spicatum)*	17	4.6	5.4	2.6	1.1	2.9	NA
Water Stargrass *Heteranthera/Zosterella dubia*	16	4.3	5.0	2.5	1.1	2.8	6
Northern Watermilfoil *Myriophyllum sibiricum*	14	3.8	4.4	2.2	1.1	2.4	7
Water Celery, or Eel Grass *Vallisneria americana*	11	3.0	3.5	1.7	1.0	1.7	6
Spatterdock *Nuphar variegata*	7	1.9	2.2	1.1	2.2	2.4	6
White Water Lily *Nymphaea odorata*	6	1.6	1.9	0.9	1.2	1.1	6
*Curly-leaf Pondweed *Potamogeton crispus*	5	1.4	1.6	0.8	1.2	1.0	NA
Small Duckweed *Lemna minor*	4	1.1	1.3	0.6	1.0	0.6	5
Slender Naiad, or Bushy Pondweed *Najas flexilis*	4	1.1	1.3	0.6	1.0	0.6	6
Common Waterweed *Elodea canadensis*	3	0.8	0.9	0.5	1.0	0.5	3
Leafy pondweed *Potamogeton foliosus*	3	0.8	0.9	0.5	1.0	0.5	6
Forked Duckweed *Lemna trisulca*	1	0.3	0.3	0.2	1.0	0.2	6
Small Pondweed *Potamogeton pusillus*	1	0.3	0.3	0.2	1.0	0.2	7
Water sedge *Carex aquatilis var. altior*	GS	GS	GS	GS	GS	GS	NA
Spotted water-hemlock *Cicuta maculata*	GS	GS	GS	GS	GS	GS	NA
Swamp loosestrife *Decodon verticillatus*	GS	GS	GS	GS	GS	GS	NA
Needle spikerush	GS	GS	GS	GS	GS	GS	5

Eleocharis acicularis							
Smooth horsetail *Equisetum laevigatum*	GS	GS	GS	GS	GS	GS	NA
Southern blue flag *Iris virginica*	GS	GS	GS	GS	GS	GS	NA
*Reed canary grass *Phalaris arundinacea*	GS	GS	GS	GS	GS	GS	NA
Willow *Salix sp.*	GS	GS	GS	GS	GS	GS	NA
Hardstem bulrush *Schoenoplectus/Scirpus acutus*	GS	GS	GS	GS	GS	GS	5
Softstem Bulrush *Schoenoplectus/Scirpus tabernaemontani*	GS	GS	GS	GS	GS	GS	NA
Bittersweet nightshade *Solanum dulcamara*	GS	GS	GS	GS	GS	GS	NA
Cattails *Typha sp.*	GS	GS	GS	GS	GS	GS	1
filamentous algae	59	16.0	18.6	9.1	1.1	10.0	NA
freshwater sponge	3	0.8	0.9	0.5	1.0	0.5	NA

* = Species not native to Wisconsin

GS = species observed during general boat survey

[a]FREQ [0-17’] = Frequency of Occurrence within depth zone defining extent of plant growth. The number of occurrences of a species divided by the number of sampling points in the 0-17’ depth range.

[b]FREQ [Veg. Sites] = Frequency of Occurrence within sites where plants were collected. The number of occurrences of a species divided by the number of sampling points with documented plant growth.

[c]RFREQ = Relative Frequency of Occurrence.

[d]ADEN = Average Density. The sum of the density ratings for a species (1-3 rake fullness scale) divided by the number of sampling points with vegetation.

[e]IV = Importance Value. The product of the relative frequency (RFREQ) and the average density, expressed as a percentage.

[f]C = Coefficient of Conservatism. Used to compute Floristic Quality Index. Values range from 0-10, with higher values indicative of plant species intolerant of habitat modification or water quality impairment caused by human disturbance.

Table 8: Statistical descriptions based on all plants inventoried (2006)

[a]Total Number of Points Sampled	398
[b]Number of Points Sampled within Depth Range of Potential Plant Growth (0-17’)	369
[c]Number of Points with Vegetation	318
[d]Maximum Depth of Plant Growth	17 ft
[e]Number of Species in Lake	31
[f]Frequency of Occurrence of Vegetation within Range of Plant Growth (0-17’)	86
[g]Simpson Diversity Index	0.85

[h]Species Richness	23
[i]Floristic Quality Index (FQI)	22.75
[j]Mean Coefficient of Conservatism (C)	5.69
Average Number of Species Sampled Per Site (0-17')	1.76
Average Number of Species Sampled Per Site (Veg. Sites Only)	2.05
Average Number of Native Species Sampled Per Site (0-17')	1.52
Average Number of Native Species Sampled Per Site (Veg. Sites Only)	2.00

[a]Does not include sample points in depths beyond 17 ft. where plant growth could not be documented

[b]Includes all sample points within the 0-17-ft. littoral zone that was shown to support plant growth

[c]Includes all sample points where vegetation was found after taking a rake sample

[d]Represents deepest point where vegetation was sampled. This depth will fluctuate from year to year depending on changes in water clarity conditions. Plants may be found at depths of over 20 ft. in clear lakes, but only in a few feet of water in stained or turbid lakes. While some species can tolerate very low light conditions, others are only found near the surface. In general, the diversity of the plant community decreases with increased depth.

[e]Includes plant species documented in the lake and along the zero-depth shoreline margin using both the point-intercept method and a general boat survey.

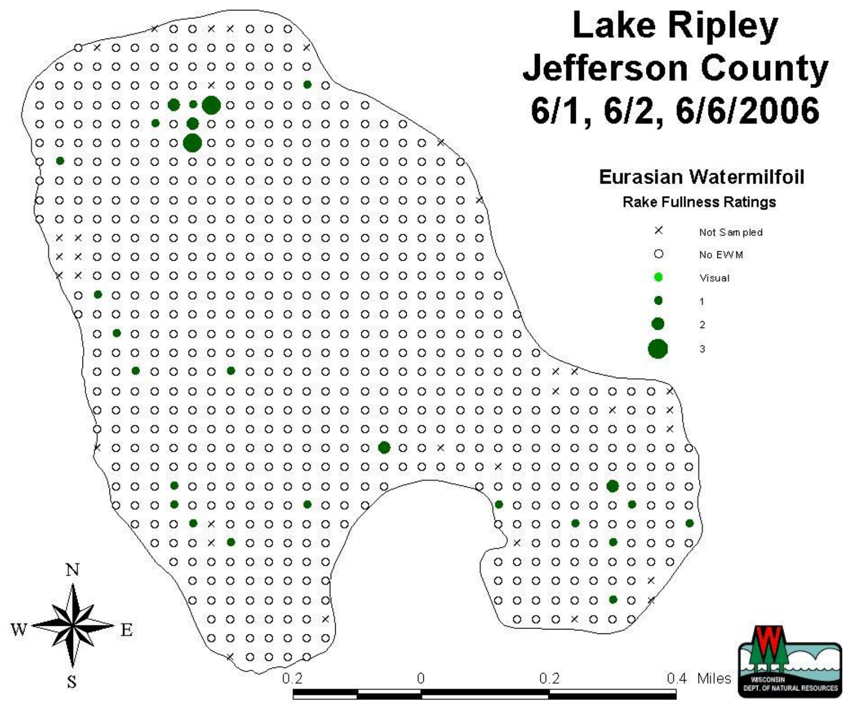
[f]Percentage of occurrence that vegetation would be sampled within the 0-17-ft. littoral zone

[g]Simpson Diversity Index: One minus the sum of each of the relative frequencies squared ($SDI = 1 - \sum(RFREQ^2)$). The closer the SDI value is to one, the greater the diversity is between communities being compared. The index allows the plant community at one location to be compared to the plant community at another location. It also allows a single location's plant community to be compared over time. The index value (on a scale of 0-1) represents the probability that two individuals (randomly selected) will be different species. The greater the index value, the higher the diversity in a given location. Plant communities with high diversity are usually representative of healthier lakes, and also tend to be more resistant to invasion by exotic species.

[h]Indicates the number of different plant species found in and directly adjacent to the lake (on the waterline). Species richness only counts those plants documented as part of the point-intercept data. It includes filamentous algae, freshwater sponge, and unidentified *Myriophyllum* and *Najas* species.

[i]Measures the impact of human development on a lake's aquatic plant community. Species in the index are assigned a Coefficient of Conservatism (C), which ranges from 3.0 to 44.6 in Wisconsin. The higher the value, the more likely the plant is negatively influenced by human activities that affect water quality or habitat. Plants with low values are tolerant of human disturbances, and often exploit these impacts to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each species found in the lake, and then multiplying that value by the square root of the number of species ($FQI = meanC\sqrt{N}$). Consequently, a higher index value indicates a healthier macrophyte community.

[j]Mean Coefficient of Conservatism (C) among species documented during point-intercept survey. Does not include species observed during the follow-up boat survey.



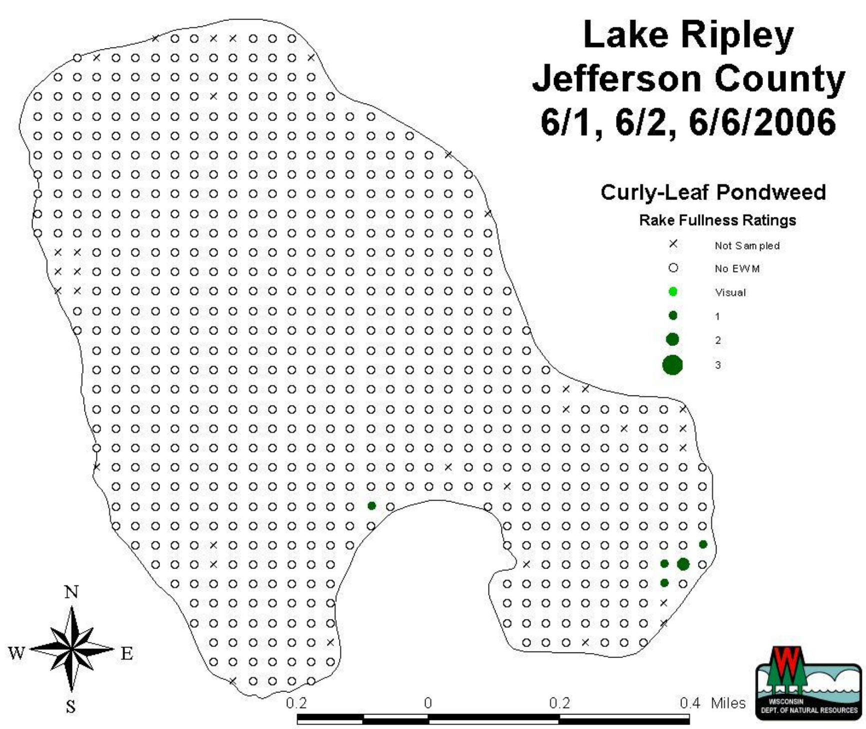


Figure 2: Distribution of the Non-Native Eurasian Watermilfoil and Curly-Leaf Pondweed (2006)

Table 9: Number of littoral-zone sample sites where each species was found (1976-2006)

Species	Year					
	1976	1989	1991	1996	2001	2006*
Muskgrass	47	7	18	23	45	196
Eurasian watermilfoil	19	45	48	53	41	25
Spiny naiad	0	11	37	46	35	123
Water celery	25	7	7	10	21	11
Sago pondweed	12	3	12	18	20	62
Bushy pondweed	0	7	8	11	13	4
Flatstem pondweed	0	0	0	0	8	0
Variable pondweed	0	2	0	0	8	0
Coontail	14	3	19	21	5	44
Water bulrush	0	0	0	0	4	0
Common waterweed	2	0	2	1	3	3
Water star grass	0	0	0	0	3	16
Curly-leaf pondweed	1	1	0	0	1	5
Floating-leaf pondweed	10	8	0	0	1	0
Illinois pondweed	0	13	0	1	0	18
Small pondweed	0	13	0	0	0	1
Northern watermilfoil	0	0	2	1	0	14
Bladderwort	6	0	2	2	1	0
Potamogeton spp.	7	0	5	7	0	0
Naiad spp.	3	0	0	0	0	0
Leafy pondweed	0	0	0	0	0	3
Forked duckweed	0	0	0	0	0	1
Small duckweed	0	0	0	0	0	4
Fries' pondweed	0	0	0	0	0	27
Spatterdock	0	0	0	0	0	7
White water lily	0	0	0	0	0	6
Total Number of Species Documented:	11	12	11	12	15	19

* 2006 had a higher number of sample sites compared to previous years due to use of the point-intercept method

Table 10: Percent frequency of occurrence of aquatic plant species (1976-2006)

Species	Year					
	1976	1989	1991	1996	2001	2006
Muskgrass	69.1	11.7	20.0	25.6	50.0	53.1
Eurasian watermilfoil	29.9	75.0	53.3	58.9	45.6	6.8
Spiny naiad	0.0	18.3	41.1	51.1	38.9	33.3
Water celery	36.8	11.7	7.8	11.1	23.3	3.0
Sago pondweed	17.6	5.0	13.3	20.0	22.2	16.8
Bushy pondweed	0.0	11.7	8.9	12.2	14.4	1.1
Flatstem pondweed	0.0	0.0	0.0	0.0	8.9	0.0
Variable pondweed	0.0	3.3	0.0	0.0	8.9	0.0
Coontail	20.6	5.0	21.1	23.3	5.6	12.2
Water bulrush	0.0	0.0	0.0	0.0	4.4	0.0
Common waterweed	2.9	0.0	2.2	1.1	3.3	0.8
Water star grass	0.0	0.0	0.0	0.0	3.3	4.3
Curly-leaf pondweed	1.5	1.7	0.0	0.0	1.1	1.4
Floating-leaf pondweed	14.7	13.3	0.0	0.0	1.1	0.0
Illinois pondweed	0.0	21.7	0.0	1.1	0.0	0.0
Small pondweed	0.0	21.7	0.0	0.0	0.0	0.3
Northern watermilfoil	0.0	0.0	2.2	1.1	0.0	3.8
Bladderwort	8.8	0.0	2.2	2.2	1.1	0.0
Potamogeton spp.	10.3	0.0	5.6	7.8	0.0	0.0
Naiad spp.	4.4	0.0	0.0	0.0	0.0	0.0
Leafy pondweed	0.0	0.0	0.0	0.0	0.0	0.8
Forked duckweed	0.0	0.0	0.0	0.0	0.0	0.3
Small duckweed	0.0	0.0	0.0	0.0	0.0	1.1
Fries’ pondweed	0.0	0.0	0.0	0.0	0.0	7.3
Spatterdock	0.0	0.0	0.0	0.0	0.0	1.9
White water lily	0.0	0.0	0.0	0.0	0.0	1.6

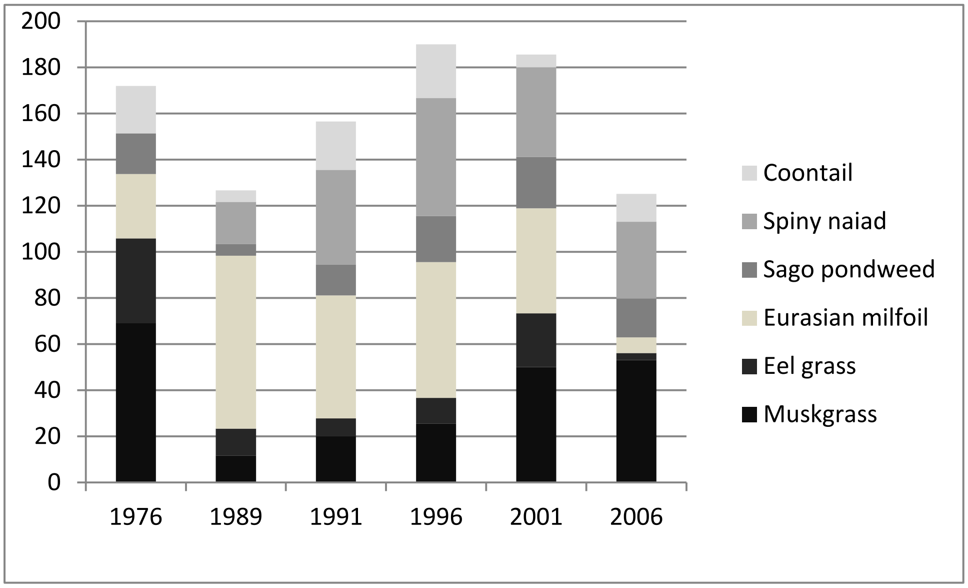


Figure 3: Frequency of Occurrences for Six Dominant Aquatic Plant Species Found Among Littoral-Zone Sample Sites (1976-2006)

