MANAGING AQUATIC PLANTS IN NORTHERN WISCONSIN

AQUATIC PLANT MANAGEMENT PLAN COMPANION DOCUMENT

Harmony Environmental

Finding a balance

People Land Water

Ecological Integrity Service, LLC

SEAL OF BURNETT COUNTY WISCONSIN

CONTENTS

FUNCTIONS AND VALUES OF NATIVE AQUATIC PLANTS

Naturally occurring native plants are extremely beneficial to lakes. They provide a diversity of habitats, help maintain water quality, sustain fish populations, and support common lakeshore wildlife such as loons and frogs.

WATER QUALITY

Aquatic plants can improve water quality by absorbing phosphorus, nitrogen, and other nutrients from the water that could otherwise fuel nuisance algal growth. Some plants can even filter and break down pollutants. Plant roots and underground stems help to prevent re-suspension of sediments from the lake bottom. Stands of emergent plants (whose stems protrude above the water surface) and floating plants help to blunt wave action and prevent erosion of the shoreline.

FISHING

Habitat created by aquatic plants provides food and shelter for both young and adult fish. Invertebrates living on or beneath plants are a primary food source for many species of fish. Other fish such as bluegills graze directly on the plants themselves. Plant beds in shallow water provide important spawning habitat for many fish species.

WATERFOWL

Plants offer food, shelter, and nesting material for waterfowl. Birds eat both the invertebrates that live on plants and the plants themselves.[1]

PROTECTION AGAINST INVASIVE SPECIES

Non-native invasive species threaten native plants in Northern Wisconsin. The most common are Eurasian water milfoil (EWM) and curly leaf pondweed (CLP). These species are described as opportunistic invaders. This means that they take over openings in the lake bottom where native plants have been removed. Without competition from other plants, these invasive species may successfully become established and spread in the lake. This concept of opportunistic invasion can also be observed on land, in areas where bare soil is quickly taken over by weeds.

Removal of native vegetation not only diminishes the natural qualities of a lake, but it increases the risk of non-native species invasion and establishment. The presence of invasive species can change many of the natural features of a lake and often leads to expensive annual control plans. Allowing native plants to grow may not guarantee protection against invasive plants, but it can discourage their establishment. Native plants may cause localized concerns to some users, but as a natural feature of lakes, they generally do not cause harm.[2]

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[1] Above paragraphs summarized from *Through the Looking Glass*. Borman et al. 1997.
[2] *Aquatic Plant Management Strategy*. DNR Northern Region. Summer 2007.

DISCUSSION OF MANAGEMENT METHODS

PERMITTING REQUIREMENTS

The Department of Natural Resources is currently revising administrative rules that regulate aquatic plant management in Wisconsin.

The Department of Natural Resources regulates the removal of aquatic plants when chemicals are used, when plants are removed mechanically, and when plants are removed manually from an area greater than thirty feet in width along the shore. The requirements for chemical plant removal are described in Administrative Rule NR 107 – Aquatic Plant Management. A permit is required for any aquatic chemical application in Wisconsin. Additional requirements exist when a lake is considered an ASNRI (Area of Special Natural Resource Interest) due, in the case of Balsam Lake, to the designation of sensitive areas.

The requirements for manual and mechanical plant removal are described in *NR 109 – Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations*. A permit is required for manual and mechanical removal except for when a riparian (waterfront) landowner manually removes or gives permission to someone to manually remove plants, (with the exception of wild rice) from his/her shoreline up to a 30-foot corridor. A riparian landowner may also manually remove the invasive plants Eurasian water milfoil, curly leaf pondweed, and purple loosestrife along his or her shoreline without a permit. Manual removal refers to the control of aquatic plants by hand or hand–held devices without the use or aid of external or auxiliary power.[3]

The *Department of Natural Resources Northern Region Aquatic Plant Management Strategy* (May 2007) requires documentation of impaired navigation or nuisance conditions before native plants may be managed with herbicides. Severe impairment or nuisance will generally mean that vegetation grows thickly and forms mats on the water surface.

Techniques to control the growth and distribution of aquatic plants are discussed in the following text. The application, location, timing, and combination of techniques must be considered carefully.

[3] More information regarding DNR permit requirements and aquatic plant management contacts is found on the DNR web site: www.dnr.state.wi.us.

MANUAL REMOVAL[4]

Manual removal—hand pulling, cutting, or raking—will effectively remove plants from small areas. It is likely that plant removal will need to be repeated more than once during the growing season. The best timing for hand removal of herbaceous plant species is after flowering but before seed head production. For plants with rhizomatous (underground stem) growth, pulling roots is not generally recommended since it may stimulate new shoot production. Hand pulling is a strategy recommended for rapid response to a Eurasian water milfoil establishment and for private landowners who wish to remove small areas of curly leaf pondweed growth. Raking is recommended to clear nuisance growth in riparian area corridors up to 30 feet wide.

SCUBA divers may engage in manual removal for invasive species like Eurasian water milfoil. Care must be taken to ensure that all plant fragments are removed from the lake. Manual removal with divers is recommended for shallow areas where sporadic EWM growth occurs.

MECHANICAL CONTROL

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

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water. The cutter head uses sickles similar to those found on farm equipment, and generally cut to depths from 1 to 6 feet. A conveyor belt on the cutter head brings the clippings onboard the machine for storage. Once full, the harvester travels to shore to discharge the load of weeds off of the vessel.

The size, and consequently the harvesting capabilities, of these machines vary greatly. As they move, harvesters cut a swath of aquatic plants that is between 4 and 20 feet wide, and can be up to 10 feet deep. The on-board storage capacity of a harvester ranges from 100 to 1,000 cubic feet (by volume) or 1 to 8 tons (by weight).

In some cases, the plants are transported to shore by the harvester itself for disposal. In other cases, a barge is used to store and transport the plants. The plants are deposited on shore, where they can be transported to a local farm for use as a soil amendment (the nutrient content of composted aquatic plants is comparable to that of cow manure) or to an upland landfill for proper disposal. Most harvesters can cut between 2 and 8 acres of aquatic vegetation per day, and the average lifetime of a mechanical harvester is 10 years.

Mechanical harvesting of aquatic plants presents both positive and negative consequences to any lake. Its results—open water and accessible boat lanes—are immediate, and can be enjoyed without the restrictions on lake use which follow herbicide treatments. In addition to the human use benefits, the clearing of thick aquatic plant beds may also increase the growth and survival of some fish. By eliminating the upper canopy, harvesting reduces the shading caused by aquatic plants. The nutrients stored in the plants are also removed from the lake, and the sedimentation that would normally occur as a result of the decaying of this plant matter is prevented. Additionally, repeated treatments may result in thinner, more scattered growth.

[4] Information from *APIS (Aquatic Plant Information System)*. U.S. Army Corps of Engineers. 2005 and the *Wisconsin Aquatic Plant Management Guidelines*.

Aside from the obvious effort and expense of harvesting aquatic plants, there are many environmentally-detrimental consequences to consider. The removal of aquatic species during harvesting is non-selective. Native and invasive species alike are removed from the target area. This loss of plants results in a subsequent loss of the functions aquatic plants perform, including sediment stabilization and wave absorption. Shoreline erosion may therefore increase. Other organisms such as fish, reptiles, and insects are often displaced or removed from the lake in the harvesting process. This may have adverse effects on these organisms' populations as well as on the lake ecosystem as a whole.

While the results of harvesting aquatic plants may be short term, the negative consequences are not so short lived. Much like mowing a lawn, harvesting must be conducted numerous times throughout the growing season. Although the harvester collects most of the plants that it cuts, some plant fragments inevitably persist in the water. This may allow invasive plant species to propagate and colonize in new, previously unaffected areas of the lake. Harvesting may also result in re-suspension of contaminated sediments and the excess nutrients they contain.

Disposal sites are a key component when considering the mechanical harvesting of aquatic plants. The sites must be on shore and upland to make sure the plants and their reproductive structures do not make their way back into the lake or to other lakes. The number of available disposal sites and their distance from the targeted harvesting areas will determine the cost and efficiency of the operation.