Table 11: Percent relative frequency of occurrence of aquatic plant species (1976-2006)

Species	Year					
	1976	1989	1991	1996	2001	2006
Muskgrass	32.2	5.8	11.3	11.9	21.5	30.1
Eurasian watermilfoil	13.0	37.5	30.0	27.3	19.6	3.8
Spiny naiad	0.0	9.2	23.1	23.7	16.7	18.9
Water celery	17.1	5.8	4.4	5.2	10.0	1.7
Sago pondweed	8.2	2.5	7.5	9.3	9.6	9.5
Bushy pondweed	0.0	5.8	5.0	5.7	6.2	0.6
Flatstem pondweed	0.0	0.0	0.0	0.0	3.8	0.0
Variable pondweed	0.0	1.7	0.0	0.0	3.8	0.0
Coontail	9.6	2.5	11.9	10.8	2.4	6.9
Water bulrush	0.0	0.0	0.0	0.0	1.9	0.0
Common waterweed	1.4	0.0	1.3	0.5	1.4	0.5
Water star grass	0.0	0.0	0.0	0.0	1.4	2.5
Curly-leaf pondweed	0.7	0.8	0.0	0.0	0.5	0.8
Floating-leaf pondweed	6.8	6.7	0.0	0.0	0.5	0.0
Illinois pondweed	0.0	10.8	0.0	0.5	0.0	0.0
Small pondweed	0.0	10.8	0.0	0.0	0.0	0.2
Northern watermilfoil	0.0	0.0	1.3	0.5	0.0	2.2
Bladderwort	4.1	0.0	1.3	1.0	0.5	0.0
Potamogeton spp.	4.8	0.0	3.1	3.6	0.0	0.0
Naiad spp.	2.1	0.0	0.0	0.0	0.0	0.0

Leafy pondweed	0.0	0.0	0.0	0.0	0.0	0.5
Forked duckweed	0.0	0.0	0.0	0.0	0.0	0.2
Small duckweed	0.0	0.0	0.0	0.0	0.0	0.6
Fries’ pondweed	0.0	0.0	0.0	0.0	0.0	4.1
Spatterdock	0.0	0.0	0.0	0.0	0.0	1.1
White water lily	0.0	0.0	0.0	0.0	0.0	0.9

Table 12: Importance value of aquatic plant species (1976-2006)

Species	Year					
	1976	1989	1991	1996	2001	2006
Muskgrass	--	8	26	26	66	45
Eurasian watermilfoil	--	105	89	70	42	5
Spiny naiad	--	18	58	54	41	19
Water celery	--	9	7	7	20	2
Sago pondweed	--	3	18	19	19	10
Bushy pondweed	--	7	13	12	12	1
Flatstem pondweed	--	--	--	--	7	--
Variable pondweed	--	2	--	--	6	--
Coontail	--	8	30	21	8	10
Water bulrush	--	--	--	--	6	--
Common waterweed	--	--	1	1	2	1
Water star grass	--	--	--	--	4	3
Curly-leaf pondweed	--	1	--	--	0	1
Floating-leaf pondweed	--	8	--	--	0	--
Illinois pondweed	--	15	--	1	--	3
Small pondweed	--	13	--	--	--	0
Northern watermilfoil	--	--	1	1	--	2
Bladderwort	--	--	2	2	0	--
Potamogeton spp.	--	--	4	4	--	--
Naiad spp.	--	--	--	--	--	--
Leafy pondweed	--	--	--	--	--	1
Forked duckweed	--	--	--	--	--	0
Small duckweed	--	--	--	--	--	0
Fries’ pondweed	--	--	--	--	--	5
Spatterdock	--	--	--	--	--	2
White water lily	--	--	--	--	--	1

5-6 CONDITION ASSESSMENT

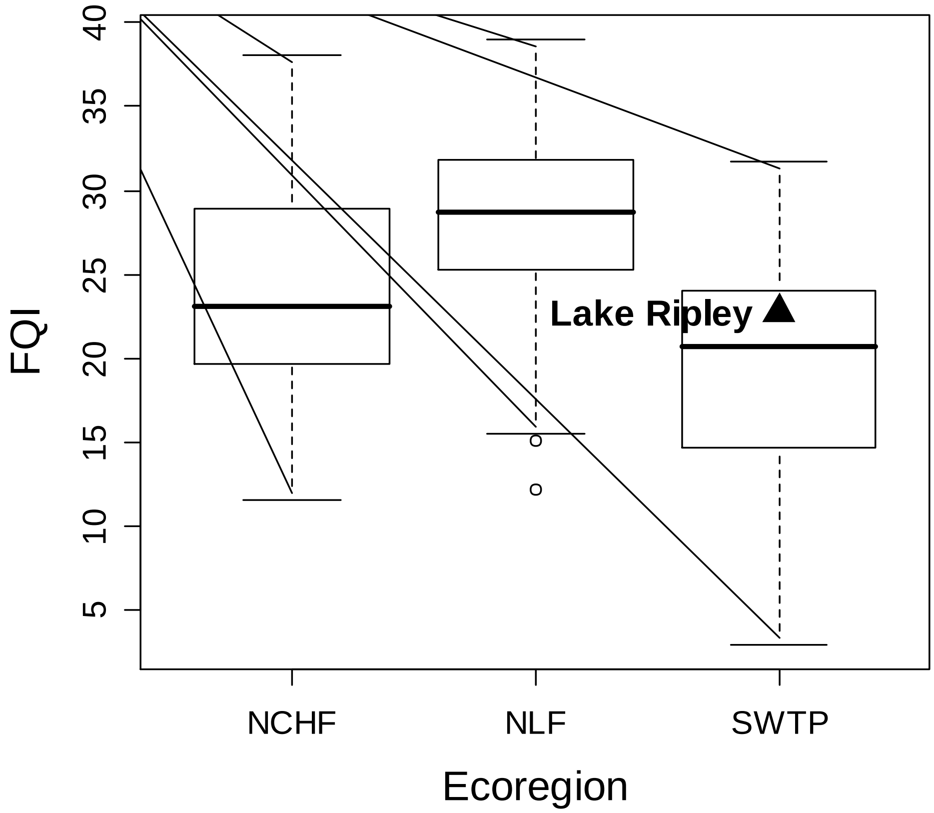
The distribution of aquatic plants has become slightly less uniform and increasingly patchy over the 30-year period of record. This shift, however, may in part be the result of variations in sampling technique. Data since 1976 indicate that the aquatic plant flora of Lake Ripley has become somewhat more diverse and spatially balanced, suggesting a shift toward a healthier lake ecosystem. Muskgrass (*Chara vulgaris*), spiny naiad (*Najas marina*), sago pondweed (*Potamogeton pectinatus*) and coontail (*Ceratophyllum demersum*) are now the most commonly occurring species.


A mixed community of aquatic plants is shown growing in Lake Ripley.

The dominance of water celery (*Vallisneria americana*) and pondweeds (*Potamogeton* sp.) first documented in 1953 was largely replaced by the non-native Eurasian watermilfoil (*Myriophyllum spicatum*) during the 1980s. This milfoil was abundant since as early as 1976, and continued to be present in quantities that approximate between one-fifth and one-third of the aquatic plant flora of the lake through 2001. As of 2006, this invasive weed no longer appears to represent a dominant position within the overall plant community.

Compared to other Wisconsin lakes, Lake Ripley ranks slightly above average in terms of total plant-species diversity (2006 data), and is in the top 25% when compared to lakes throughout the Southeast Till Plains Ecoregion. The percentage of sample sites in which Eurasian watermilfoil was found has decreased from 75% in 1989 to less than 7% in 2006, revealing a precipitous decline in dominance by this non-native species. The relative frequency of occurrence for milfoil also decreased from 37.5% (highest of all species) in 1989 to 3.8% (10th highest) in 2006.

With respect to the Wisconsin Floristic Quality Index, Lake Ripley's computed value of 22.75 (2006) puts it just above the median for Wisconsin and the larger ecoregion (see Figures 43-44). The Floristic Quality Index (FQI) was developed to help assess lake quality by evaluating the number and types of aquatic plants that live in a lake. The FQI for Wisconsin ranges from 3.0 to 44.6, with a median of 22.2. The FQI is particularly valuable for comparing lakes around the state or looking at a single lake over time. Generally, higher FQI numbers indicate better lake quality that can support more pollution-sensitive plant species. Lake Ripley's 2006 FQI of 22.75 is a marked improvement over prior years when the FQI averaged 15.63 (1976: 12.85, 1989: 16.67, 1991: 14.85, 1996: 16.00, and 2001: 17.78).



FQI
40
35
30
25
20
15
10
5
Lake Ripley
NCHF
NLF
SWTP
Ecoregion

Figure 4: Lake Ripley's Floristic Quality Index (FQI) Relative to All Lakes Inventoried in Ecoregion

Box plot shows variation in FQI by region. Mean is center, box covers 50% of the data, whiskers indicate range, with outliers marked as open circles. Ecoregions are as follows: NCHF = North Central Hardwood Forests (triangular swath across north central Wisconsin from Marquette County north through Marathon), SWTP = Southeastern Wisconsin Till Plains (southeastern corner of Wisconsin: Green Bay south to Illinois and east to through Columbia County) and NLF = Northern Lakes and Forests (northern Wisconsin).[8]

[8] Graph produced by Alison Mikulyuk, Wisconsin Department of Natural Resources

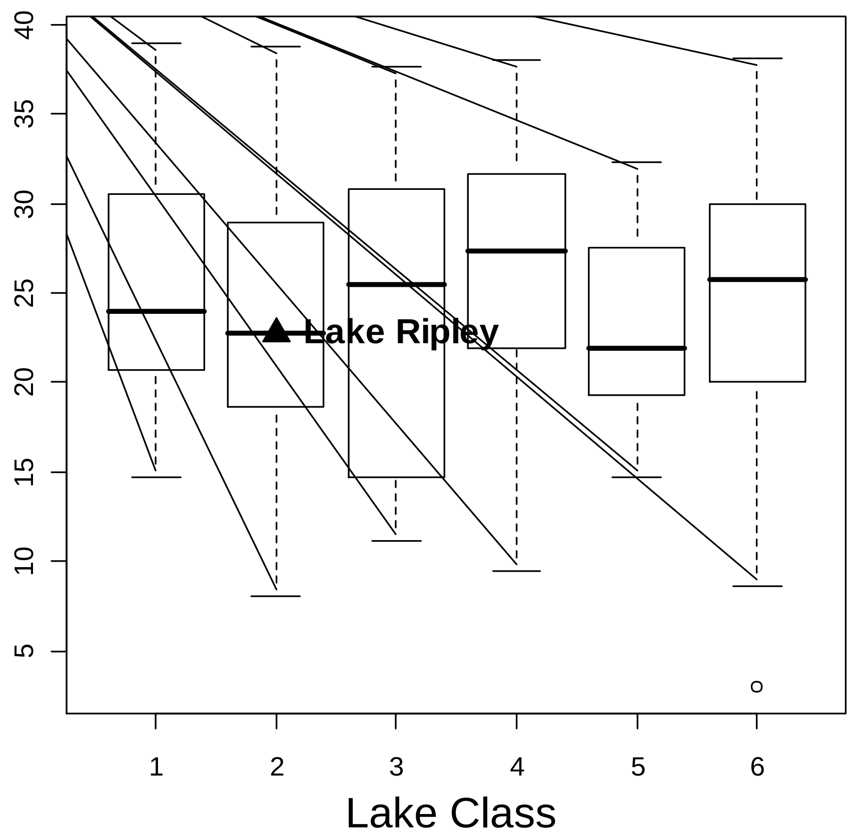


Figure 5: Lake Ripley's Floristic Quality Index (FQI) Relative to All Lakes Inventoried by Lake Class

Box plot shows variation in FQI by lake class. Mean is center, box covers 50% of the data, whiskers indicate range, with outliers marked as open circles. Lakes classes are as follows: 1 = shallow headwater drainage, 2 = deep headwater drainage, 3 = shallow lowland drainage, 4 = deep lowland drainage, 5 = shallow seepage, 6 = deep seepage.[9]

In terms of plant diversity, the Simpson Diversity Index has ranged from 0.82 to 0.86 (on a 0-1.00 scale) during the 30-year period of record. This suggests that the plant community has remained somewhat diverse throughout this period.

In terms of importance values, muskgrass (*Chara vulgaris*) and spiny naiad (*Najas marina*) remain the most commonly occurring species, while Eurasian watermilfoil has continued its steady decline in importance. Sago pondweed (*Potamogeton pectinatus*) and coontail (*Ceratophyllum demersum*) have also maintained relatively consistent importance values. The overall decline in importance values among the different plant species suggests a shift toward a healthier lake ecosystem, with no one species becoming overly dominant. While the precise

[9] Graph produced by Alison Mikulyuk, Wisconsin Department of Natural Resources

reasons for changes in the plant community are unclear, they are most likely related to a combination of factors. These factors include the implementation of aquatic plant management practices; changes in land use that affect nutrient supply and availability; alterations in lake-use patterns and behavior; climatic factors; and natural biological processes contributing to inter-annual variability among plant communities.

Recent inventory results are fairly encouraging, especially with respect to the overall decline in Eurasian watermilfoil dominance. Despite these positive observations, signs of degradation still remain and suggest there is still room for improvement. Evidence of degradation includes the continued presence of non-native vegetation, dominance of pollution/disturbance-tolerant species, and limited overall biodiversity. These conditions are likely to change for the better as recommendations contained within this plan are implemented over time.

5-7 CRITICAL HABITAT AREAS

In 1989, changes to Wisconsin DNR Administrative Code (NR 107) governing the Aquatic Plant Management Program went into effect. Recognizing that responsible management of aquatic plants can enhance water recreation was only one aspect of the program. NR 107 also underscored the value of native aquatic plants to water quality and lake ecology, and recognized the need to protect them.

Among several program changes, the Wisconsin DNR was required to identify ecologically sensitive areas (now called "Critical Habitat Areas") in lakes where aquatic plants are managed. These areas were designated to protect water quality, high-value native aquatic plants, critical fisheries and wildlife habitat, and shorelines susceptible to erosion. On Lake Ripley, Critical Habitat Areas were first designated by Wisconsin DNR and incorporated into a Town pier ordinance in 1995 (see map in Appendix D).[10] They were most often associated with relatively undeveloped shorelines and wetlands within South and East Bay, and were found to support excellent biodiversity. Water lilies, bulrush stands, and lakeshore wetlands that are important for shoreline protection, habitat for fish and wildlife, and water quality protection are among the features that commonly characterize these area designations. Water celery (*Vallisneria americana*) and several submersed pondweeds (*Potamogeton* sp.) were also identified as deserving protection, but it was noted that these plants occur in low densities and are widely dispersed throughout the lake. Consequently, these species cannot be protected within defined areas.