Timing is also important. The ideal time to harvest, in order to maximize the efficiency of the harvester, is just before the aquatic plants break the surface of the lake. For curly leaf pondweed, it should also be before the plants form turions (reproductive structures) to avoid spreading the turions within the lake. If the harvesting is conducted too early, the plants will not be close enough to the surface, and the cutting will not do much damage to them. If too late, turions may have formed and may be spread, and there may be too much plant matter on the surface of the lake for the harvester to cut effectively.

If the harvesting work is contracted, the equipment should be inspected before and after it enters the lake. Since these machines travel from lake to lake, they may carry plant fragments with them, facilitating the spread of aquatic invasive species from one body of water to another. Prevailing winds may also blow cut vegetation into open areas of the lake or along shorelines.

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

Plant fragments can result from diver dredging, but fragmentation is not as great a problem when infestations are small. Diver dredging operations may need to be repeated more than once to be effective. When applied to a pioneering infestation, control can be complete. However, periodic inspections of the lake should be performed to ensure that all the plants have been found and collected.

Lake substrates play an important part in the effectiveness of a diver dredging operation. Soft substrates are very easy to work in. Divers can remove the plant and root crowns with little difficulty. Hard substrates, however, pose more of a problem. Divers may need hand tools to help dig the root crowns out of hardened sediment. Diver dredging will be considered as a rapid response control measure for Eurasian water milfoil if discovered in the lakes.

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

BIOLOGICAL CONTROL[5]

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

The effectiveness of biocontrol efforts varies widely (Madsen, 2000). Beetles are commonly and successfully used to control purple loosestrife populations in Wisconsin. Tilapia and carp are used to control the growth of filamentous algae in ponds. Grass carp, an herbivorous fish, is sometimes used to feed on pest plant populations, but grass carp introduction is not allowed in Wisconsin.

Weevils[6] have potential for use as a biological control agent against Eurasian water milfoil. There are several documented “natural” declines of EWM infestations. In these cases, EWM was not eliminated, but its abundance was reduced enough so that it did not achieve dominance. These declines are attributed to an ample population of native milfoil weevils (*Euhrychiopsis lecontei*). Weevils feed on native milfoils but will shift preference over to EWM when it is present. Lakes where weevils can become an effective control have an abundance of native northern water milfoil and fairly extensive natural shoreline where the weevils can over winter. Any control strategy for EWM that would also harm native milfoil may hinder the ability of this natural bio-control agent. Lakes with large bluegill populations are not good candidates for weevils, because bluegills feed on the weevils. The presence and efficacy of stocking weevils in EWM lakes is being evaluated in Wisconsin lakes. So far, stocking does not appear to be effective.

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

[6] *Control of Eurasian Water Milfoil & Large-scale Aquatic Herbicide Use*. Wisconsin Department of Natural Resources. July 2006.

Purple Loosestrife Biocontrol[7]

Biocontrol may be the most viable long term control method for purple loosestrife control.

The DNR and University of Wisconsin-Extension (UWEX), along with hundreds of citizen cooperators, have been introducing natural insect enemies of purple loosestrife, from its home in Europe to infested wetlands in the state since 1994. Careful research has shown that these insects are dependent on purple loosestrife and are not a threat to other plants. Insect releases monitored in Wisconsin and elsewhere have shown that these insects can effectively decrease purple loosestrife's size and seed output, thus letting native plants reduce its numbers naturally through enhanced competition.

A suite of four different insect species has been released as biological control organisms for purple loosestrife in North America and Wisconsin. Two leaf beetle species called "Cella" beetles that feed primarily on shoots and leaves were the first control insects to be released in Wisconsin, and are the insects available from DNR for citizens to propagate and release into their local wetlands. A root-mining weevil species and a type of flower-eating weevil have also been released and are slowly spreading naturally. The Purple Loosestrife Biocontrol Program offers cooperative support, including free equipment and starter beetles from DNR and UWEX, to all state citizens who wish to use these insects to reduce their local purple loosestrife.

The length of time required for effective biological control of purple loosestrife in any particular wetland ranges from one to several years depending on such factors as site size and loosestrife densities. The process offers effective and environmentally sound control of the plant, not elimination, in most cases. It is also typically best done in some combination with occasional use of more traditional control methods such as digging and herbicide use. Biocontrol with beetles is recommended for large inaccessible patches of purple loosestrife growth.

There are advantages and disadvantages to the use of biological control as part of an overall aquatic plant management program. Advantages include longer-term control compared to other technologies, lower overall costs, and plant-specific control. On the other hand, there are several disadvantages to consider, including very long control times (years instead of weeks), a lack of available agents for particular target species, and relatively specific environmental conditions necessary for success. Biological control is not without risks; new non-native species introduced to control a pest population, may cause problems of its own.

RE-VEGETATION WITH NATIVE PLANTS

Another aspect to biological control is native aquatic plant restoration. The rationale for re-vegetation is that restoring a native plant community should be the end goal of most aquatic plant management programs (Nichols 1991; Smart and Doyle 1995). However, in communities that have only recently been invaded by nonnative species, a propagule (seed) bank probably exists that will restore the community after nonnative plants are controlled (Madsen, Getsinger, and Turner, 1994). Re-vegetation following plant removal may not be necessary if a healthy, diverse native plant population is present.

[7] http://dnr.wi.gov/topic/Invasives/loosestrife.html

PHYSICAL CONTROL[8]

In physical management, the environment of the plants is manipulated. Several physical techniques are commonly used: dredging, drawdown, benthic (lake bottom) barriers, and shading or light attenuation. Because these methods involve placing a structure on the bed of a lake and/or affect lake water level, a Chapter 30 or 31 WDNR permit is required.

Dredging removes accumulated bottom sediments that support plant growth. Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, need deepening, or require removal of toxic substances (Peterson 1982). Lakes that are very shallow due to sedimentation tend to have excess plant growth. Dredging can form an area of the lake too deep for plants to grow, thus creating an area for open water use (Nichols 1984). By opening more diverse habitats and creating depth gradients, dredging may also create more diversity in the plant community (Nichols 1984). Results of dredging can be very long term. However, due to the cost, environmental impacts, and the problem of disposal, dredging should not be performed for aquatic plant management alone. It is best used as a lake remediation technique.

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

Although drawdown can be inexpensive and have long-term effects (2 or more years), it also has significant environmental effects and may interfere with use and intended function of the water body during the drawdown period. Lastly, species respond in very different manners to drawdown and responses can be inconsistent (Cooke 1980a). Drawdowns may provide an opportunity for the spread of highly weedy species, particularly annuals.

Benthic barriers, or other bottom-covering approaches, are another physical management technique. The basic idea is to cover the plants with a layer of a growth-inhibiting substance. Many materials have been used, including sheets or screens of organic, inorganic, and synthetic materials; sediments such as dredge sediment, sand, silt or clay; fly ash; and various combinations of the above materials (Cooke 1980b; Nichols 1974; Perkins 1984; Truelson 1984). The problem with synthetic sheeting is that the gases evolved from plant and sediment decomposition collect underneath and lift the barrier (Gunnison and Barko 1992). The problem with using sediments is that new plants establish on top of the added layer (Engel and Nichols 1984).

Benthic barriers will typically kill the plants under them within 1 to 2 months, after which time they may be removed (Engel 1984). Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively (Carter et al. 1994). Sites from which barriers are removed will be rapidly re-colonized (Eichler et al. 1995). Synthetic barriers, if left in place for multi-year control, will eventually become sediment-covered and will allow colonization by plants. Benthic barriers may be best suited to small, high-intensity use areas such as docks, boat launch areas, and swimming areas. However, they are too expensive to use

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

over widespread areas, and heavily affect benthic communities by removing fish and invertebrate habitat. A WDNR permit would be required for a benthic barrier, and these barriers are not recommended.