Historically, important near-shore aquatic habitats were abundant around the lake, but have largely disappeared as a consequence of wetland drainage and shoreline development. The few remaining Critical Habitat Areas along the southern shoreline are protected, and herbicide treatments, dredging, and sand blankets are prohibited within those locations. A Town of Oakland ordinance currently prohibits the placement of piers, wharves and swimming rafts within designated "sensitive" areas without a DNR permit.[11] Town ordinance also provides for

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[10] Town of Oakland. 1995. Ordinance No. 42: An Ordinance to Regulate the Location of Piers, Wharves and Swimming Rafts on Lake Ripley.
[11] Ibid.

slow-no-wake buoyed restricted zones in each bay, a 200-feet-from-shore no-wake zone, and a prohibition on motor use of any kind in Vasby's Channel. These ordinances are intended, in part, to better protect Critical Habitat Areas from frequent motor boat disturbance.[12] While mechanical harvesting is allowed in accordance with Wisconsin DNR permit conditions, operations are governed by a harvesting plan that largely targets the invasive milfoil in high-traffic navigational corridors. The weed-harvesting plan is incorporated into this document and can be referenced in chapter 5-13 and 5-14.

The Wisconsin DNR, in partnership with the Lake District, is currently in the process of re-evaluating and re-mapping Critical Habitat Areas on Lake Ripley. When completed, any key findings, re-delineations and recommendations from this effort shall be considered a part of this Lake Management Plan. A draft Critical Habitat Areas map is included as Figure 45. It should be noted that these mapped locations will be subject to public review and comment, and therefore may be adjusted depending on the input received.

[12]Town of Oakland. 1995. Ordinance No. 2: An Ordinance to Create Section 4.AMN of Ordinance No. 2 to Create an Additional "Buoyed Restricted Area" in the South Bay of Lake Ripley.

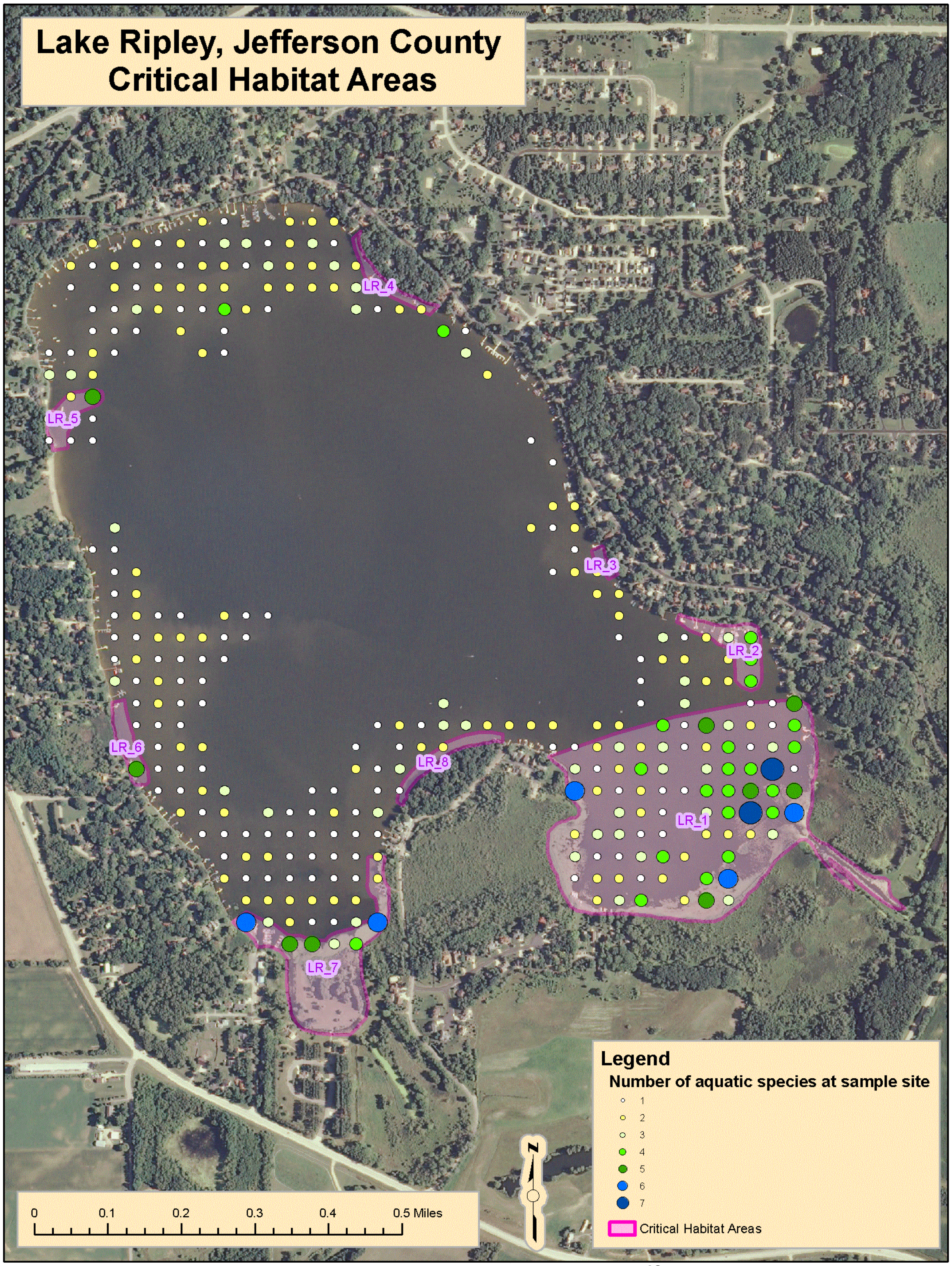

Figure 6: Critical Habitat Areas on Lake Ripley (DRAFT)[13]

[13] Draft map produced by Wisconsin DNR (2008)

5-8 LAKE RIPLEY PLANT DESCRIPTIONS

Aquatic plants, also called macrophytes, include all macroscopic plants (observable with the naked eye) found in aquatic environments. They are represented by a diverse group of aquatic and wetland plants, including flowering vascular plants, mosses, ferns and macroalgae. Aquatic vegetation is naturally present to some extent in all lakes, and represents an important component of a healthy ecosystem. There are four basic plant types: emergent, free-floating, floating-leaf and submersed.

Emergents (e.g. cattail and bulrush) are rooted in water-saturated or submerged soils, but have stems that grow above the water surface. These plants most often grow in shallow-water areas along lakeshore margins and within riparian wetlands. Free-floating plants (e.g. duckweed) are not rooted in the lake bottom, but have extensive root systems that hang beneath floating leaves. They obtain most of their required nutrients from the surrounding water column. These plants are often quite small, and may completely cover the water surface in small, fertile water bodies. Floating-leaf macrophytes (e.g. water lilies) have leaves that float on the lake surface with a long rooted stem anchored to the lake bottom. Because the leaves of these plants are delicate and easily torn by wave action, they are typically found only in quiet, sheltered bays. Submersed plants (e.g. milfoil, water celery and Illinois pondweed) grow entirely under the water surface in areas where there is sufficient sunlight penetration. They may or may not be rooted to the lake bottom.

Aquatic plants can also be described in terms of their regional nativity. Native species are those that were historically found in a particular geographic region. On the other hand, non-native or "exotic" species evolved outside the region of interest and are frequently referred to as weeds. These transplanted species are no longer controlled by their native predators, and can sometimes take over an entire water body, forming large monotypic colonies. This prolific and uncontrolled growth can threaten biodiversity, water quality and the recreational value of the invaded water body.

The following aquatic plants were identified in Lake Ripley during prior inventories. Descriptions and illustrations of each species are provided below.[14]

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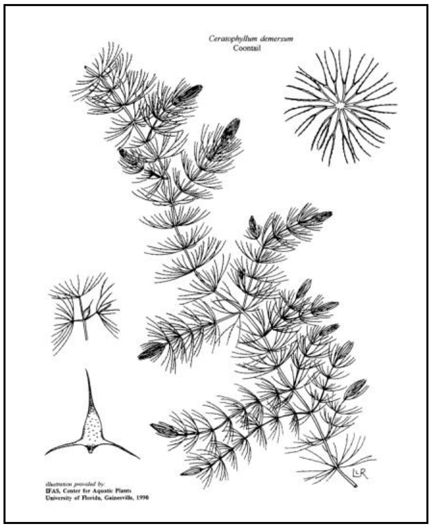
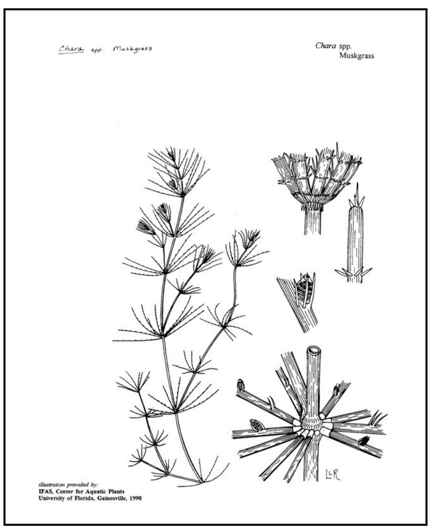
[14]Nichols, Stanley A. 1999. Distribution and Habitat Descriptions of Wisconsin Lake Plants. Wisconsin Geological and Natural History Survey.
Welsch, Jeff. 1992. Guide to Wisconsin Aquatic Plants. Wisconsin Department of Natural Resources. PUBL-WR-173 92rev.
Borman, Susan, Robert Korth and Jo Temte. 1997. Through the Looking Glass… A Field Guide to Aquatic Plants. Wisconsin Lakes Partnership. DNR Publication No. FH-207-97.



<u>Common Name</u>: **Coontail**
<u>Scientific Name</u>: ***Ceratophyllum demersum***
<u>Plant Type</u>: Submersed
<u>Duration</u>: Perennial
<u>U.S. Nativity</u>: Native

Coontail typically grows in clear water up to 15 feet deep. It is found over a broad range of water chemistries, prefers soft substrates, and is tolerant of turbid waters. New plants are formed primarily by stem fragmentation because seeds rarely develop. This plant has long trailing stems that lack true roots, but may be loosely anchored to the sediment by pale modified leaves. Because it is not rooted, it can drift between depth zones. Coontail can tolerate cool temperatures and low light conditions. These qualities allow it to overwinter as an evergreen plant, continuing photosynthesis at a reduced rate under the ice.

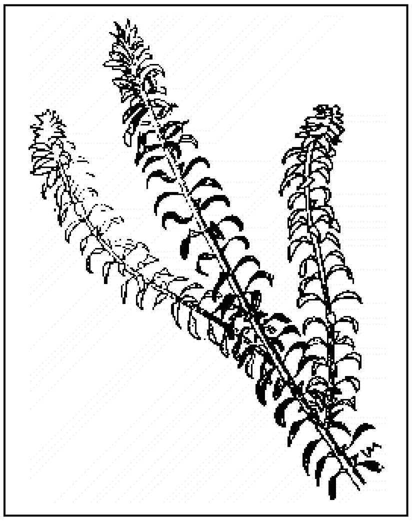
Although coontail has the capacity to grow at nuisance levels, it should not be entirely eliminated from a water body since it offers good habitat for fish and invertebrates. The plant is often found on drop-offs, producing tree-like cover for bluegills, perch, largemouth bass and northern pike. Bushy stems of coontail harbor many invertebrates and provide important shelter and foraging opportunities for fish. Both foliage and fruit of coontail are grazed by a variety of waterfowl. Coontail is also effective at removing phosphorus from the water column.



<u>Common Name</u>: **Muskgrass**
<u>Scientific Name</u>: ***Chara vulgaris***
<u>Plant Type</u>: Submersed (Macroalgae)
<u>Duration</u>: Perennial
<u>U.S. Nativity</u>: Native

Muskgrass is actually an unusual type of algae, but has a growth form that resembles a higher plant. This plant is simple in structure and has rhizoids rather than true roots. It ranges in size from ankle-high to knee high, and grows entirely below the water surface. The main branches of muskgrass have ridges that are often encrusted by calcium carbonate, giving the plant a harsh, crusty feel. Muskgrass is usually found in hard waters, and prefers muddy or sandy substrate. It can often be found in deeper water than other plants, and its dense growth is capable of covering an entire lake bottom.

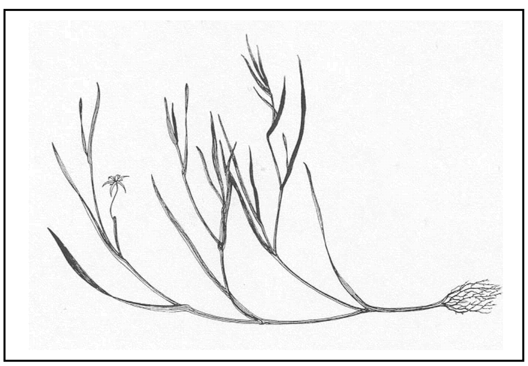
Muskgrass has several ecological benefits. It is a favorite food for waterfowl. It also supports algae and invertebrates that provide additional grazing. Beds of muskgrass are considered valuable fish habitat, offering cover and food for young largemouth and smallmouth bass. As far as enhancing water quality, the rhizoids of muskgrass slow the movement and suspension of sediments. It is a good bottom stabilizer and is often the first plant to colonize open areas. It also softens water by removing lime and carbon dioxide. This plant is best left alone since it grows close to the bottom and generally doesn't interfere with water uses.



Common Name: **Common waterweed**
Scientific Name: ***Elodea canadensis***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Native

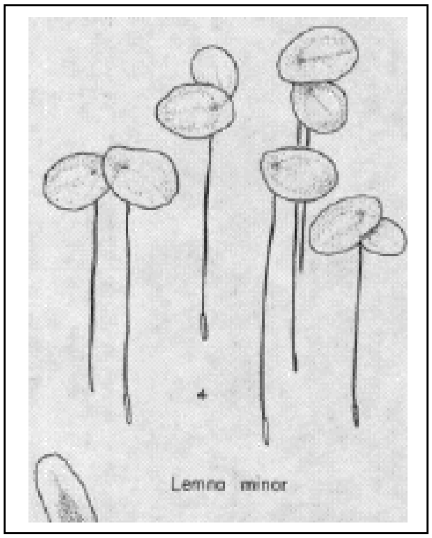
Common waterweed prefers soft, silty substrate, and is tolerant of turbid, low-light water conditions. This plant grows in a range of water depths, but prefers cool, nutrient-rich waters. It has a broad but generally alkaline pH distribution and moderate conductivity and alkalinity distributions. Common waterweed lives entirely underwater with the exception of small white flowers that bloom at the surface and are attached to the plant by delicate stalks. In the fall, leafy stalks will detach from the parent plant, float away, root, and start new plants. This is its most important method of spreading, with seed production playing a relatively minor role.

This plant generally over-winters as an evergreen, allowing photosynthesis to continue at a reduced rate under the ice. The branching stems of this plant provide excellent habitat for fish and invertebrates, but dense stands can obstruct fish movement and become a nuisance. The plant provides food for muskrats and waterfowl.



Common Name: **Water stargrass**
Scientific Name: ***Heteranthera/Zosterella dubia***
Plant Type: Submersed
Duration: Annual/Perennial
U.S. Nativity: Native

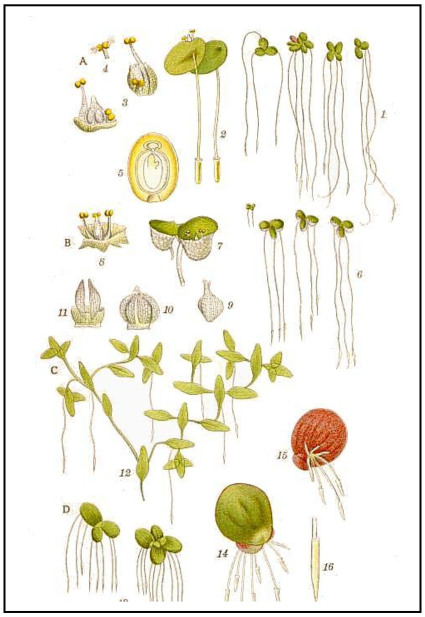
Water stargrass is found in water depths to 10 feet, shows no substrate preference, and is tolerant to turbidity. It grows over a moderate and somewhat alkaline pH range, and moderate conductivity and alkalinity ranges. This plant can be a locally important source of food for geese and ducks. It also offers good cover and foraging opportunities for fish.