Shading or light attenuation reduces the amount of light available for plant growth. Shading has been achieved by fertilization to produce algal growth; application of natural or synthetic dyes, shading fabric, or covers; and establishing shade trees (Dawson 1981, 1986; Dawson and Hallows 1983; Dawson and Kern-Hansen 1978; Jorga et al. 1982; Martin and Martin 1992; Nichols 1974). During natural or cultural eutrophication, algae growth alone can shade aquatic plants (Jones et al. 1983). Although light manipulation techniques may be useful for narrow streams or small ponds, in general, these techniques are of only limited applicability.

HERBICIDE AND ALGAECIDE TREATMENTS

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

An important caveat is that these products are considered safe when used according to the label. The U.S. Environmental Protection Agency (EPA)-approved label gives guidelines protecting the health of the environment, the humans using that environment, and the applicators of the herbicide. WDNR permits under Chapter NR 107 are required for herbicide application.

General descriptions of herbicide classes are included below.[9]

CONTACT HERBICIDES

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

SYSTEMIC HERBICIDES

Systemic herbicides are absorbed into the living portion of the plant and move within the plant. Different systemic herbicides are absorbed to varying degrees by different plant parts. Systemic herbicides that are absorbed by plant roots are referred to as soil active herbicides and those that are absorbed by leaves are referred to as foliar active herbicides. **2,4-D, dichlobenil, fluridone, and glyphosate** are systemic aquatic herbicides. When applied correctly, systemic herbicides act slowly in comparison to contact herbicides. They must move to their site of action within

[9] This discussion is taken from: *Managing Lakes and Reservoirs*. North American Lake Management Society.

the plant. Systemic herbicides are generally more effective for controlling perennial and woody plants than contact herbicides. Systemic herbicides also generally have more selectivity than contact herbicides.

BROAD SPECTRUM HERBICIDES

Broad spectrum (sometimes referred to as nonselective) herbicides are those that are used to control all or most species of vegetation. This type of herbicide is often used for total vegetation control in areas such as equipment yards and substations where bare ground is preferred. **Glyphosate** is an example of a broad spectrum aquatic herbicide. **Diquat, endothall, and fluridone** are used as broad spectrum aquatic herbicides, but can also be used selectively under certain circumstances.

SELECTIVE HERBICIDES

Selective herbicides are those that are used to control certain plants but not others. Herbicide selectivity is based upon the relative susceptibility or response of a plant to an herbicide. Many related physical and biological factors can contribute to a plant's susceptibility to an herbicide. Physical factors that contribute to selectivity include herbicide placement, formulation, timing, and rate of application. Biological factors that affect herbicide selectivity include physiological factors, morphological factors, and stage of plant growth.

ENVIRONMENTAL CONSIDERATIONS

Aquatic communities consist of aquatic plants including macrophytes (large plants) and phytoplankton (free floating algae), invertebrate animals (such as insects and clams), fish, birds, and mammals (such as muskrats and otters). All of these organisms are interrelated in the community. Organisms in the community require a certain set of physical and chemical conditions to exist such as nutrient requirements, oxygen, light, and space. Aquatic weed control operations can affect one or more of the organisms in the community, and in turn, affect other organisms. These operations can also impact water chemistry which may result in further implications for aquatic organisms.

General descriptions of the breakdown of commonly used aquatic herbicides are included below.[10]

COPPER

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

2,4-D

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

10 These descriptions are taken from Hoyer/Canfield: *Aquatic Plant Management*. North American Lake Management Society. 1997.

DIQUAT

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

ENDOTHALL

Like 2,4-D, endothall is rapidly and completely broken down into naturally occurring compounds by microorganisms. The by-products of endothall dissipation are carbon dioxide and water. Complete breakdown usually occurs in about 2 weeks in water and 1 week in bottom sediments.

FLURIDONE

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

GLYPHOSATE

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

FLORPYRAUXIFEN-BENZYL

Florpyrauxifen-benzyl was registered with the EPA for aquatic use in 2017. Florpyrauxifen-benzyl is a systemic herbicide that is taken up by aquatic plants. The herbicide is a member of a new class of synthetic auxins, the arylpicolinates, that differ in binding affinity compared to other currently registered synthetic auxins. The herbicide mimics the plant growth hormone auxin that causes excessive elongation of plant cells that ultimately kills the plant. (WDNR Fact Sheet 2018)

ALGAECIDE TREATMENTS FOR FILAMENTOUS ALGAE

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

HERBICIDE USED TO MANAGE INVASIVE SPECIES

EURASIAN WATER MILFOIL

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies the following herbicides for control of Eurasian water milfoil: complexed copper, 2,4-D, diquat, endothall, fluridone, and triclopyr. Florpyrauxifen-benzyl was registered with the EPA for aquatic use in 2017. Early season treatment of Eurasian water milfoil is also recommended by the Department of Natural Resources to limit the impact on native aquatic plant populations. Herbicide use may be necessary to rapidly respond to an infestation if discovered in a lake.

2,4-D is frequently used to target EWM (a dicot) over many other native plants (monocots).

However, large-scale treatments can result in significant damage to both monocots and dicots.

- Dicots susceptible to both 2,4-D and fluridone include native water milfoils (particularly northern), bladderworts, water lilies, and coontail.
- Monocot species such as elodea, several narrow leaf pondweeds, and naiads are also impacted by fluridone and some 2,4-D use.
- Fewer natives are affected at lower dosages. (WDNR, 2011)

Wisconsin DNR research indicates that larger scale treatments seem to have more consistent reduction from herbicide use than smaller treatments. These results are based upon data collection in many Wisconsin lakes where herbicides were used for EWM control. (Nault, 2015)

Herbicides can dissipate off of a small treatment site very rapidly. 2,4-D dissipated rapidly after treatment after it was applied to 98 small (0.1-10 acre) treatment areas across 22 study lakes with application rates of 2-4 parts per million (ppm). The following results were found:

- Initial 2,4-D concentrations detected in the water column were well below application targets.
- Herbicide moved quickly away from treatment sites within a few hours after treatment.
- The rapid dissipation of herbicide indicates that the concentrations in target areas may be lower than what is needed for effective EWM control. (Nault, 2012)

Florpyrauxifen-benzyl (ProcellaCOR) has been used since 2017 to control Eurasian water milfoil (EWM). Early results on Cedar Lake in St. Croix County, WI are favorable with good control of EWM. On June 6, 2019 the herbicide ProcellaCOR (Florpyrauxifen-benzyl) was utilized to reduce *Myriophyllum spicatum* (EWM) in two beds totaling 12.2 acres. The frequency of occurrence (FOO) had a significant reduction ($p<0.0001$ from chi square analysis) with an FOO of 59.5% within the treatment bed before treatment to 0% after treatment. There was one significant reduction in native species (*Potamogeton pusillus*) and three significant increases in native species (based upon chi square analysis before and after treatment). (Schieffer, 2019)

CURLY LEAF PONDWEED

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

Early season herbicide treatment:[11]

Studies have demonstrated that curly leaf pondweed can be controlled with Aquathol K (a formulation of endothall) in 50 - 60 degree F water, and treatments of curly leaf this early in its life cycle can prevent turion formation. Since curly leaf pondweed is actively growing at these low water temperatures and many native aquatic plants are yet dormant, this early season treatment selectively targets curly leaf pondweed. To prevent drift of herbicide and allow greater contact time, application in shallow bays is likely to be most effective. Herbicide applied to a narrow band of vegetation along the shoreline is likely to drift, rapidly decrease in concentration, and be rendered ineffective.[12]

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[11] Research in Minnesota on Control of Curly Leaf Pondweed. Minnesota Wendy Crowell, Minnesota Department of Natural Resources. Spring 2002.
[12] Personal communication, Frank Koshere. March 2005.