Common Name: **Small duckweed**
Scientific Name: ***Lemna minor***
Plant Type: Free-floating
Duration: Perennial
U.S. Nativity: Native

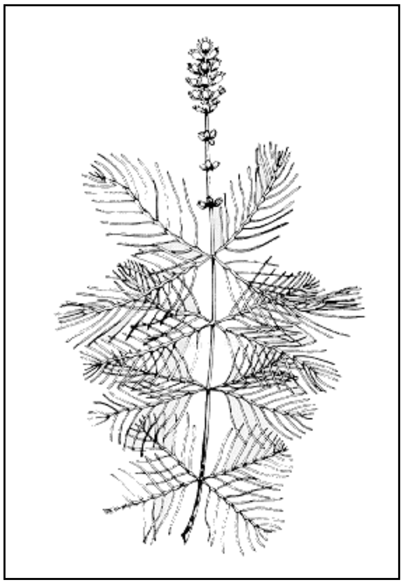
These tiny, free-floating plants grow in bays and quiet areas protected from wind and wave action. Small duckweed drifts with the wind or current and is not dependent on depth, sediment type or water clarity. It is found over a moderate pH range and broad ranges of alkalinity and conductivity. Duckweed is often associated with eutrophic conditions, and can become a nuisance in stagnant, fertile water bodies. It has the ability to rapidly reproduce in nutrient-rich water, doubling in population within three to five days. Since the plant is free-floating, it must obtain all of its nutrition from the water by absorbing nutrients through dangling roots and leaf undersurface. In fact, it is capable of removing large amounts of nutrients from the water in this way.

Rafts of small duckweed provide shade and cover for fish and invertebrates, but may shade out larger, submersed plants. Small duckweed does not provide ideal fish habitat due to excessive shading and poor food value. The plant is a food source for waterfowl and marsh birds (providing up to 90% of the dietary needs for a variety of ducks and geese), and does supports insect valuable as food for fish. It is also consumed by muskrat, beaver and fish. Conventional physical removal and chemical control are usually ineffective. Limiting growth of duckweed is best accomplished through nutrient-reduction strategies.



Common Name: **Forked duckweed**
Scientific Name: ***Lemna trisulca***
Plant Type: Free-floating
Duration: Perennial
U.S. Nativity: Native

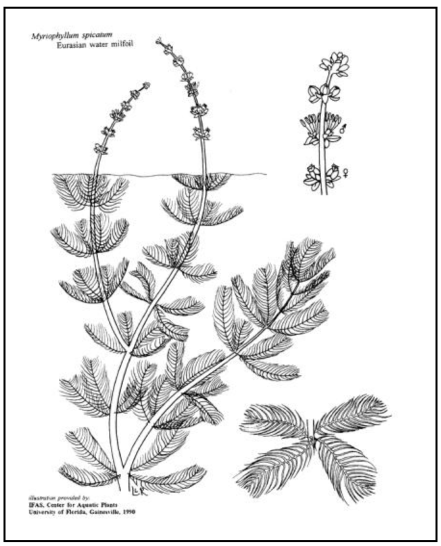
Forked duckweed differs from other duckweed species by the stalk-like, “rowboat and oars” shape of the fronds and olive green color. This species is often found just beneath the surface of quiet water. It drifts with the wind or current and is not dependent on depth, sediment type or water clarity. However, there must be sufficient nutrient content in the water to sustain growth. Like other temperate-climate duckweeds, this species overwinters by producing winter buds that rest on the sediment. In spring, the buds become buoyant and float to the surface where plant growth continues through the summer. Forked duckweed is a good food source for waterfowl, and provides cover for fish and invertebrates.



Common Name: **Northern/spiked watermilfoil**
Scientific Name: ***Myriophyllum sibiricum***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Native

This species is easily confused with the non-native Eurasian watermilfoil (*Myriophyllum spicatum*). The plant can grow in water more than 13 feet deep, prefers soft sediment, and is sensitive to turbidity. It grows over a broad alkalinity range and moderate conductivity and pH ranges. Since it is sensitive to reduced water clarity, this plant has been shown to decline in lakes that become increasingly eutrophic. Stems emerge in spring and can produce flower spikes by early to midsummer that stick out of the water.

Leaves and fruit of northern watermilfoil are consumed by a variety of waterfowl. The feathery foliage traps detritus and provides invertebrate habitat. Beds of northern watermilfoil offer shade, shelter and foraging opportunities for fish.



Common Name: **Eurasian watermilfoil**
Scientific Name: ***Myriophyllum spicatum***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Non-native

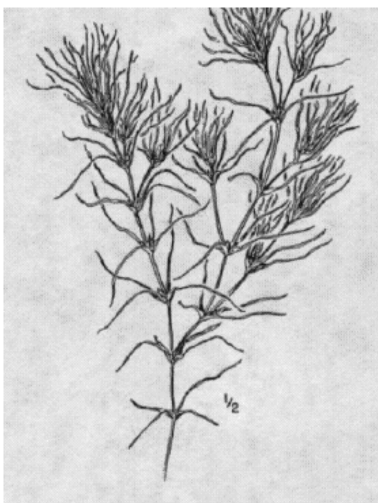
This plant is not native to the U.S., and is considered a nuisance weed in many lakes. It can grow in water depths of over 13 feet deep, and is found over broad alkalinity, moderate conductivity, and moderate but high pH ranges. The average fruiting date is middle to late summer; however, it can flower and fruit twice, once in early summer and once in late summer. The late flowering can be prolonged and fruiting plants can be found into early November. Flower stalks do not develop until the stems reach the surface.

In the spring, shoots begin to grow rapidly in response to rising water temperatures (starting at about 59°F). As shoots grow, lower leaves drop off in response to shading. When the plant reaches the surface, shoots branch profusely to form a dense, floating canopy above leafless vertical stems. Plants then reproduce by flowering at the surface and through fragmentation. Both broken stems and plant fragments are able to regenerate into new plants.

Dominance by this species is often established early in the growing season, owing to a combination of high over-wintering biomass and rapid spring growth. Conditions of low light and high water temperature, characteristics of many eutrophic environments, stimulate shoot elongation and canopy formation. It grows most poorly on highly organic sediments and coarse substrates like sand and gravel, and best in finely textured, inorganic sediment. Shallow, moderately turbid lakes with nutrient-rich sediments will experience the most severe problems.

Eurasian watermilfoil is an invasive, pioneer species that quickly colonizes disturbed areas of the lake bottom. Disturbances may be in the form of sediment deposition, plant removal, water level fluctuations, or bottom scouring caused by motor boats. Once introduced to a water body, milfoil can quickly out-compete and displace other species. Milfoil boom and bust growth cycles are well documented in other lakes, and are characteristic of ecosystems dominated by only a few species. Excessive milfoil growth primarily affects recreation by interfering with swimming and boating following canopy formation, by reducing the quality of sport fisheries, and by reducing the aesthetic appeal of water bodies. As for ecological value, this species provides limited cover for fish when poor water clarity prevents broad-leaved pondweeds and other species from growing. Waterfowl graze on fruit and foliage to a limited extent. Milfoil beds also provide invertebrate habitat, but studies have shown mixed stands of pondweeds and wild celery have higher invertebrate numbers and diversity.[15]

Eurasian watermilfoil is commonly treated with aquatic herbicides such as 2,4-D early in the summer before plants flower. However, there are a number of negative consequences that can occur following chemical treatments. These include dissolved oxygen depletion and nutrient releases from the resulting plant decay, as well as the creation of "disturbance" areas that can be re-colonized by other milfoil. Most control efforts have been directed toward maintenance (e.g. mechanical harvesting), since eradication of this particular species is rarely if ever likely to succeed due to its aggressive growth and propagation characteristics. Since growth usually covers large areas, treatment efforts should be directed at well-defined areas where they will produce the greatest benefits.

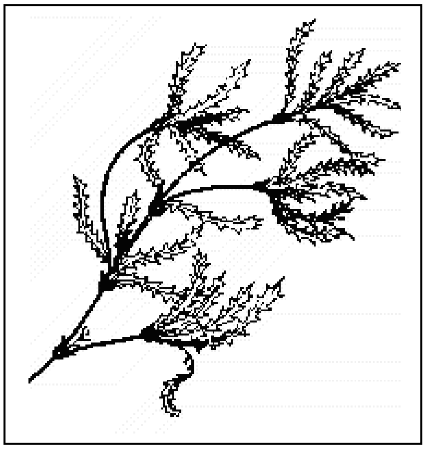


Common Name:	**Bushy pondweed, slender naiad**
Scientific Name:	***Najas flexilis***
Plant Type:	Submersed
Duration:	Annual
U.S. Nativity:	Native

This plant grows at a wide range of depths, prefers hard substrates like sand and gravel, and is not sensitive to turbidity. It is an annual plant that often acts as a pioneer species by invading open or disturbed areas. It can tolerate broad alkalinity and conductivity ranges and a moderate pH range. Bushy pondweed is firmly rooted and has slender, bright green leaves that are crowded near the tip. Fruits or seeds appear as tiny swellings at the base of the leaves. It usually grows in clumps or beds among other species.

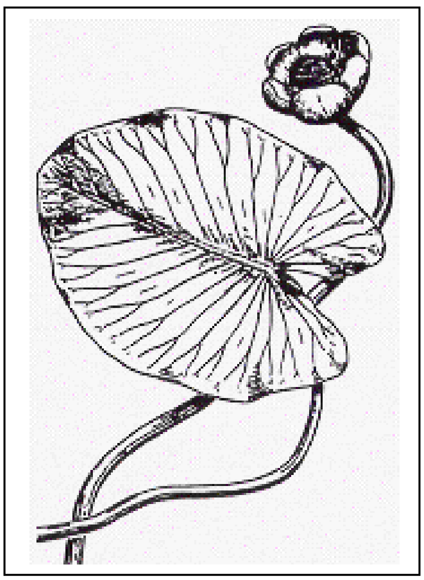
[15]Engel, Sandy. 1990. Ecosystem Responses to Growth and Control of Submerged Macrophytes: A Literature Review. Wisconsin Department of Natural Resources. Technical Bulletin No. 170.

Bushy pondweed is an important plant for waterfowl, marsh birds and muskrats. Stems, leaves and seeds are all consumed by a wide variety of ducks. It is also a good producer of food and shelter for fish. Bushy pondweed is often best left alone since it's a low-growing plant that usually does not overpopulate an area.



Common Name: **Spiny naiad**
Scientific Name: ***Najas marina***
Plant Type: Submersed
Duration: Annual
U.S. Nativity: Native

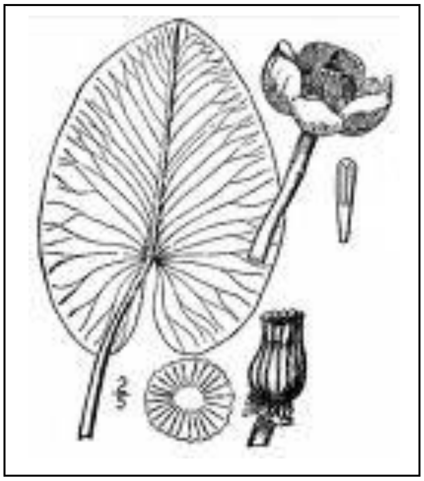
This annual, naturalized plant is found in high alkalinity, high conductivity and high pH waters. It prefers soft substrate and can grow up to about 10 feet deep. Spiny naiad is tolerant of higher than normal chloride concentrations, and often grows were concentrations exceed 10 mg/L. It is not shown to associate with any other species. Spiny naiad provides food and shelter for fish, and is a food source for waterfowl. Its leaves and seeds are consumed by a wide variety of ducks.



Common Name: **Yellow water lily**
Scientific Name: ***Nuphar advena***
Plant Type: Floating-leaf
Duration: Perennial
U.S. Nativity: Native

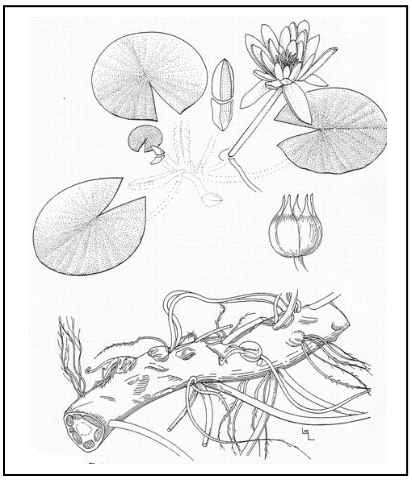
This plant usually grows in shallow, soft sediment areas of lakes, ponds or slow-moving streams. It is found in water 6.5 feet or less deep. Turbidity tolerance is not a consideration since the plant has floating leaves that quickly reach the water surface in the spring. Most of the leaves are emergent, growing at an assortment of angles above the water's surface. It can grow in sun or shade, but flowering is more abundant in good light.

In addition to their aesthetically pleasing yellow flowers, water lilies provide good shade and shelter for fish as well as habitat for invertebrates. The insects that grow under the leaves are a food source for fish. Waterfowl and marsh birds eat the seeds, muskrat and beaver eat the rhizomes, and deer graze on the leaves, stems and flowers.



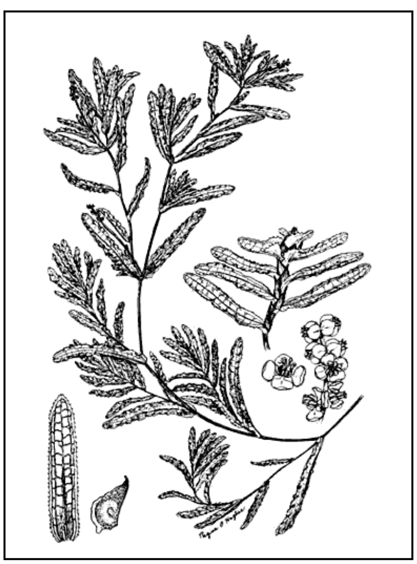
Common Name: **Bullhead pond lily, spatterdock**
Scientific Name: ***Nuphar variegata***
Plant Type: Floating-leaf
Duration: Perennial
U.S. Nativity: Native

This species is usually found in ponds or slow-moving streams. It can grow in sun or shade, and shows a preference for soft sediment and water depths less than 6.5 feet. Flowering occurs throughout the summer, with the flowers rising above the floating leaves. Later in the summer, the sepals drop and the central flower structure develops into a fleshy, well-rounded fruit. This plant provides seeds for waterfowl. The leaves, stems and flowers are grazed by deer. Muskrat and beaver are known to eat the rhizomes. The floating leaves offer shade and shelter for fish as well as habitat for invertebrates.



Common Name: **White/fragrant water lily**
Scientific Name: ***Nymphaea odorata/tuberosa***
Plant Type: Floating-leaf
Duration: Perennial
U.S. Nativity: Native

This species is found over moderate alkalinity and conductivity ranges and a wide pH range. It grows at a median depth of about 3-3.5 feet, and shows no substrate or turbidity preference. Leaves and stems are round, with most of the leaves floating on the water's surface. White water lily is usually found in quiet water of lakes or ponds. Waterfowl eat the seeds of this plant, while deer, muskrat, beaver and moose eat the rhizomes. The leaves offer shade and shelter for fish.



Common Name: **Curly-leaf pondweed**
Scientific Name: ***Potamogeton crispus***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Non-native

This plant is not native to the U.S., and has a tendency to become a nuisance weed in many lakes. It is usually one of the first plants visible in the spring, and may cause temporary problems due to its early, rapid growth. It has wavy and finely serrated leaves that help distinguish it from other pondweeds. The plant can grow under the ice while most plants are dormant, but declines by early to mid-July when other species are realizing peak growth. In the spring, curly-leaf pondweeds produce flower spikes that stick up above the water surface. It typically grows in soft sediments and shallower water depths up to 12 feet. It can tolerate cool temperatures and low light, and will grow in turbid water. Curly-leaf is found over a broad conductivity range, and moderate pH and alkalinity ranges.