Table 1. Management Options for Aquatic Plants				
Option	**Permit Needed?**	**How it Works**	**PROS**	**CONS**
No Management	No	Do not actively manage aquatic plants	Minimizing disturbance can protect native species that provide habitat for aquatic fauna, reduce shoreline erosion, may improve water clarity, and may limit spread of invasive species. No financial cost. No system disturbance. No unintended effects of chemicals. Permit not required.	May allow small populations of invasive plants to become larger, and more difficult to control later. Excessive plant growth can hamper navigation and recreational use. May require modification of lake users' behavior and perception.
Mechanical Control	May be required under NR 109	Plants reduced by mechanical means. Wide range of techniques, from manual to highly mechanized.	Flexible control. Can balance habitat and recreational needs.	Must be repeated, often more than once per season. Can suspend sediments and increase turbidity and nutrient release.
Hand pulling/raking	Yes/No	SCUBA divers or snorkelers remove plants by hand or plants are removed with a rake. Works best in soft sediments.	Little to no damage done to the lake or to native plant species. Can be highly selective. Can be done by shoreline property owners without permits within an area <30 feet wide OR where selectively removing exotics.	Very labor intensive. Needs to be carefully monitored. Roots, runners, even fragments of some species, particularly EWM will start new plants, so all of the plant must be removed. Small-scale control only.
Harvesting	Yes	Plants are "mowed" at depths of 2-5 feet. Harvest invasives only if invasive is already present throughout the lake.	Immediate results. EWM removed before it has the opportunity to auto-fragment, which may create more fragments than created by harvesting. Harvested lanes through dense weed beds can increase growth and survival of some fish. Can remove some nutrients from the lake.	Not selective in species removed. Fragments of vegetation can re-root sometimes causing increased invasive species expansion. Can remove some small fish and reptiles from the lake. Initial cost of the harvester is expensive.

Option	Permit Needed?	How it Works	PROS	CONS
Harvesting	Yes	Plants are “mowed” at depths of 2-5 feet. Harvest invasives only if invasive is already present throughout the lake.	Immediate results. EWM removed before it has the opportunity to auto-fragment, which may create more fragments than created by harvesting. Harvested lanes through dense weed beds can increase growth and survival of some fish. Can remove some nutrients from the lake.	Not selective in species removed. Fragments of vegetation can re-root sometimes causing increased invasive species expansion. Can remove some small fish and reptiles from the lake. Initial cost of the harvester is expensive.
Biological Control	Yes	Living organisms (e.g. insects or fungi) eat or infect plants.	Self-sustaining; organism will over-winter, resume eating its host the next year. Lowers density of problem plant to allow the growth of natives.	Effectiveness will vary as control agent’s population fluctuates. Provides moderate control – complete control unlikely. Control response may be slow. Must have enough control agent to be effective.
Weevils on EWM	Yes	Native weevil prefers EWM to other native water-milfoils.	Native to Wisconsin – weevil cannot “escape” and become a problem. Selective control of target species. Longer-term control with limited management.	Need to stock large numbers, even if there are some already present. Need good habitat for overwintering on shore (leaf litter) associated with undeveloped shorelines. Bluegill populations decrease densities through predation.
Pathogens	Yes	Fungal, bacterial, or viral pathogen introduced to target species to induce mortality.	May be species specific. May provide long term control. Few dangers to humans or animals.	Largely experimental; effectiveness and longevity unknown. Possible side effects not understood.
Allelopathy	Yes	Aquatic plants release chemical compounds that inhibit other plants from growing.	May provide long-term, maintenance-free control. Spikerushes (*Eleocharis spp.*) appear to inhibit EWM growth.	Initial transplanting slow and labor-intensive. Spikerushes native to WI, and have not effectively limited EWM growth. Wave action along the shore makes it difficult to establish plants; plants will not grow in deep turbid water.

Option	Permit Needed?	How it Works	PROS	CONS
Native Plantings	Yes	Diverse native plant community established to compete with invasive species.	Native plants provide food and habitat for aquatic fauna. Diverse native community more repellant to invasive species.	Initial transplanting slow and labor-intensive. Nuisance invasive plants may outcompete plantings. Transplants from another lake or nursery may unintentionally introduce invasive species.
Physical Control	Yes	Plants are reduced by altering variables that affect growth, such as water depth or light levels.	Varies by treatment.	Varies by treatment.
Fabrics/Bottom Barriers	Yes	Prevents light from getting to the lake bottom.	Reduces turbidity in soft-substrate areas. Useful for small areas.	Eliminates all plants, including native plants important to a healthy lake ecosystem. May inhibit spawning of some fish, and affects benthic invertebrates. Needs maintenance or will become covered in sediment and be ineffective. Gas accumulation under the blankets can cause them to dislodge from the bottom. Anaerobic environment forms that can release excessive nutrients from the sediment.

Option	Permit Needed?	How it Works	PROS	CONS
Drawdown	Yes, may require an environmental assessment.	Lake water lowered with siphon or water control device; plants killed when sediment dries, compacts, or freezes. Season or duration of drawdown can change effects.	Winter drawdown can be effective at restoration, provided drying and freezing occur. Sediment compaction is possible over winter. Summer drawdown can restore large portions of shoreline and shallow areas as well as provide sediment compaction. Emergent plant species often rebound near shore providing fish and wildlife habitat, sediment stabilization, and increased water quality. Success demonstrated for reducing EWM, variable success for curly leaf pondweed (CLP).	Plants with large seed bank or propagules that survive drawdown may become more abundant upon refilling. May impact attached wetlands and shallow wells near shore. Species growing in deep water (e.g. EWM) that survive might increase, particularly if desirable native species are reduced. Can affect fish, particularly in shallow lakes if oxygen levels drop or if water levels are not restored before spring spawning. Winter drawdown must start in early fall or will kill hibernating reptiles and amphibians. Navigation and use of lake is limited during a drawdown.
Dredging	Yes	Plants are removed along with sediment. Most effective when soft sediments overlay a harder substrate. For extremely impacted systems. Extensive planning required.	Increases the water depth. Removes nutrient rich sediments. Removes soft bottom sediments that may have high oxygen demand.	Severe impact on the lake ecosystem. Increases turbidity and releases nutrients. Exposed sediments may be recolonized by invasive species. Sediment testing may be necessary. Removes benthic organisms. Dredged materials must be disposed of.
Dyes	Yes	Colors the water, reducing light. This reduces plant and algal growth.	Impairs plant growth without increasing turbidity. Usually non-toxic, degrades naturally over a few weeks.	Appropriate for very small waterbodies. Should not be used in a pond or lake having an outflow. Impairs aesthetics. Effects to microscopic organisms unknown.

Option	Permit Needed?	How it Works	PROS	CONS
Non-point source nutrient control	No	Runoff of nutrients from the watershed are reduced (e.g., by controlling construction erosion or reducing fertilizer use) thereby providing fewer nutrients available for growth.	Attempts to correct source of the problem, not treat symptoms. Could improve the water clarity and reduce occurrences of algal blooms. Native plants may be able to better compete with invasive species in low-nutrient conditions.	Results can take years to be evident due to internal recycling of already present lake nutrients. Requires landowner cooperation and regulation. Improved water clarity may increase plant growth.
Chemical Control	Required under NR 107	Granules or liquid chemicals kill plants or cease algal growth. Chemical must be used to label guidelines.	Results usually within 10 days of treatment, but repeat treatments may be needed. Some flexibility for different situations. Some can be selectively applied. Can be used for restoration activities.	Possible toxicity to aquatic animals or humans, especially applicators. Often affect desirable plant species that are important to lake ecology. Treatment set-back requirements from potable water sources and/or drinking water. May cause severe drop in dissolved oxygen.
2, 4-D	Yes	Systemic herbicide selective to broadleaf plants that inhibits cell division in new tissue. Applied as a liquid or granules during early plant growth phase.	Moderately to highly effective, especially on EWM. Monocots, such as pondweeds (e.g. CLP) and many other native species are not affected. Can be used in synergy with endothall for early season CLP and EWM treatments. Can be selective depending on concentration and seasonal timing. Widely used aquatic herbicide.	May cause oxygen depletion after plants die and decompose. May affect native dicots such as water lilies and coontail. Can be used in combination with copper herbicides (used for algae). Toxic to fish.