Young curly-leaf plants emerge from the sediments during fall, remain dormant during winter, and grow rapidly after ice-out, forming dense surface mats over expansive meadows. This growth cycle allows curly-leaf pondweed to out-compete other species for nutrients, sediment area and light. It grows especially well in areas where mechanical harvesting or herbicides were used inappropriately and without careful planning. The dead vegetation tends to either wash onto the lakeshore or sink to the lake bottom. Plant decay can deplete dissolved oxygen levels, eliminating habitat and causing the internal release of phosphorus from sediments on the lake bottom. Curly-leaf pondweed provides food and shelter for some fish and invertebrates, especially in the winter and spring when most other aquatic plants are reduced to rhizomes and winter buds. However, the midsummer die-off creates a sudden loss of habitat and releases nutrients into the water column that can trigger algal blooms and create turbid water conditions.

Early seasonal control during the initial stages of growth is recommended, allowing plants to be controlled before the population collapses after full growth. Chemical treatment of the young plants during fall or spring may prevent formation of nuisance mats and depletion of oxygen while allowing other native macrophyte species to re-vegetate those areas. Protection and restoration of native species, and improving water clarity can help keep this plant in check without the use of aquatic herbicides.

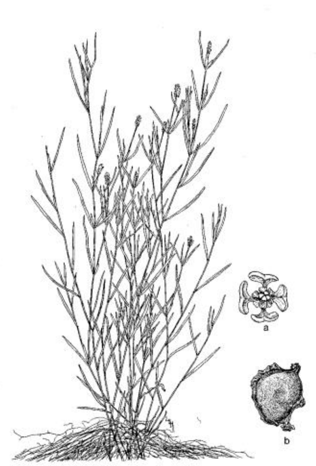


Fig. 6. Leafy pondweed (*Potamogeton foliosus*). Plant with threadlike stems and leaves; also the tiny flowers in very small flowering spikes. *a*. Flower showing four petallike parts. *b*. Nutlet with scalloped keel and erect beak.

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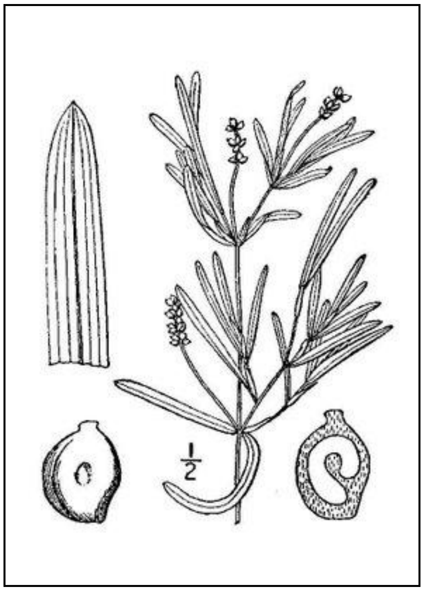
<u>Common Name</u>: **Leafy pondweed**
<u>Scientific Name</u>: ***Potamogeton foliosus***
<u>Plant Type</u>: Submersed
<u>Duration</u>: Perennial
<u>U.S. Nativity</u>: Native

Leafy pondweed can grow in a wide variety of habitats and water quality conditions. It is most often found in shallow water, and shows a preference for soft sediments. This plant is tolerant to eutrophic water conditions. It overwinters by rhizomes and winter buds. The early-season fruit of leafy pondweed can be a locally important food source for geese and a variety of ducks. It may also be grazed by muskrat, deer, beaver and moose. The bushy form of this pondweed offers good surface area for invertebrates and cover for juvenile fish.



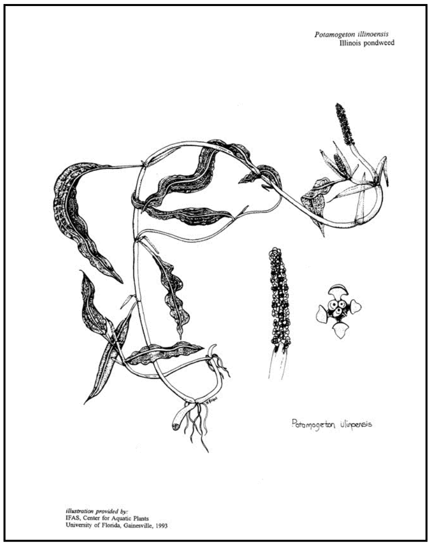
Common Name: **Fries' pondweed**
Scientific Name: ***Potamogeton friesii***
Plant Type: submersed
Duration: Perennial
U.S. Nativity: Native

Closely related to and often confused with small pondweed, this plant will tolerate turbid conditions. It is found in both shallow and moderately deep water. This plant overwinters by rhizomes and winter buds. Seeds and vegetation provide food and cover for a variety of aquatic life, including fish, ducks, geese, muskrats and beavers.

Common Name: **Variable-leaf pondweed**
Scientific Name: ***Potamogeton gramineus***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Native

This plant is an extremely variable species that has a number of varieties that may be the result of habitat differences. It also hybridizes with most broad-leaved pondweeds. It is found over broad alkalinity and pH ranges, and a limited conductivity range. Variable pondweed grows at a median depth of about 3.5 feet, prefers firm substrate, but shows no turbidity preference. It is often found growing in association with muskgrass (*Chara spp.*), slender naiad (*Najas flexilis*) and wild celery (*Vallisneria americana*).

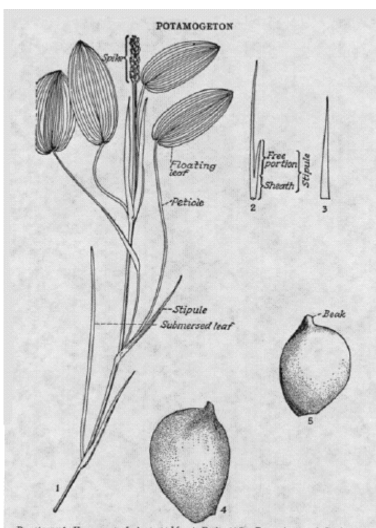
The fruits and tubers of variable pondweed are grazed by a variety of waterfowl, including geese and wood duck. Muskrat, beaver, deer and moose may also eat the foliage and fruit. This plant provides cover for panfish, largemouth bass, muskellunge and northern pike, as well as nesting grounds for bluegill. An extensive network of leafy branches offers invertebrate habitat and foraging opportunities for fish.



Common Name: **Illinois pondweed**
Scientific Name: ***Potamogeton illinoensis***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Native

This plant is found over a broad alkalinity range, a moderate and high pH range, and a moderate conductivity range. It flowers and fruits in midsummer and shows no substrate preference. Illinois pondweed is not turbidity tolerant and is probably becoming increasingly rare where water clarity has decreased. It is commonly found in water less than 6.5 feet deep, but its maximum depth distribution is greater than 10 feet.

The fruit produced by Illinois pondweed can be a locally important food source for a variety of ducks and geese. Muskrat, deer, beaver and moose are known to consume this plant. This pondweed offers excellent shade and cover for fish such as panfish, largemouth bass, muskellunge and northern pike, and provides nesting grounds for bluegills. The large leaves offer good surface area for invertebrates.

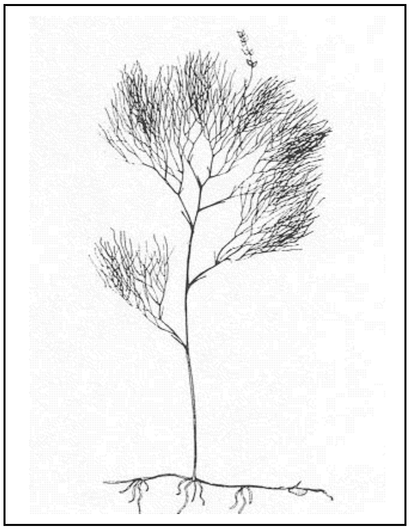


P. natans: 1. Upper part of plant, × ½. 4. Fruit, × 8. P. pectinatus: 2. Leaf, × 2. 3. Leaf tip, × 2. 5. Fruit, × 8.

Common Name: **Floating-leaf pondweed**
Scientific Name: ***Potamogeton natans***
Plant Type: Submersed & floating-leaf
Duration: Perennial
U.S. Nativity: Native

This plant shows no substrate preference and is most commonly found in water less than 5 feet deep. It can grow in highly turbid water, but shows no turbidity preference. It is found over a broad range of water chemistries. Floating-leaf pondweed has firmly rooted thick stems, and can have both submersed and floating leaves. Submersed leaves are typically thin and slender, while floating leaves are oval shaped. Flower or seeds may extend above the water surface.

The fruit of floating-leaf pondweed is held on the stalk until late in the growing season. This provides valuable grazing opportunities for ducks and geese. Muskrat, beaver, deer and moose may also consume portions of the plant. Floating-leaf pondweed is considered good fish habitat as it provides shade, cover and foraging opportunities.

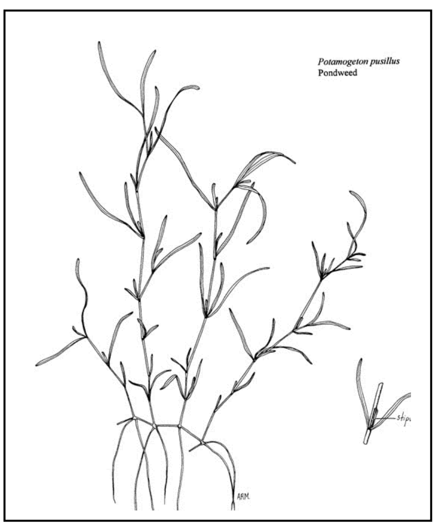


Common Name: **Sago pondweed**
Scientific Name: ***Potamogeton pectinatus***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Native

Sago pondweed grows below the water surface at depths greater than 13 feet, although it is most common in 3-7-foot water depths. It grows in a variety of sediment types and a wide range of water conditions. In fact, it is often the last surviving rooted plant in very turbid water. It has a broad alkalinity range and moderate conductivity and pH ranges. Flowers and fruit are produced on a slender stalk that may be submersed or floating on the water surface.

Sago's rapid growth rate allows it to quickly occupy large areas and smother potential competitors. It is also very pollution tolerant and can rapidly colonize unoccupied habitats. This may be one reason why the plant is typically not found with a diversity of other species, but tends to occur in discrete beds in stressed environments. Sago pondweed is firmly rooted and has branched, slender stems and grass-like narrow leaves.

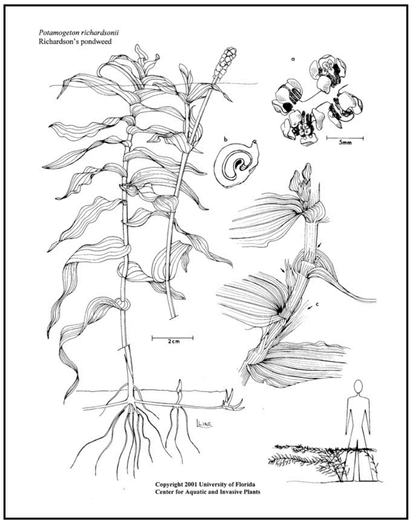
This plant provides limited cover for bluegills, perch, northern pike and muskellunge, and is good cover for walleye. It supports insects valuable as food for fish and ducklings, and is considered one of the top food producers for waterfowl. Both the fruit and tubers are heavily grazed and are considered critical for a variety of migratory waterfowl. Sago communities also provide escape cover for invertebrates, thus allowing them to thrive in the presence of small fish.



Common Name: **Small pondweed**
Scientific Name: ***Potamogeton pusillus***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Native

Small pondweed is found over moderate ranges of alkalinity and pH, and a limited conductivity range. It grows in soft substrate to a depth of about 9 feet, and is tolerant to turbid water conditions. The plant grows below the surface, but may have flowers or seeds extending out of the water. It is firmly rooted to the bottom, and has branched, slender stems and grass-like narrow leaves.

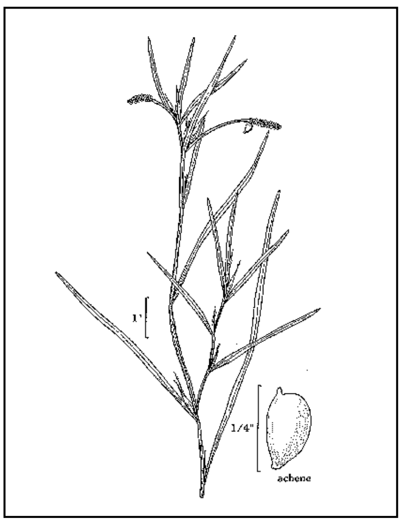
This plant can be a locally important food source for a variety of ducks and geese. It provides some cover for bluegills, perch, northern pike and muskellunge, and good cover for walleyes. It also supports insects valuable as food for fish and ducklings.



Common Name: **Richardson's/clasping-leaf Pondweed**
Scientific Name: ***Potamogeton richardsonii***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Native

This plant shows no turbidity or substrate preference and can withstand environmental disturbance. It is many times the only broad-leaf pondweed found in degraded water. Clasping-leaf pondweed is found over moderate ranges of water chemistries and in water depths to 13 feet. It is often found growing with coontail (*Ceratophyllum demersum*) and small pondweed (*Potamogeton pusillus*).

The fruit produced by clasping-leaf pondweed can be a locally important food source for a variety of waterfowl. Muskrat, deer, beaver and moose may also eat the plant. The leaves and stem are colonized by invertebrates and offer foraging opportunities and cover for fish.



Common Name: **Flat-stem pondweed**
Scientific Name: ***Potamogeton zosteriformis***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Native

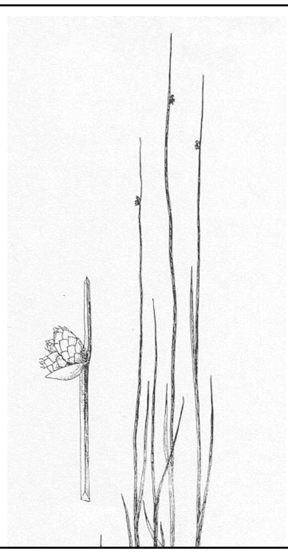
This plant grows in soft sediment, below the water surface, and in a variety of water depths up to about 13 feet. It is found over broad alkalinity and pH ranges and a moderate conductivity range. Because of its sensitivity to turbidity, the plant does not do well in lakes with poor water clarity. It is firmly rooted with branched, slender stems and grass-like narrow leaves.

Flat-stem pondweed provides limited cover for bluegills, perch, northern pike and muskellunge. It also provides good cover for walleye, and supports insects valuable as food for fish and ducklings. Flat-stem pondweed is a food source for waterfowl, muskrat, deer and beaver.

Common Name: **Arrowhead, duck potato**
Scientific Name: ***Sagittaria latifolia***
Plant Type: Emergent
Duration: Perennial
U.S. Nativity: Native

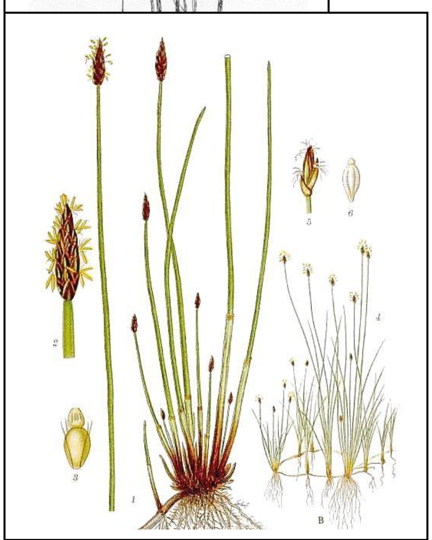
This plant grows above the surface in shallow water up to 4 feet deep, and shows no substrate or turbidity preference. It is found over broad pH and alkalinity ranges and a moderate conductivity range. Reaching about 3-4 feet tall, the plant has individual leaves that can be more than a foot long. Leaves are usually arrow-shaped with backward-pointing lobes, but vary in shape and may be long, linear, and grass-like. White flowers are about an inch in diameter, with three rounded petals, growing from the thick stem in whorls of three. Arrowhead's horizontal roots have short, thick stems or tubers at their tips in autumn.

Arrowhead protects shorelines from wave erosion. It is also one of the highest value aquatic plants for wildlife. It provides cover for waterfowl and young fish, and spawning areas for northern pike. Muskrats, beaver, and other wildlife eat the tubers. Geese and ducks eat both seeds and tubers, giving this plant the name "duck potato." Arrowhead is capable of rapidly removing phosphorus from sediments and can store high levels in its leaf tissue.



Common Name: **Three-square bulrush, chairmaker's rush**
Scientific Name: ***Scirpus americanus***
Plant Type: Emergent
Duration: Perennial
U.S. Nativity: Native

Three-square bulrush grows in deep and shallow marshes and along lakes and streams. It is found in higher pH waters than many other species, and grows in moderate conductivity and alkalinity ranges, but with low median values. It is found in water depths to 6 feet, shows no substrate preference, and is not tolerant of turbidity. This plant has moderately tall (up to 5 feet), sharply triangular stems that emerge from a firm rhizome. Short, inconspicuous leaves sheath the base of each stem.

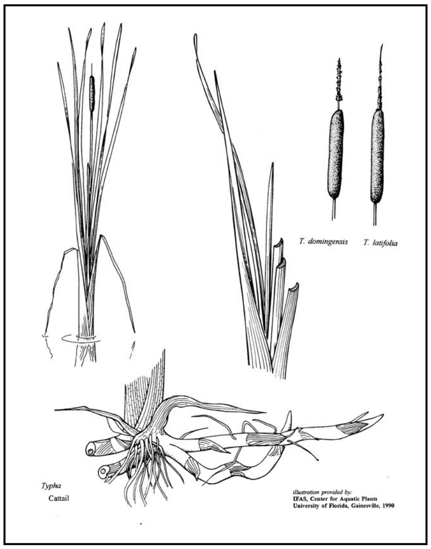


Rigid stems survive winter and provide important spawning areas for northern pike and cover for other fish in early spring. This plant is known to attract marsh and song birds. A wide variety of ducks rely on three-square bulrush as a food source. It is heavily grazed by muskrat and provides cover for waterfowl and other shallow marsh wildlife.

Common Name: **Water bulrush**

Scientific Name: ***Scirpus subterminalis***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Native

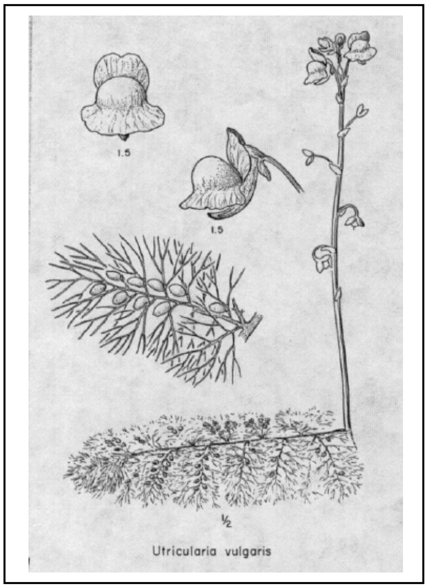
Water bulrush is mostly submersed with only the tips of fertile stems poking above surface. This plant is found over a moderate range of pH, conductivity and alkalinity conditions. It is found growing in shallow water and on a variety of substrates, including sand, marl, muck and peat. Slender, limp stems (to more than 3 feet in length) extend from a fine rhizome. The stems float in water along with hair-like leaves that arise near the base. Grass-like meadows of water bulrush provide invertebrate habitat and shelter for fish.



Common Name: **Narrow-leaf & broad-leaf cattail**
Scientific Name: ***Typha angustifolia & Typha latifolia***
Plant Type: Emergent
Duration: Perennial
U.S. Nativity: Native

These plants grow 3-10 feet tall above the water surface in marshes, along shorelines, and in quiet water up to 2.5-3 feet deep, often in disturbed areas. They are found over broad alkalinity and pH ranges and a moderate conductivity range. Narrow-leaf is more tolerant of chloride and alkalai than broad-leaf cattail.

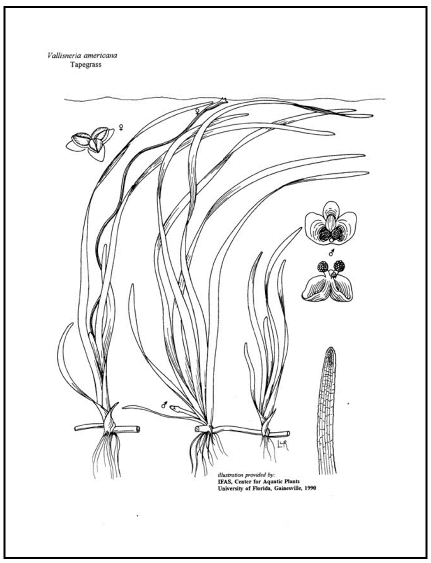
Cattails help stabilize marshy borders of lakes, protect shorelines from wave erosion, provide spawning sites for northern pike, and provide cover and nesting sites for marsh birds and waterfowl. Muskrat and beaver eat the stalks and roots. Cutting stalks under water during the early summer before the “cattail” appears works best to control growth. Cutting under water just before the lake freezes is also effective.



Common Name: **Common/great bladderwort**
Scientific Name: ***Utricularia vulgaris***
Plant Type: Free-floating
Duration: Perennial
U.S. Nativity: Native

Bladderwort is a carnivorous, free-floating plant that prefers soft substrate, tolerates turbid water, and grows in water depths from only a few inches to about 8 feet. It is found over a broad pH range, including some acid water with a pH of less than 5. Its alkalinity range is moderate and conductivity range is limited. This plant is most successful in still water where the bladders that trap prey can function properly, and where the finely divided stems are not torn by wave action.

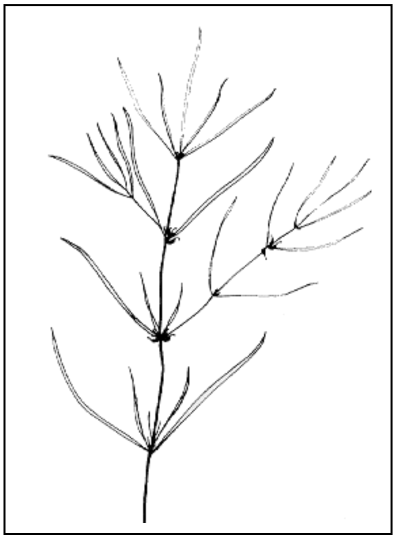
The trailing stems of common bladderwort provide food and cover for fish. Because it is free-floating, the plant can grow in areas with very loosely consolidated sediment. This provides needed fish habitat in areas that are not readily colonized by rooted plants.



Common Name: **Eel/tape grass, water/wild celery**
Scientific Name: ***Vallisneria americana***
Plant Type: Submersed
Duration: Perennial
U.S. Nativity: Native

This species prefers semi-hard substrate, is turbidity tolerant, and grows in water depths up to 10-15 feet. It is found over broad pH and alkalinity ranges and a moderate conductivity range. Flowering occurs in late summer on a coiled stalk. It spreads by rhizomes and tuberous tips that, along with the fruits, are relished by waterfowl. Wild celery often grows in beds near pondweeds such as bushy pondweed.

Wild celery is a premier source of food for waterfowl, especially for canvasback ducks in the fall. All portions of the plant are consumed, including foliage, rhizomes, tubers and fruit. This plant is also important for marsh birds and shore birds, including rail, plover, sand piper and snipe. Muskrats are also known to graze on it. Beds of wild celery are considered good fish habitat providing shade, shelter and feeding opportunities. Wild celery is usually best left alone unless excessive growth in shallow water presents a problem.



Common Name: **Horned Pondweed**
Scientific Name: ***Zannichellia palustris***
Plant Type: Submersed
Duration: Annual
U.S. Nativity: Native

Horned pondweed has long, narrow leaves and slender stems that emerge from an equally slight rhizome. This annual species is found in high alkalinity, high pH, and high conductivity water. It is turbidity tolerant and prefers hard substrate. Horned pondweed is commonly found in water less than 12 feet deep, and is often partly buried in silt or mud. Waterfowl eat the fruit and foliage of horned pondweed. It is also considered a fair food producer for trout.

Several varieties of algae are found in Lake Ripley, including green, bluegreen and filamentous algae. Brief descriptions are provided below.[16]

Filamentous algae *(Cladophora, Spirogyra)*: This type of macroalgae consists of single cells that are connected end-to-end. It appears as green-colored thin threads, branched filaments or an interwoven net. Filamentous algae do not have roots, stems or leaves. It begins growing along the shoreline or on the lake bottom, and later buoys to the surface forming green mats that frequently attach to rocks or other plants. Abundant growth identifies lakes polluted with excessive nutrients. Although filamentous algae provide cover for insects valuable as fish food, it is often viewed as an unsightly nuisance. Preventative actions that reduce the flow of nutrients into the lake are the best means of control.

Planktonic algae: These are microscopic, single-celled organisms that may form multi-cellular colonies or filaments. Common varieties include green algae, bluegreen algae and diatoms. Abundant growth results in “blooms” that color water green or brown. Surface scums of bluegreen algae may form on the water surface during the summer. Abundant growth identifies lakes polluted with excessive nutrients such as nitrogen and phosphorus. Planktonic algae provide food for zooplankton and some food for fish fry. Preventative actions to reduce the flow of nutrients into the lake are the best means of control.

5-9 FACTORS CONTROLLING PLANT GROWTH

A few of the major factors affecting the abundance and distribution of aquatic plants in Lake Ripley are light and nutrient availability, water chemistry, sediment type, and the amount of wind and wave energy.

[16] Welsch, Jeff. 1992. Guide to Wisconsin’s Aquatic Plants. Wisconsin Department of Natural Resources. PUBL-WR-173 92rev.

Light availability: Light availability, which is directly linked to water clarity, regulates the maximum depth of plant growth. The amount and spectral quality of light at the lake bottom diminishes as water clarity decreases, generally as a result of increasing water depth. Submersed aquatic plants typically grow to a depth of about two times the Secchi depth. Other factors that influence light availability are phytoplankton (algae) concentrations, water color, and the concentration of suspended particulate matter, also called turbidity. Turbidity may be caused by runoff entering the lake, or through sediment re-suspension caused by boat traffic, wind mixing, and biotic factors such as carp-feeding activities. The extent of the littoral zone, or the area that can support rooted aquatic plant growth, will fluctuate based on these and other photosynthesis-limiting factors.

Nutrient availability: Plant growth can be limited if at least one nutrient that is critical for growth (e.g. phosphorus or nitrogen) is in short supply. However, nutrients supplied from bottom sediments combined with those in solution are generally adequate to meet nutritional demands of rooted aquatic plants, even in nutrient-poor (oligotrophic) systems. Rooted plants usually fulfill most of their phosphorus and nitrogen requirements by direct uptake from sediments, although the preferred source of some nutrients such as potassium, calcium, magnesium, sulfate and sodium appears to be the open water. Oligotrophic lakes generally maintain less total biomass of aquatic plants and usually different species than eutrophic lakes.

Water chemistry: Water chemistry is another environmental factor that can control plant growth. For instance, some species are very tolerant of acidic conditions while other species are very intolerant of these conditions. Most plants prefer slightly alkaline water chemistries as opposed to acidic environments. Lake Ripley is considered a hardwater, alkaline lake that is capable of supporting an abundance of aquatic vegetation.

Sediment type: Variations in the quality and quantity of bottom sediment play a significant role in controlling the distribution and growth of rooted aquatic vegetation. Rocky, sandy, silty and mucky substrates will each favor different plants. The distribution of different substrate types along the lake bottom is dictated by a number of factors. For instance, wave action and currents allow coarse material to remain in shallow water (a higher energy environment) while finer material is transported to deeper water where a lower energy environment prevails. The strength and direction of the wind in conjunction with the morphology of the lake basin will play a large role in determining where the substrates will move. In general, points and shallows where wind and wave energy are highest tend to be swept clean, while bays and deep areas in a lake tend to fill with sediment.

Wind and wave energy: Finally, high-energy environments caused by wind, water current and/or wave action can significantly limit plant growth. These and similar disturbances, if frequent, will prevent vegetation from being able to take root in the substrate, especially if the substrate is unsuitable for most plants due to scouring. As noted above, these factors are usually greatest in unprotected and wind-swept shallows.

5-10 FACTORS AFFECTED BY PLANT GROWTH

The preceding section dealt with some of the main factors that can control the amount and type of plant growth in a particular lake. This section describes how the resulting plant growth (or lack thereof) can impact the overall ecosystem. The presence or absence of plant growth can have a dramatic effect on the aquatic environment. A number of these plant-induced, ecosystem impacts are discussed briefly below.

Littoral Zone Productivity: The littoral zone is the shallow portion of a lake that is able to support rooted aquatic plant growth. Small and irregularly shaped lakes usually have more miles of shoreline per acre of lake surface area, so they have greater potential for a more productive littoral zone. The accumulation of organic sediments from the decay of plant matter causes expansion of this littoral zone and filling in of the lake.

Water Clarity: Rooted aquatic plant growth and water clarity are inextricably linked. As rooted plant abundance increases in a lake, the abundance of suspended particulate matter (e.g. algal cells, organic matter and clay particles) decreases, and vice versa. This relationship exists because aquatic plants act as water quality filters, help cover and therefore stabilize bottom sediments, and compete for the same nutrients that fuel algal blooms.

Water Temperature/Circulation: Shading and reduced water circulation caused by dense stands of aquatic plants produces vertical temperature gradients as steep as 18°F over three feet of water depth. Reduction in water flow through plant beds also enhances trapping and deposition of fine sediment and organic matter. This process improves water clarity and increases the accumulation of sediments or organic material in shallow areas. The reduction in water circulation, if significant, can limit the ability of the lake to naturally aerate.

Dissolved Oxygen: Heavy plant growth is shown to cause large fluctuations in dissolved oxygen concentrations. The water column can become supersaturated with dissolved oxygen when peak photosynthesis occurs during daylight hours. Anoxia (oxygen depletion) is likely to follow as respiration exceeds photosynthesis during non-daylight hours, especially in the absence of sufficient water circulation, or when microbial decomposition increases as a result of a plant die-off. Whenever anoxic conditions are produced, the survivability of oxygen-dependent aquatic organisms is compromised. Dense growths of floating vegetation can exacerbate the situation by restricting atmospheric oxygen exchange at the water surface and limiting light penetration.

pH: Changes in pH of up to two standard units are known to occur within a 24-hour period due to the metabolic processes of submersed plants. A high degree of primary productivity can cause the pH of a water body to increase significantly, and vice versa.

Phosphorus Availability: Sediment re-suspension is shown to be a mechanism for introducing phosphorus into the water column. The root systems of plants help stabilize loose bottom sediment to prevent this from happening. Aquatic vegetation also influences nutrient cycles by assimilating phosphorus from the sediments during the growing season, and releasing phosphorus during death and decay. This means fewer nutrients are available for algae growth during the growing season, resulting in better water clarity. If nutrients are then released in the fall during decomposition of plant matter, water temperatures are usually cool enough to prevent noxious algae blooms from occurring. Those that do occur will generally pose fewer problems since the peak recreational period has passed. If anoxic conditions are caused as a result of plant decomposition, phosphorus may be released from the bottom sediment into the surrounding water column, fueling additional algal blooms.

Habitat and Water Quality: Too few plants generally do not provide enough cover for fish and aquatic life, while too many plants may lead to stunted panfish populations and poor gamefish growth. The latter is caused by an overabundance of structural habitat for small fish, allowing these smaller fish to escape predation and achieve high population densities. This means there is not enough food available for the existing fish, so both panfish and gamefish become size stunted. The Trophic Cascade Hypothesis predicts that water quality is linked to the success of certain fish species, which can cause a "cascading" effect down the food chain. Simply stated, water quality improves as larger gamefish (piscivores) become more successful at feeding on the smaller panfish (planktivores). As planktivore populations are diminished, there is less consumption of the microscopic animals (zooplankton) that graze on algae (phytoplankton). The amount and quality of the vegetative habitat usually plays a sizeable role in determining the outcome of this process. A moderate amount of high quality aquatic vegetation with plenty of edge habitat is generally the most conducive to larger fish populations and better water quality.