Option	Permit Needed?	How it Works	PROS	CONS
Endothall (e.g. Aquathol)	Yes	Broad-spectrum, contact herbicide that inhibits protein synthesis. Applied as liquid or as granules.	Especially effective on CLP and also effective on EWM. May be effective in reducing reestablishment of CLP if reapplied several years in a row during early spring. Can be selective depending on concentration and seasonal timing. Can be combined with 2, 4-D for early season CLP and EWM treatments, or with copper compounds. Limited off-site drift.	Affects many native pondweeds. Not as effective in dense plant beds; heavy vegetation requires multiple treatments. Not to be used in water supplies; post-treatment restriction on irrigation. Toxic to aquatic fauna (to varying degrees).
Diquat (e.g. Reward)	Yes	Broad-spectrum, contact herbicide that disrupts cellular functioning. Applied as a liquid, can be combined with copper treatments.	Mostly used for water-milfoil and duckweed. Rapid action. Limited direct toxicity on fish and other animals.	May affect non-target plants, especially native pondweeds, coontail, elodea, and naiads. Toxic to aquatic invertebrates. Must be reapplied several years in a row. Ineffective in muddy or cold water (<50F).
Fluridone (e.g. Sonar or Avast)	Yes; special permit and environmental assessment may be required.	Broad-spectrum, systemic herbicide that inhibits photosynthesis. Must be applied during the early growth stage. Available with a special permit only; chemical applications beyond 150 feet from shore are not allowed under NR 107. Applied at very low concentration at whole lake scale.	Effective on EWM for 1 to 4 years with aggressive follow-up treatments. Some reduction in non-target effects can be achieved by lowering dosage. Slow decomposition of plants may limit decreases in dissolved oxygen. Low toxicity to aquatic animals.	Affects native milfoils, coontail, elodea, and naiads, even at low concentrations. Requires long contact time: 60-90 days. Often decreases water clarity, particularly in shallow eutrophic systems. Demonstrated herbicide resistance in hydrilla subjected to repeat treatments. Unknown effect of repeat whole-lake treatments on lake ecology.

Option	Permit Needed?	How it Works	PROS	CONS
Glyphosphate (e.g. Rodeo)	Yes	Broad-spectrum, systemic herbicide that disrupts enzyme formation and function. Usually used for purple loosestrife stems or cattails. Applied as a liquid spray or painted on.	Effective on floating and emergent plants. Selective if carefully applied to individual plants. Non-toxic to most aquatic animals at recommended dosages. Effective control for 1-5 years.	RoundUp is often illegally substituted for Rodeo; surfactants in RoundUp believed to be toxic to reptiles and amphibians. Human exposure should be limited as well. Cannot be used near potable water intakes. Ineffective in muddy water. No control of submerged plants.
Triclopyr (e.g. Renovate)	Yes	Systemic herbicide selective to broadleaf plants that disrupts enzyme function. Applied as liquid spray.	Effective on many emergent and floating plants. Most effective on dicots, such as purple loosestrife; may be more effective than glyphosate. Control of target plants occur in 3-5 weeks. Low toxicity to aquatic animals. No recreational use restrictions following treatment.	Impacts may occur to some native plants at higher doses (e.g. coontail). May be toxic to sensitive invertebrates at higher concentrations. Retreatment opportunities may be limited due to maximum seasonal rate (2.5 ppm). Sensitive to UV light; sunlight can break herbicide down prematurely.
Copper compounds (e.g. Cutrine Plus)	Yes	Broad-spectrum, systemic herbicide that prevents photosynthesis. Used to control planktonic and filamentous algae. Wisconsin allows small-scale control only.	Reduces algal growth and increases water clarity. No recreational or agricultural restrictions on water use following treatment. Herbicidal action on hydrilla.	Elemental copper accumulates and persists in sediments. Short-term results. Long-term effects of repeat treatments to benthic organisms unknown. Toxic to invertebrates, trout and other fish, depending on the hardness of the water. Clear water may increase plant growth.

Table 2. Aquatic Plant Control Techniques Not Allowed in Wisconsin			
Option	**How it works**	**PROS**	**CONS**
Biological Control			
Carp	Plants are eaten by stocked carp.	Effective at removing aquatic plants. Involves species already present in Madison Lakes.	Illegal to transport or stock carp in Wisconsin. Carp cause re-suspension of sediments, increased water temperature, lower dissolved oxygen levels, and reduction of light penetration. Widespread plant removal deteriorates habitat for other fish and aquatic organisms. Complete alteration of fish assemblage possible. Dislodging of plants such as EWM and CLP can lead to accelerated spreading of the plants.
Crayfish	Plants are eaten by stocked crayfish.	Reduces macrophyte biomass.	Illegal to transport or stock crayfish in Wisconsin. Control not selective and may deteriorate the plant community. Not successful in productive, soft-bottom lakes with many fish predators. Complete alteration of fish assemblage possible.
Mechanical Control			
Cutting (no removal)	Plants are "mowed" with underwater cutter.	Creates open water areas rapidly. Works in water up to 25 feet.	Root system remains for regrowth. Fragments of vegetation can re-root and spread infestation throughout the lake. Nutrient release can cause increased algae and bacteria and be a nuisance to riparian land owners. Not selective in species removed. Small-scale control only.
Rototilling	Sediment is tilled to uproot plants and stems. Works in deep water (17 feet).	Decreases stem density, can affect entire plant. Small-scale control. May provide long-term control.	Creates turbidity. Not selective in species removed. Fragments of vegetation can re-root. Complete elimination of fish habitat. Releases nutrients into the water column. Increased likelihood of invasive species recolonization.
Hyrdroraking	Mechanical rake removes plants from the lake. Works in deep water (14 feet).	Creates open water areas rapidly.	Fragments of vegetation can re-root, and creates turbidity in the lake. Requires plant disposal. May impact the lake fauna. Plants re-grow quickly.

AQUATIC PLANT MONITORING METHODS

POINT INTERCEPT SURVEY

Field Methods

A point intercept method is employed for the aquatic macrophyte sampling. The Wisconsin Department of Natural Resources (Wisconsin DNR) generates the sampling point grids for each lake. All points are initially sampled for maximum depth of plant growth only. Once the data was established, only points at that depth (or less) are sampled. If no plants are found at a sample point, one point beyond that depth is sampled. In areas such as bays that appear to be under-sampled, a boat or shoreline survey is conducted to record plants that may have otherwise been missed. The process involves surveying that area for plants and recording the species viewed and/or sampled as well as habitat type. These data are not used in the statistical analysis nor is the density recorded. Only plants sampled at predetermined points are used in the statistical analysis. Any plant within 6 feet of the boat are recorded as "viewed". A handheld Global Positioning System (GPS) is used to locate the sampling points in the field. The Wisconsin DNR guidelines for point location accuracy are followed. The accuracy depends upon the GPS device used.

The sample grid are generally surveyed twice. The first survey occurs in June to mostly survey for the invasive species *Potamogeton crispus* (curly-leaf pondweed). This plant grows early and has typically senesced when the late-season survey is conducted (late July and early August) and most aquatic plants are actively growing.