5-11 MANAGEMENT IMPLICATIONS

The first step toward implementing a successful aquatic plant management program is to recognize the important functions and values of a healthy plant community. A diversity of emergent and submersed native aquatic vegetation provides critical habitat for fish and wildlife, primarily in the form of structural refuge and spawning substrate. Fish and wildlife also rely on plants as a source of food. Some plant varieties are consumed directly, while others support large populations of invertebrates that form the base of the food chain. Through photosynthesis, aquatic vegetation produces the aerobic conditions that oxygen-dependent organisms rely upon for their survival. Aquatic plants also stabilize loose bottom sediment, trap suspended particles, protect against shoreline erosion, provide refuge for zooplankton (algae consumers), and compete for the same nutrients that fuel algal blooms—each of which is vitally important for maintaining optimal water quality.

Fertile lakes with nutrient-rich bottom sediment, shallow water depths, and relatively clear water generally support the most abundant plant growth. This growth occurs in the littoral zone—the most biologically diverse and productive part of the lake—that extends from the shoreline out to about the 15-foot water depth in Lake Ripley. Unfortunately, this critical area is also the most vulnerable to the affects of shoreline development, runoff pollution, motor boating impacts and other recreational pressures. As a result, ecologically valuable but sensitive plant species are often displaced by less desirable species that are more tolerant of disturbances and poor water quality. These "weeds" may aggressively out-compete native, beneficial plants until the entire plant community is dominated by only one or two species. Without proper management intervention, such changes could lead to a host of water quality, habitat and recreational impairments. Clogged boating lanes, reduced species diversity and habitat value, stunted fish growth, dramatic fluctuations in dissolved oxygen concentrations, and boom-and-bust plant growth cycles are just some of the problems that may be experienced.

Control methods should be employed that do not significantly disrupt native, beneficial plant communities that provide critical fish and wildlife habitat and water quality protection benefits. Maintaining these more desirable plant communities should prevent the continued spread of the more aggressive, nuisance species such as Eurasian watermilfoil. In most instances, the control of native aquatic plants should be discouraged or limited to only high-use areas like public swimming beaches and motor boat access channels.

Algae and rooted aquatic plant growth are inversely related given that each depends upon and competes for similar nutrients and available sunlight. This relationship allows for two alternate states of equilibrium: a lake that is clear and has an abundance of vegetation, and one that is murky and frequented by thick algal blooms. Consequently, a large-scale, plant-eradication effort could potentially trade a clear and "weedy" lake for a turbid, algae-covered and plant-barren lake with little nutrient buffering capabilities or aquatic habitat.

5-12 PRIOR PLANT-CONTROL MEASURES

According to *Webster's*, a weed is defined as "any plant growing where it is not desired." This loose definition does not make value distinctions among different plants, nor does it clarify who or what user group gets to determine level of desirability. Consequently, some early plant-control efforts on Lake Ripley were relatively aggressive and reactionary, particularly with respect to the use of chemical applications.

Herbicide use was first documented in 1977, and was discontinued by 1990. In contrast to many lakes in southern Wisconsin, Lake Ripley is not reported to have been subject to the use of sodium arsenite as an aquatic plant control measure.[17] Likewise, although some copper sulfate use was reported on Lake Ripley in the past, there are few records of the widespread use of this algaecide in the lake.[18] The chemical treatment history on Lake Ripley is summarized in Table 30, and is based on Wisconsin DNR permit records dating back to 1950.

Table 13: Chemical treatment history on Lake Ripley (1950-Present)

Date	Acres Treated	Herbicides	Quantity	Target Species
7-77	1.65	Hydrothol 47	150 lbs.	Wild celery
8-81	0.13	Aquathol granual	20 lbs.	Milfoil
5-82	0.16	Aquathol granual	50 lbs.	Milfoil
6-83	0.03	Aquathol granual	50 lbs.	Milfoil
6-86	26.00	Cu, Diquat, Aquathol K	26 gals.	Milfoil
6-88	10.00	Same	22 gals.	Milfoil

[17] L.A. Lueschow. 1972. Biology and Control of Aquatic Nuisances in Recreational Waters. Wisconsin Department of Natural Resources Technical Bulletin No. 57.
[18] Ibid.

6-89	9.00	Same	15 gals.	Milfoil
6-89	0.04	Aquathol granual	37 lbs.	Milfoil
6-90	0.04	Aquathol granual	30 lbs.	Milfoil
6-90	3.60	2,4-D	11 gals.	Milfoil

From about 1989 to the present, mechanical harvesting has been used as the primary method for controlling nuisance weed growth. The District currently uses an Aquarius Systems Model HM-420 mechanical harvester with a 7.0-foot cutting width and a 5.5-foot cutting depth. Ancillary equipment include a 28.5-foot shore conveyor, 1977 GMC Sierra Series 6000 dump truck, and a 42-foot Aquarius Systems harvester trailer with electric winch. Most mechanical weed harvesting is currently confined to East Bay, and particularly out from the inlet where expansive milfoil and curly-leaf pondweed beds are the densest.

5-13 MANAGEMENT RECOMMENDATIONS

MONITORING

- Monitor land-use changes and promote watershed Best Management Practices (BMPs) to prevent sediment and nutrient runoff from reaching the lake.

- Repeat the aquatic plant inventory for Lake Ripley at least every 5-6 years. Inventories are used to track changes in the aquatic plant community over time. They are also used to monitor harvesting impacts on species diversity, distribution and densities within management zones.

- Monitor the lake's carp population to make sure carp numbers do not increase or start to dominate the fish community. Carp are known to uproot plants and muddy the water, and can have a deleterious impact on native vegetation that is sensitive to water clarity changes or lakebed disturbances.

MANAGEMENT INTERVENTION

- Employ management strategies that promote a diverse and thriving native plant community—both on shore and throughout the lake's littoral zone—to protect water quality and enhance fishery habitat.

- Provide technical, permitting and cost-share assistance to lakefront property owners willing to establish native lakeshore buffers or restore aquatic plant beds. The right types of native plants can be planted to increase species diversity, attract certain wildlife, promote fish spawning, retard shoreline erosion, improve water clarity, enhance natural property aesthetics, and prevent the continued spread of nuisance species. Well-vegetated shorelines also provide important overwintering habitat for a native weevil (*Euhrychiopsis lecontei*) that provides a biological control on Eurasian watermilfoil.

- Selectively control non-native weed beds while minimizing disturbances to native and mixed-species plant communities. Target control efforts in a priority-driven manner that 1) recognizes the root causes of nuisance weed growth; 2) preserves important ecological values of the larger plant community; 3) facilitates reasonable public access and navigation within high-traffic boating lanes, and 4) balances the needs of competing recreational uses.

- Support plant-control programs and policies that support moderate amounts of vegetative cover (at least 15-20% aerial cover). Plant growth should be sufficient to provide habitat and water quality benefits. However, unusually high densities of plant growth can restrict predator-prey dynamics, cause fish stunting, and contribute to excessive respiration and dissolved oxygen depletion during non-daylight hours.

- Use mechanical harvesting to manage non-native, nuisance weed growth in approved locations. Mechanical harvesting is recommended as an effective method for removing Eurasian watermilfoil canopies, establishing edge habitat for fish, and opening boating lanes to improve access to open-water areas. It is also considered an environmentally-sound technique for controlling milfoil in large, off-shore areas. Finally, the District already has a significant investment in the capital equipment and trained staff necessary for carrying out a successful mechanical-harvesting program.

- If warranted, mechanical harvesting may be complimented with spot herbicide treatments in approved locations. Herbicides are best used to suppress isolated colonies of invasive species that cannot be controlled by other means, and where chemical drift will pose a limited threat to non-target plant and animal species. [Note: Endothall, diquat and copper are contact herbicides that may be effective on annuals. Dichlobenil, 2,4-D, fluridone and glyphosphate are more species-specific, systemic herbicides that may be effective on perennials. The herbicide 2,4-D (2,4-dichlorophenoxyacetic acid) is probably most commonly and effectively used to control Eurasian watermilfoil.] Herbicides are not advocated as a lake-wide control method due to non-target toxicity concerns, as well as problems associated with the resulting decomposing plant biomass. The most appropriate potential use of herbicide at this time is to suppress curly-leaf pondweed (*Potamogeton crispus*) beds in East Bay. Considerable caution is warranted given the location of these weed beds in relation to mapped Critical Habitat Areas.

PUBLIC OUTREACH

- Build public support and cooperation by clearly communicating the goals and objectives for managing aquatic plants, and the steps required to achieve desired outcomes. Public-awareness campaigns should focus on the value of native aquatic plants, how to identify and control problem species, local and state rules related to the protection or control of aquatic plants, and the role and limitations of management programs.

- Advocate for lake-use and zoning policies that help protect shallow, ecologically-sensitive areas from unnecessary motor boat disturbance and degradation. By dividing a lake into separate and distinct user zones, competing recreational interests can be more equitably accommodated and at greater densities. Lake zoning also allows for more effective targeting of plant-control efforts, depending on the specific need and level of management intensity required by the particular lake-use zone. Lake Ripley's current no-wake and no-motor policies appear to be accomplishing these objectives.

- Encourage lakefront property owners to properly manage nuisance weed growth that occurs around their own piers, boatlifts and swimming rafts. Lakefront residents should also be encouraged to remove floating plant debris that washes to shore. Floating plant debris may include Eurasian watermilfoil fragments that can re-root and grow into new weeds. Decomposing plant debris also releases phosphorus and other nutrients that can contribute to algal blooms.

5-14 MECHANICAL HARVESTING GUIDANCE

OVERVIEW

A load of cut weeds is being inspected on the weed harvester by two employees of the Lake District.

Mechanical harvesting should be viewed as a long-term commitment where operational intensity may vary from year to year depending on actual need. An effective harvesting program involves maintaining, storing and deploying multiple pieces of equipment. It also involves administering permits; training and supervising machine operators; carrying appropriate insurance coverage; locating disposal areas for harvested plant material; recordkeeping; and maintaining public relations. However, once the capital equipment is acquired and a program is established, significant cost savings and other benefits are generally realized.

The role of a mechanical harvester is to cut and collect aquatic vegetation growing within a few feet of the water surface. Root systems remain in place after harvesting, allowing plants to quickly regenerate. About one acre of lake surface can typically be harvested per hour, and relief can last as little as several days or up to three months depending on growing conditions.

Harvesting exhibits both selective and non-selective impacts on aquatic plants. Non-selectivity is demonstrated by the removal of all plant species that fall within the reach of the cutter bars. Some species selectivity is achieved by targeting monotypic stands of nuisance vegetation, operating at specific times during the growing season, and altering the depth of cut. It may be possible for harvesting to alter the composition of a plant community by encouraging the success of shorter-growing and disturbance-tolerant species, and by allowing additional sunlight to reach the understory.

PERMIT AUTHORITY

The District carries out its mechanical harvesting program in accordance with an operating permit issued by the Wisconsin DNR. This permit must be renewed every five years at a cost of $300, and is currently set to expire on 12/31/2011. The permit grants authority to the District to conduct harvesting operations under Section 23.24, Wisconsin Statutes, and Administrative Code NR 109. Harvesting is only allowed in approved locations and using approved methods. Annual reports must be submitted to the Wisconsin DNR by November 1st of each year. At a minimum, these reports should describe hours worked, locations harvested, total acres harvested, amount of plant material removed, and the types and relative amounts of each species harvested.

NOTE: A Wisconsin DNR permit is not currently required for manual cutting and raking if the area of plant removal is kept to a contiguous, maximum width of 30 feet along the shoreline and is not located within a designated sensitive area. Any piers, boatlifts, swim rafts, and other recreational devices must be located within the 30-foot zone. All cut plants must be removed from the water. A permit is presently required if the plant removal area is more than 30 feet wide along the shoreline, or if the area is within a designated sensitive area.

EQUIPMENT

The District currently owns and operates a 1993 Aquarius Systems' Model HM-420 mechanical harvester with a 7.0-foot cutting width, 5.5-foot cutting depth, 10.8-19.8" draft, and a 440 cubic feet capacity (8,500 lbs.). It was purchased new for $66,000 with the help of a 50% matching grant through the Wisconsin Waterways Commission.

The harvester is constructed upon a low-draft barge controlled by side-mounted paddle wheels, and is equipped with one horizontal and two vertical cutter bars that can be hydraulically positioned to a depth of 5.5 feet. Hydraulic conveyors built into the harvester hoist cut plant debris onto the deck of the barge. When full, the plant material can be transported back to shore to be off-loaded into an awaiting dump truck using a shore-conveyor system.

Ancillary equipment presently includes a 28.5-foot shore conveyor, 1977 GMC Sierra Series 6000 dump truck, and a 42-foot Aquarius Systems' harvester trailer with mounted electric winch. The shore conveyor and dump truck are quite old and have started to require increasing levels of maintenance. These two pieces of equipment will likely need to be replaced in the near future.

At the close of each season, all equipment is cleaned, inspected, lubricated and winterized for storage purposes. The equipment is currently stored in a cold-storage shed located at the Oakland Town Hall. Table 31 lists storage dimensions for each piece of equipment. The District has a 10-year storage-lease agreement with the Town of Oakland that expires on December 31, 2015. This arrangement was purchased for an upfront cost of $8,000 as stipulated in a Memorandum of Understanding dated 12/27/05.

Table 14: Storage dimensions for harvester and accessory equipment

	Length	Width	Height
Harvester (on trailer)	42 ft.	14.2 ft. (with paddles) 9 ft. (without paddles)	9 ft.
Harvester (off trailer)	39 ft.	Same	Same
Conveyor	28.5 ft.	6.5 ft. (at wheels)	9.5 ft. (max.) 6.7 ft. (min. – center

			pivot)
Dump truck	21 ft.	8 ft.	7.5 ft.

STAGING AREA

The mechanical harvester is launched and removed from the lake using the Town of Oakland boat landing on Island Lane. Launching and removal of the harvester remains problematic due to the absence of an adequately sized turnaround. The turnaround should be a minimum of 60x60 feet since the trailer cannot be rotated at greater than a 90° angle when hitched. Consequently, the trailer must be slowly backed into position starting from Forested Road.

During summer operations, the harvester, shore conveyor and dump truck are parked at the Hoard-Curtis Scout Camp (approximately mid-June to late-October). The District currently rents the Camp property for $150/month during the operating season.

WEED DISPOSAL

Many farmers are more than willing to accept aquatic plants since they are used as a source of nutrients (2.5% nitrogen, 0.6% phosphorus, and 2.3% potassium) and can add valuable, seed-free organic matter to the soil. Locating a disposal site in close proximity to the off-loading conveyor station is one of the keys to managing costs and increasing program efficiency. Harvested plant material is currently trucked to the Rude Farm at W9156 USH 12 in Cambridge for composting. This location is ideal since it is only about a mile from the staging area. The property owner does not currently charge for this convenience.

STAFFING

Weed-harvesting staff currently consists of two operators who are trained and supervised by the District's Lake Manager. These part-time, seasonal employees are in charge of operating and maintaining the machinery on an as-needed basis. They are paid on an hourly wage basis, and are covered by Workers' Compensation Insurance. The established starting wage rate is currently $10/hour, with $1/hour annual raises for returning employees up to a maximum $15/hour wage rate. Any specialized mechanical work beyond routine equipment maintenance is reimbursed at a rate of $18/hour.[19] Operators are required to comply with a "Weed Harvesting Operations Plan" that was adopted in 2008 and is presented in its entirety below.[20]

[19] Lake Ripley Management District, 05/12/07 meeting minutes
[20] Lake Ripley Management District, 04/12/08 meeting minutes

Weed Harvesting Operations Plan
Adopted: 04-12-08

Operations Period: June 15th – October 1st on as-needed basis

Staffing Levels: Two, part-time operators shall be hired to work in concert during the conduct of actual harvesting. A two-person operating team is recommended for both safety and logistical reasons (i.e., response to injury/mechanical breakdowns, off-loading coordination, etc.). A third employee shall be hired *only* if a consistent and compatible scheduling arrangement cannot be worked out between the two primary employees.