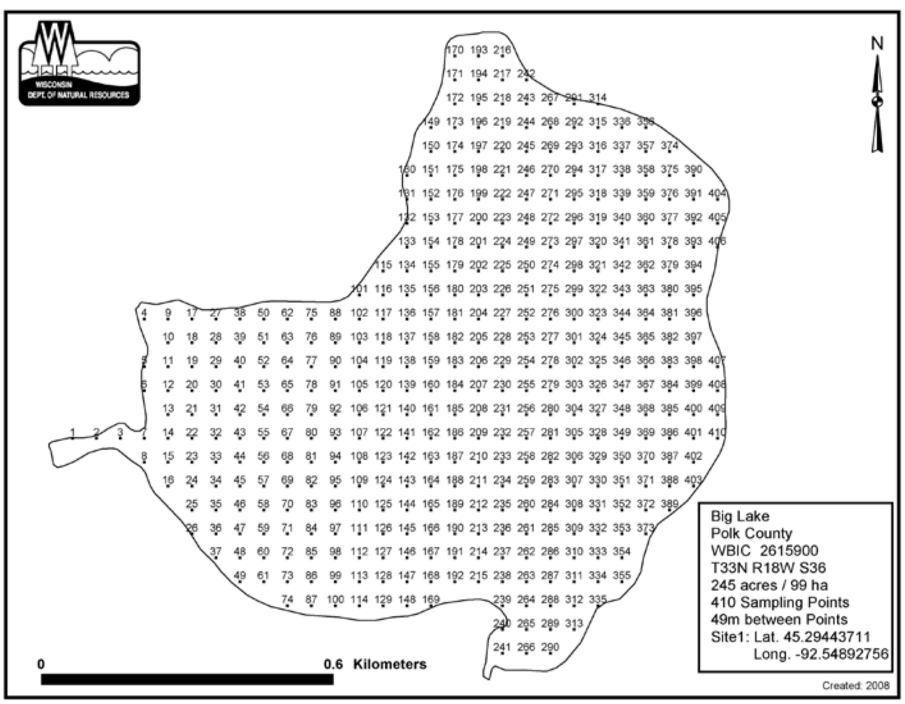

Figure 1. Example point intercept sample grid for Big Lake, Polk County

At each sample location, a double-sided fourteen-tine rake is used to rake a 1-meter tow off the bow of the boat. All plants present on the rake, and those that fall off the rake, are identified and rated for rake fullness. The rake fullness value is used based on the criteria contained in Figure 2 and Table 1 below. Plants within 6 feet of the boat are recorded as “viewed”, but no rake fullness rating is given. Any under-surveyed areas, such as bays and/or areas with unique habitats, are monitored. These areas are referred to as a “boat survey or shoreline survey.”

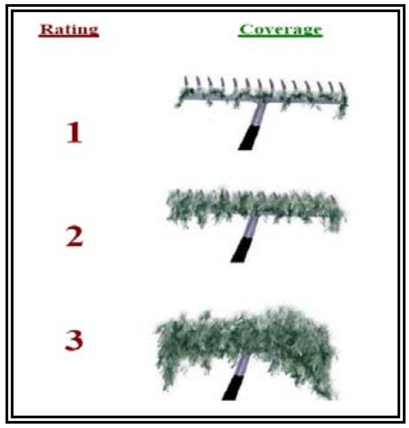

Figure 2. Rake fullness diagram

Table 1. Rake fullness criteria descriptions.

Rake fullness rating	Criteria for rake fullness rating
1	Plant present occupies less than ½ of tine space
2	Plant present occupies more than ½ tine space
3	Plant present occupies all or more than tine space
v	Plant not sampled but observed within 6 feet of boat

The depth and predominant sediment types are also recorded for each sample point. Since discerning between muck and sand with a rope rake is difficult, especially in deeper water, caution is used in determining the sediment type data. All plants needing verification are bagged and cooled for later examination. Two specimens of each plant species requiring verification are mounted, pressed for a voucher collection, and one is submitted to a University of Wisconsin herbarium for review. On rare occasions, a single plant sampled may be needed for verification, used as a voucher specimen, and therefore missing from the pressed voucher collection.

Data analysis methods

Data collected and analyzed resulting in the following information:

- Frequency of occurrence (FOO) in sample points with vegetation (littoral zone)
- Relative frequency
- Total points in sample grid
- Total points sampled
- Sample points with vegetation
- Simpson's diversity index
- Maximum plant depth
- Species richness
- Floristic Quality Index

An explanation of each of these data is provided below.

Frequency of occurrence for each species - Frequency is expressed as a percentage by dividing the number of sites the plant is sampled by the total number of sites, which calculates two possible values. Frequency of occurrence at vegetated sample points is the number of sites with that plant divided by the total number of points with vegetation. The frequency of occurrence in the littoral zone is the number of sites with that plant divided by the number of sampled points that have a depth less than the deepest depth with plants. The littoral zone frequency shows how often the plant would be present in the defined littoral zone (by depth), while the vegetated frequency shows the frequency of the plant in vegetated areas only. In either case, the greater this value, the more frequent the plant is present in the lake. When comparing frequency in the littoral zone, plant frequency is observed at maximum depth. This frequency value is used to analyze the occurrence and location of plant growth based on depth. The frequency of occurrence is usually reported using sample points where vegetation was present.

Frequency of occurrence example:

Plant A sampled at 35 of 150 littoral points = 35/150 = 0.23 = 23%

Plant A's frequency of occurrence = 23% considering littoral zone depths.

Plant A sampled at 12 of 40 vegetated points = 12/40 = 0.3 = 30%

These two frequencies will show how common the plant was sampled in the littoral zone or how common the plant was sampled at points where plants grow. Generally, the second will have a higher frequency since that is where plants are growing as opposed to where they could grow. This analysis will consider vegetated sites for frequency of occurrence (FOO) in most cases.

Relative frequency - This value shows a percentage of the frequency of a particular plant relative to other plants which is not dependent on the number of points sampled. The relative frequency of all plants totals 100%. If plant A had a relative frequency of 30%, it occurred 30% of the time or accounts for 30% of all plants sampled. This value demonstrates which plants are the dominant species in the lake. The higher the relative frequency, the more frequent the plant in comparison to the other plants.

Relative frequency example:

Suppose 10 points were sampled in a small lake with the following results:

	Frequency sampled
Plant A present at 3 sites	3 of 10 sites
Plant B present at 5 sites	5 of 10 sites
Plant C present at 2 sites	2 of 10 sites
Plant D present at 6 sites	6 of 10 sites

Results show Plant D is the most frequent sampled plant at all points with 60% (6/10) of the sites having Plant D. However, the relative frequency displays what the frequency is in comparing the other plants without considering the number of sites. Relative frequency is calculated by dividing the number of times a plant is sampled by the total of all plants sampled. If all frequencies are added (3+5+2+6), the sum is 16. In this case, the relative frequency is calculated by dividing the individual frequencies by 16.

Plant A = 3/16 = 0.1875 or 18.75%

Plant B = 5/16 = 0.3125 or 31.25%

Plant C = 2/16 = 0.125 or 12.5%

Plant D = 6/16 = 0.375 or 37.5%

In comparing plants, Plant D is still the most frequent, but the relative frequency tells us, of all plants sampled at those 10 sites, 37.5% of them are Plant D. This is much lower than the frequency of occurrence (60%). Although Plant D was sampled at 6 of 10 sites, many other plants were also sampled thereby giving a lower frequency when compared to those other plants. This shows the true value of the dominant plants present.

Total points in sample grid - The Wisconsin DNR establishes a sample point grid that covers the entire lake. Each GPS coordinate is mapped and used to locate the points.

Sample sites less than the maximum depth of plants - The maximum depth at which a plant is sampled is recorded which defines the depth plants can grow (littoral zone). Any sample point, with a depth less than or equal to this depth, is recorded as a sample point less than the maximum depth of plants. This depth is used to determine the potential littoral zone.

Sample sites with vegetation - The number of sites where plants were sampled which gives a projection of plant coverage on the lake. Vegetation in 10% of all sample points implies about 10% coverage of plants in the whole lake assuming an adequate number of sample points have been established. The littoral zone is observed for the number of sample sites with vegetation. If 10% of the littoral zone had sample points with vegetation, then the estimated plant coverage in the littoral zone is 10%.

Simpson's diversity index - Simpson's diversity index is used to measure the diversity of the plant community. This value can run from 0 to 1.0. The greater the index value, the more diverse the plant community. In theory, the value is the chance that two species sampled are different. An index of "1" indicates that the two will always be different (diverse) and a "0" indicates that the species will never be different (only one found). The higher the diversity in the native plant community, the healthier the lake ecosystem.