Compensation: As adopted by the Board in 2007 (and amended on 9/26/09), employees shall start out earning a $10/hour wage rate to operate and maintain the harvesting equipment. A $1/hour raise shall be awarded to returning employees at the start of each subsequent operating season, until the current $15/hour cap is reached. Any specialized mechanical work beyond routine equipment maintenance shall be reimbursed at a rate of $18/hour. Routine maintenance tasks are those that can be performed with very little to no mechanical expertise (i.e., greasing, lubricating and power-washing machine parts, replacing batteries, inspecting hoses, checking fluid levels, etc.). Specialized mechanical work requires a level of training or experience that cannot be performed by the average employee (i.e., engine diagnostics and repairs, replacement of bearings, oil changes, bodywork, etc.). Wage adjustments as a result of inflation, employee performance, local market rates and other factors shall be considered by the Board every two years, or as deemed appropriate.

Minimum Qualifications: Operators should be at least 18 years old; possess a valid commercial driver's license (CDL) ***or*** have competence in driving a dump truck and operating heavy equipment; perform occasional heavy lifting; conduct basic equipment maintenance; and be able to follow an aquatic plant management plan and permitting requirements.

Training: All operators shall complete a minimum of 3 hours of on-the-water training under the direction of the Lake Manager. Operators must be able to demonstrate a strong work ethic, and competence in both running the equipment and identifying nuisance weed conditions. In addition, operators must have reviewed and be able to follow all operating guidelines contained in the latest version of the Lake Ripley Aquatic Plant Management Plan and DNR Harvesting Permit.

Scheduling: Operators must be generally available to work during established time blocks throughout the harvesting period. Weekly time blocks shall be 7:30-11:00 a.m. Monday through Friday, corresponding with the slow-no-wake period. This provides, if needed, a maximum of 17.5 hours per week of harvesting time. By noon on Friday, operators shall propose a joint work schedule for the upcoming week to the Lake Manager. Proposed schedules shall be based on the latest assessment of weed-growth conditions and other needs, and may be adjusted later if such conditions change. Any proposed scheduling changes must be approved in advance by the Lake Manager.

Timesheet Reporting: Operators shall be responsible for filling out their timesheets at the end of each work day. Operators shall accurately document start/finish times; estimated percentage of time spent harvesting vs. operational-support tasks; approved out-of-pocket expenses for supplies and authorized mileage; descriptions of the specific work tasks performed; lake areas harvested; the number of harvester loads removed from the lake; and number of machine hours logged on the harvester meter on a bi-weekly basis. Timesheets shall be delivered to the Lake Manager by 12:00 p.m. on the first and third Friday of each month. The Lake Manager shall then review and forward the timesheets to the Board Treasurer for payment. Two weeks shall be allowed for payroll processing following receipt of the timesheets.

Oversight: Operators shall immediately notify the Lake Manager of any alterations to the approved work schedule. At least every three weeks, an oversight committee shall perform brief visual inspections to assess operator performance and help identify new problem areas. The oversight committee shall consist of the Lake Manager and at least one LRMD Board member. If possible, one of the operators should accompany the oversight committee. The oversight committee shall investigate citizen complaints regarding specific weed-related concerns, and forward any appropriate follow-up instructions to the operators.

Board Reporting: The Lake Manager shall provide a brief harvesting report at each Board meeting during the operating period. The report shall include the schedule of operations since the last meeting; general harvesting locations; number of loads harvested; any significant problems encountered; status of the equipment; general assessment of nuisance weed-growth conditions, and a summary of actions/recommendations by the oversight committee.

I have read and agree to comply with the Operator requirements outlined in the above Weed Harvesting Operations Plan *as a condition of my employment with the Lake Ripley Management District:*

____________________________________ ___________
Signature of Operator Date

COSTS

Operating costs are highly variable but generally average around several thousand dollars per year. Costs include fuel, equipment storage, maintenance/repairs, payroll and insurance. Actual operating expenses depend on the number of people employed to operate the equipment, the nature of their employment (volunteer, part-time or full-time), and the hours of operation. The Lake District should recognize that it takes dedicated and skilled individuals to properly maintain and operate the equipment. Appropriate compensation incentives must be provided to maintain a qualified operating crew and to avoid a high, staff turnover rate each year. An activity report summarizing program details over the last several years is presented in Table 32.

Table 15: Harvesting program summary report (2001-2009)

	2001	2002	2003	2004	2005	2006	2007	2008	2009
Launch/ removal date	6/28–10/17	6/20–11/13	6/25–10/20	6/24–10/19	6/20–10/20	6/29–9/26	6/27–10/22	6/24-10/06	6/15-10/05
Operators	3	3	3	2	2	2	2	2	2
Total hours[1]	82.5	125.5	209.5	245	83	221.5	160	228.5	266
Total expenses[2]	$3,554	$5,404	$4,009	$5,656	$3,111	$6,597	$3,474	$6,749	$6,027 (as of 11/7/09)
% supplies, repairs, fuel	41%	39%	9%	15%	10%	52%	17%	38%	27%
% storage, shore rental	38%	33%	28%	22%	44%	4% (winter storage lease not included)	12% (winter storage lease not included)	8% (winter storage lease not included)	9% (winter storage lease not included)
% operator wages	21%	28%	63%	63%	46%	44%	62%	54%	64%
Extra-ordinary expenses	$719 for winch	$1,641 for truck repairs	$1,345 for conveyor repairs			$2,600 for harvester repairs	$330 permit fee	$900 for truck repairs; $1,000+ for harvester repairs	
Machine hours at end of season[3]	NA	NA	NA	2423	2502 (79 hrs)	2721 (219 hrs)	2921 (200 hrs)	3115 (194 hrs)	3523 (408 hrs)
# harvester loads[4]	11.5	18	18	17	7	19	18	18.5	33

[1] All employee hours, including combined shifts to operate harvester and "off-season" equipment maintenance. Note that a significant number of hours are devoted to non-cutting activities (i.e., off-loading, dumping, weed surveying, equipment maintenance/repair, fuel/part-supply runs).

[2] Does not include approximately $3,000 in insurance costs.

[3] Machine hours are recorded on a meter and refer to the total amount of time the engine has been operating.

[4] A full harvester load is equal to about 300-440 cubic feet of wet plant material

Operations Checklist

Prior to Start of Season

1. Review prior year expenses and adjust budget as needed
2. Hire and train operators as needed
   (Establish wage rate; complete payroll tax-reporting forms; sign operations plan; supply timesheets; and review safety, maintenance and operational procedures)
3. Schedule launch date and confirm arrangements with interested parties
   (Contact insurance agent, harvester operators, off-season and summer storage providers, disposal site manager, and Town of Oakland)
4. Ensure that all equipment is serviced and in sound operating condition
   (Check batteries, tire pressure, fluid levels, filters, hydraulics, lubricated fittings, spark plugs, bearings, hoses, etc.)
5. Inspect launch facility and off-loading area
6. Provide certificate of liability insurance to Scout Camp

Equipment Mobilization

1. Finalize launch date and re-activate insurance for dump truck
2. Coordinate with operators and storage provider to move harvesting equipment back to the lake
   (Gather supplies such as tire blocks, work gloves, waders, gate/harvester/truck keys, two-way radios, emergency tools, 12-volt battery, first aid kit, road barricades, rope, pruning saw, etc.)
3. Place signs at entrance to public landing announcing date and time that landing will be closed
4. On the date of the move, barricade entry to the public landing and disassemble pier
5. Transport harvester to the public landing, launch and park at the Scout Camp
   (Cover operator's console to protect against weather, and tie harvester to nearest tree)
6. Return the harvester trailer to the Town Hall storage shed
7. Transport and park the shore conveyor at the Scout Camp
   (Cover tires and engine to protect against weather)

Summer Operations

1. Provide operators with gate/harvester/truck keys, two-way radios, work gloves, pitch forks, small ladder, hand tools, extra timesheets, polarized sunglasses, sun protection, PFDs, etc.
2. Review safety protocols, operating procedures, and equipment-maintenance requirements
3. Perform boat survey of lake to identify problem areas as they develop
4. Maintain detailed records on hours worked, tasks performed, locations harvested, and number of loads removed from the lake.

Off-Season Tasks

1. Schedule equipment removal date following removal of Town pier
   (Contact insurance agent, harvester operators, off-season and summer storage providers, disposal site manager, and Town of Oakland)
2. Return all equipment to the Town Hall; clean and lubricate prior to storage
3. Gather keys and supplies from the operators; pay Scout Camp rental fee
4. Review off-season maintenance needs with mechanic/storage provider

6. Deactivate insurance on the dump truck

Safety Precautions

There are numerous safety precautions that should be taken when operating heavy machinery. The following safety measures will help prevent personal injuries and damage to the harvesting equipment and other property. This is not an exhaustive list, and should be used only as a guide.

- Operators shall be experienced and have sufficient training on the safe and proper use of the machinery.
- Operators shall be trained in how to respond in the event of a system malfunction or other emergency.
- Operators shall posses a coast guard approved personal floatation device.
- Operators shall not drink alcohol, smoke, wear headphones, or operate the machinery when tired or sick.
- Operators shall wear the proper, weather protective gear (polarized sunglasses, hat, etc.).
- Operators shall abide by all equipment safety and operational rules.
- No swimming or fishing shall be allowed to occur in the area of the harvester.
- No person shall be allowed within the immediate vicinity of the harvester during operations.
- Harvesting shall be postponed during inclement weather conditions or when boat traffic is excessive.
- The equipment shall not be operated after dark or in high winds.
- The equipment shall not be operated in less than 3-foot water depths, or around piers and other structures.
- The harvester shall be equipped with the proper safety equipment (first aid kit, fire extinguisher, etc.)
- No pets or extra people shall be allowed on the harvester during operations.
- The harvester shall not be overloaded with plant material at any time.
- The harvester engine shall be shut off before any repairs are made, or before any obstructions are cleared.
- The harvester engine shall never be allowed to idle unattended.
- Regular inspections shall be performed to ensure all mechanical parts are in proper operating condition.

General Operating Procedure

Operators shall be trained on how to safely and properly use and maintain the equipment. It is imperative that operators understand their objective, and that they are able to identify targeted, non-native plant species. Operators should also become familiar with the locations of nuisance weed beds, potential underwater obstructions, shallow water depths, and any areas that might be off limits to mechanical harvesting (i.e., critical spawning habitat, high quality plant beds, confined channel areas, etc.).

Selective harvesting shall be performed in accordance with Wisconsin DNR permit conditions and within guidelines set forth in this chapter. Selective harvesting involves reshaping as much habitat as lake users need, and leaving the rest for aquatic communities. Cutting intensity will vary depending on the extent of weed growth and the management requirements of the particular user zone. This approach is recommended for Lake Ripley as a planned approach to multiple lake use.

Operations should commence no sooner than mid-June to allow time for the vegetation to grow within reach of the harvester, as well as to avoid most of the fish-spawning season. Cutting is to be performed during calm and clear weather conditions, and during weekdays when there is minimal boat traffic, preferably during the morning no-wake period. The actual amount of time needed for harvesting each season can vary dramatically, making scheduling difficult at best.

<table>
<tr><td>Approved Locations:</td><td>Water depths greater than 3.0 ft.
At least 10 ft. from private piers, boat hoists, swim rafts, and other structures
Permit-approved locations dominated by non-native, invasive plant species growing at or near the surface
Permit-approved navigational lanes that route motor boat traffic to open water areas and that conform to surface zoning objectives</td></tr>
<tr><td>Advantages:</td><td>Direct, physical cutting and removal of problem weeds
Immediate relief from nuisance weed conditions
Targets growth within five feet of the surface where it is most problematic
Quicker and more efficient than manual harvesting
Minimum health and safety risk to lake users
Limited interference imposed on most lake uses
Some species selectivity achieved due to timing and location of cutting
May favor slower and lower growing species
Effectively clears boating lanes and provides edge habitat through dense weed beds
Reduces the potential for floating plant debris caused by motor boat “prop chop” and high winds
Avoids the need for chemicals that can affect sensitive aquatic organisms
Most harvested plant material is efficiently removed from the lake
Lower long-term costs and environmental impacts compared to other strategies</td></tr>
<tr><td>Disadvantages:</td><td>Short-term effectiveness as weeds regenerate
Requires repeated implementation throughout growing season
High initial cost for the acquisition of capital equipment
Involves annual costs for operator wages, insurance, equipment maintenance and storage
Not as effective on fast growing and non-rooted plant species
Minimum species selectivity achieved in areas with mixed plant communities
May benefit disturbance-tolerant species</td></tr>
</table>

	• Not appropriate within less than three-foot water depths and in confined areas • Potential to remove small fish and other organisms along with the cut plant material • Overuse could eliminate critical aquatic habitat • Improper operation could disturb the lake bottom and stir up sediment, increasing the likelihood of colonization by invasive species • Collection of all floating plant debris may not be possible • Attacks symptoms rather than root cause of nuisance weed growth • Requires DNR permit • Requires the use and maintenance of multiple pieces of heavy machinery

Operator performance shall be based on proficiency in operating and maintaining the equipment, ability to target approved areas and plant species, and ability to respond to weed-growth conditions as they fluctuate throughout the season. The amount of lake surface area covered, number of plant loads collected, or hours spent on the lake harvesting is often irrelevant to a successful program and should not be used to gauge success. These factors are also subject to vary depending on the operational status of the equipment. Furthermore, changes in plant abundance and rate of growth are influenced by a number of variables independent of a harvesting program. Instead, operators should simply focus their efforts on safely and efficiently harvesting nuisance weed growth within approved locations, while avoiding high quality native plant beds.

Some areas may need to be cut multiple times per season during heavy growth. Exotic plant species such as Eurasian watermilfoil should be harvested when they are at high densities and visible at the surface within designated target areas. Mechanical harvesters work best in waters that are three to six feet deep, and where nuisance vegetation begins to canopy at the surface. To avoid disturbing bottom sediments, no harvesting is performed any closer than one foot from the bottom of the lake or in water less than three feet deep. Loose, mucky or silty substrates in shallow areas should be avoided to prevent the re-suspension of bottom sediments or damage to the machinery.

Operators shall monitor the number and types of fish picked up by the harvester. If feasible from a safety perspective, larger fish and turtles should be safely and expeditiously returned to the lake upon capture. When large numbers of fish are encountered, harvesting shall be temporarily stopped in that area until the fish have moved on. Known spawning beds are to be avoided entirely during the early part of the season. Operators can return to these areas later in the season when spawning has ended.

While harvesting, all floating plant debris shall be immediately removed from the water. The operator should make every effort to pick up floating plant fragments when making turns and during trips to and from the loading site. However, attempts should not be made to recover widely scattered plant fragments, especially those that cannot be easily captured or were not produced as a result of harvesting activities. Lakefront property owners are to be encouraged to manage weed growth and collect floating plant debris around their own piers, boatlifts and swimming rafts. Operating a large weed harvester in such tight, shallow areas is hazardous given the risk of damaging the equipment or private property. Although many people associate floating plant debris with harvesting, other factors are usually to blame. These factors include "prop chop" from motor boats, severe weather, and auto-fragmentation of certain plant species.

Operators will be asked to submit detailed timesheets and harvesting logs. Harvesting logs are a good way of documenting program activities, keeping track of costs, estimating downtime, and identifying weed growth patterns. A typical harvesting log will ask for name, date, start/finish times, description of areas harvested, number of loads collected/disposed, plant types harvested, machine hours logged, equipment maintenance performed, expenses incurred, and any problems encountered.