Simpson's diversity example:

If a lake were sampled and observed just one plant, the Simpson's diversity would be "0" because if two plants were randomly sampled, there would be a 0% chance of them being different since they would have to be the same species.

If every plant sampled was different, then the Simpson's diversity would be "1", because if two plants were randomly sampled, there is a 100% chance they would be different since every plant is different.

These are extreme and theoretical scenarios, but they demonstrate how this index works. The greater the Simpson's index for a lake, the more likelihood that two plants sampled are different.

Maximum depth of plants - This depth indicates the greatest depth that plants were sampled. Generally, clear lakes have a greater depth of plants, while lower water clarity limits light penetration and reduces the depth at which plants are found.

Species richness - The number of different individual species found in the lake. There is a value for the species richness of plants sampled and another value that documents plants viewed, but not sampled, during the survey.

Floristic Quality Index - The Floristic Quality Index (FQI) is an index developed by Dr. Stanley Nichols of the University of Wisconsin-Extension. The FQI is a measure of the plant community in response to development (and human influence) on the lake which considers the species of aquatic plants sampled and their tolerance for changing water and habitat quality. The index uses a conservatism value assigned to various plants ranging from 1 to 10. A higher conservatism value indicates that a plant is intolerant, while a lower value indicates tolerance. Those plants with higher values are more apt to respond adversely to water quality and habitat changes largely due to human influence (Nichols, 1999). The FQI is calculated using the number of species and the average conservatism value of all species used in the index.

The formula is: FQI = Mean C ·√N

Where C is the conservatism value and N is the number of species (sampled on rake only).

Therefore, a higher FQI indicates a healthier aquatic plant community which is an indication of better plant habitat. This value is compared to the median for other lakes in the assigned eco-region. There are four eco-regions used throughout Wisconsin: Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area, and Southeastern Wisconsin Till Plain.

Summary of Northern Central Hardwood Forests Median Values for Floristic Quality Index:

(Nichols, 1999)

Northern Central Hardwood Forests

Median species richness	14
Median conservatism	5.6
Median Floristic Quality	20.9

*Floristic Quality has a significant correlation with area of lake (+), alkalinity (-),

conductivity (-), pH (-) and Secchi depth (+). In a positive correlation as that value rises, so will FQI; while with a negative correlation as a value rises, the FQI will decrease.

PRE AND POST HERBICIDE TREATMENT MONITORING

AQUATIC INVASIVE SPECIES INFORMATION

CURLY LEAF PONDWEED

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

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

> It is widely distributed throughout Wisconsin lakes, but the actual number of waters infested is not known. Curly-leaf pondweed is native to northern Europe and Asia where it is especially well adapted to surviving in low temperature waters. It can actively grow under the ice while most plants are dormant, giving it a competitive advantage over native aquatic plant species. By June, curly-leaf pondweed can form dense surface mats that interfere with aquatic recreation. By mid-summer, when other aquatic plants are just reaching their peak growth for the year, it dies off. Curly-leaf pondweed provides habitat for fish and invertebrates in the winter and spring when most other plants are reduced to rhizomes and buds, but the mid-summer decay creates a sudden loss of habitat. The die-off of curly-leaf pondweed also releases a surge of nutrients into the water column that can trigger algal blooms and create turbid water conditions. In lakes where curly-leaf pondweed is the dominant plant, the summer die-off can lead to habitat disturbance and degraded water quality. In other waters where there is a diversity of aquatic plants, the breakdown of curly-leaf may not cause a problem.[13]

The state of Minnesota DNR web site explains that curly leaf pondweed often causes problems due to excessive growth. At the same time, the plant provides some cover for fish, and some waterfowl species feed on the seeds and winter buds.[14]

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[13] *Wisconsin's Comprehensive Management Plan to Prevent Further Introductions and Control Existing Populations of Aquatic Invasive Species*. Prepared by Wisconsin DNR. September 2003.

[14] Information from Minnesota DNR (www.dnr.state.mn.us/aquatic_plants).

The following description is taken from a Great Lakes Indian Fish and Wildlife Commission handout. [15]

IDENTIFICATION

Curly leaf pondweed is an invasive aquatic species found in a variety of aquatic habitats, including permanently flooded ditches and pools, rivers, ponds, inland lakes, and even the Great Lakes. Curly leaf pondweed prefers alkaline or high nutrient waters one to three meters deep. Its leaves are strap-shaped with rounded tips and undulating and finely toothed edges. Leaves are not modified for floating, and are generally alternate on the stem. Stems are somewhat flattened and grow to as long as two meters. The stems are dark reddish-green to reddish-brown, with the mid-vein typically tinged with red. Curly leaf pondweed is native to Eurasia, Africa, and Australia and is now spread throughout most of the United States and southern Canada.

CHARACTERISTICS

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

REPRODUCTION AND DISPERSAL

Curly leaf pondweed reproduces primarily vegetatively. Numerous turions are produced in the spring. These turions consist of modified, hardened, thorny leaf bases interspersed with a few to several dormant buds. The turions are typically 1.0 to1.7 cm long and 0.8 to 1.4 cm in diameter. Turions separate from the plant by midsummer and may be carried in the water column supported by several leaves. Humans and waterfowl may also disperse turions. Stimulated by cooler water temperatures, turions germinate in the fall, over-wintering as a small plant. The next summer plants mature producing reproductive tips of their own. Curly leaf pondweed rarely produces flowers.

ECOLOGICAL IMPACTS

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

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

[15] Information from GLIFWC Plant Information Center (http://www.glifwc.org/epicenter).

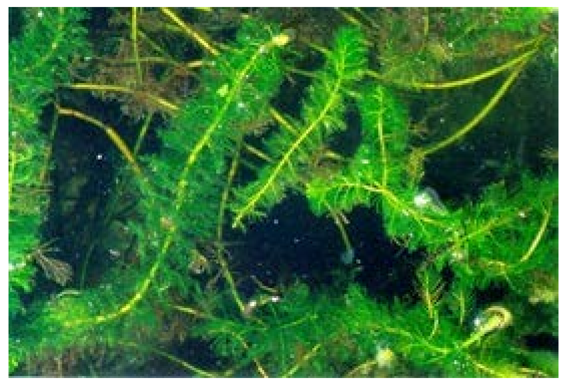
CONTROL

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

Control of large populations requires a long-term commitment that may not be successful. A prudent strategy includes a multi-year effort aimed at killing the plant before it produces turions, thereby depleting the seed bank over time. It is also important to maintain, and perhaps augment, native populations to retard the spread of curly leaf and other invasive plants. Invasive plants may aggressively infest disturbed areas of the lake, such as those where native plant nuisances have been controlled through chemical applications.

EURASIAN WATER MILFOIL (MYRIOPHYLLUM SPICATUM)

INTRODUCTION



Eurasian water milfoil is a submersed aquatic plant native to Europe, Asia, and northern Africa. It is the only non-native milfoil in Wisconsin. Like the native milfoils, the Eurasian variety has slender stems whorled by submersed feathery leaves and tiny flowers produced above the water surface. The flowers are located in the axils of the floral bracts, and are either four-petaled or without petals. The leaves are threadlike, typically uniform in diameter, and aggregated into a submersed terminal spike. The stem thickens below the inflorescence and doubles its width further down, often curving to lie parallel with the water surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits, Eurasian water milfoil is nearly impossible to distinguish from Northern water milfoil. Eurasian water milfoil has 9-21 pairs of leaflets per leaf, while Northern milfoil typically has 7-11 pairs of leaflets. Coontail is often mistaken for the milfoils, but does not have individual leaflets.

DISTRIBUTION AND HABITAT

Eurasian milfoil first arrived in Wisconsin in the 1960s. During the 1980s, it began to move from several counties in southern Wisconsin to lakes and waterways in the northern half of the state. As of 1993, Eurasian milfoil was common in 39 Wisconsin counties (54%) and at least 75 of its lakes, including shallow bays in Lakes Michigan and Superior and Mississippi River pools.

Eurasian water milfoil grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen and phosphorous-laden runoff, and heavily used lakes. Optimal growth occurs in alkaline systems with a high concentration of dissolved inorganic carbon. High water temperatures promote multiple periods of flowering and fragmentation.

LIFE HISTORY AND EFFECTS OF INVASION

Unlike many other plants, Eurasian water milfoil does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces vegetatively by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. Milfoil is readily dispersed by boats, motors, trailers, bilges, live wells, or bait buckets, and can stay alive for weeks if kept moist.

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, Eurasian water milfoil is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of Eurasian milfoil provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish, and reducing the number of nutrient-rich native plants available for waterfowl.

Dense stands of Eurasian water milfoil also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by Eurasian water milfoil may lead to deteriorating water quality and algae blooms of infested lakes. [16]

[16] Taken in its entirety from WDNR, 2008 http://www.dnr.state.wi.us/invasives/fact/milfoil.htm

REED CANARY GRASS (*PHALARIS ARUNDINACEA*)

DESCRIPTION

Reed canary grass is a large, coarse grass that reaches 2 to 9 feet in height. It has an erect, hairless stem with gradually tapering leaf blades 3 1/2 to 10 inches long and 1/4 to 3/4 inch in width. Blades are flat and have a rough texture on both surfaces. The lead ligule is membranous and long. The compact panicles are erect or slightly spreading (depending on the plant's reproductive stage), and range from 3 to 16 inches long with branches 2 to 12 inches in length. Single flowers occur in dense clusters in May to mid-June. They are green to purple at first and change to beige over time. This grass is one of the first to sprout in spring, and forms a thick rhizome system that dominates the subsurface soil. Seeds are shiny brown in color.

Both Eurasian and native ecotypes of reed canary grass are thought to exist in the U.S. The Eurasian variety is considered more aggressive, but no reliable method exists to tell the ecotypes apart. It is believed that the vast majority of our reed canary grass is derived from the Eurasian ecotype. Agricultural cultivars of the grass are widely planted.

Reed canary grass also resembles non-native orchard grass (*Dactylis glomerata*) but can be distinguished by its wider blades, narrower, more pointed inflorescence, and the lack of hairs on glumes and lemmas (the spikelet scales). Additionally, bluejoint grass (*Calamagrostis canadensis*) may be mistaken for reed canary in areas where orchard grass is rare, especially in the spring. The highly transparent ligule on reed canary grass is helpful in distinguishing it from the others. Ensure positive identification before attempting control. The ligule is a transparent membrane found at the intersection of the leaf stem and leaf.

DISTRIBUTION AND HABITAT

Reed canary grass is a cool-season, sod-forming, perennial wetland grass native to temperate regions of Europe, Asia, and North America. The Eurasian ecotype has been selected for its vigor and has been planted throughout the U.S. since the 1800s for forage and erosion control. It has become naturalized in much of the northern half of the U.S. and is still being planted on steep slopes and banks of ponds and created wetlands.

Reed canary grass can grow on dry soils in upland habitats and in the partial shade of oak woodlands, but does best on fertile, moist organic soils in full sun. This species can invade most types of wetlands, including marshes, wet prairies, sedge meadows, fens, stream banks, and seasonally wet areas; it also grows in disturbed areas.

LIFE HISTORY AND EFFECTS OF INVASION

Reed canary grass reproduces by seed or creeping rhizomes. It spreads aggressively. The plant produces leaves and flower stalks for 5 to 7 weeks after germination in early spring, then spreads laterally. Growth peaks in mid-June and declines in mid-July. A second growth spurt occurs in the fall. The shoots collapse in mid to late summer, forming a dense, impenetrable mat of stems and leaves. The seeds ripen in late June and shatter when ripe. Seeds may be dispersed from one wetland to another by waterways, animals, humans, or machines.

This species prefers disturbed areas but can easily move into native wetlands. Reed canary grass can invade a disturbed wetland in less than twelve years. Invasion is associated with disturbances including ditching of wetlands, stream channelization, deforestation of swamp forests, sedimentation, and intentional planting. The difficulty of selective control makes reed canary grass invasion of particular concern. Over time, it forms large, monotypic stands that harbor few other plant species and are subsequently of little use to wildlife. Once established, reed canary grass dominates an area by building up a tremendous seed bank that can eventually erupt, germinate, and recolonize treated sites.[17]

PURPLE LOOSESTRIFE (*LYTHRUM SALICARIA*)[18]

DESCRIPTION

Purple loosestrife is a non-native plant common in Wisconsin. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

Purple loosestrife is a perennial herb 3 to 7 feet tall with a dense bushy growth of 1 to 50 stems. The stems, which range from green to purple, die back each year. Showy flowers vary from purple to magenta, possess 5 to 6 petals aggregated into numerous long spikes, and bloom from July to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes (underground stems) that form a dense mat.

CHARACTERISTICS

Purple loosestrife is a wetland herb that was introduced as a garden perennial from Europe during the 1800's. It is still promoted by some horticulturists for its beauty as a landscape plant, and by beekeepers for its nectar-producing capability. Currently, about 24 states have laws prohibiting its importation or distribution because of its aggressively invasive characteristics. It has since extended its range to include most temperate parts of the United States and Canada. The plant's reproductive success across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America.

17 Taken from WDNR, 2008 http://www.dnr.state.wi.us/invasives/fact/reed_canary.htm
18 Wisconsin DNR invasive species factsheets from http:/dnr.wi.gov/invasives.

REPRODUCTION AND DISPERSAL

Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60 to 70%, resulting in an extensive seed bank. Most of the seeds fall near the parent plant, but water, animals, boats, and humans can transport the seeds long distances. Vegetative spread through local disturbance is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. Vegetative disturbances, such as water drawdown or exposed soil, accelerate the process by providing ideal conditions for seed germination. When the right disturbance occurs, loosestrife can spread rapidly, eventually taking over the entire wetland.

ECOLOGICAL IMPACTS

Purple loosestrife displaces native wetland vegetation and degrades wildlife habitat. As native vegetation is displaced, rare plants are often the first species to disappear. Eventually, purple loosestrife can overrun wetlands thousands of acres in size and almost entirely eliminate the open water habitat. The plant can also be detrimental to recreation by choking waterways.

MECHANICAL CONTROL

Purple loosestrife (PL) can be controlled by cutting, pulling, digging, and drowning. Cutting is best done just before plants begin flowering. Cutting too early encourages more flower stems to grow than before. If done too late, seed may have already fallen. Since lower pods can drop seed while upper flowers are still blooming, check for seed. If none, simply bag all cuttings (to prevent them from rooting). If there is seed, cut off each top while carefully holding it upright, then bend it over into a bag to catch any dropping seeds. Dispose of plants/seeds in a capped landfill, or dry and burn them. Composting will not kill the seeds. Keep clothing and equipment seed-free to prevent its spread. Rinse all equipment used in infested areas before moving into uninfested areas, including boats, trailers, clothing, and footwear.

Pulling and digging can be effective but can also create disturbed bare spots, which are good sites for PL seeds to germinate or leave behind root fragments that grow into new plants. Use these methods primarily with small plants in loose soils, since they do not usually leave behind large gaps nor root tips, while large plants with multiple stems and brittle roots often do. Dispose of plants as described above.

Mowing has not been effective with loosestrife unless the plants can be mowed to a height where the remaining stems will be covered with water for a full twelve months. Burning has also proven largely ineffective. Mowing and flooding are not encouraged because they can contribute to further dispersal of the species by disseminating seeds and stems.

Follow-up treatments are recommended for at least three years after removal.

CHEMICAL CONTROL

Chemical control is usually the best way to eliminate PL quickly, especially with mature plants. The chemicals used have a short soil life. Timing is important. Treat in late July or August but before flowering to prevent seed set. Always back away from sprayed areas as you go to prevent getting herbicide on your clothes. The best method is to cut stems and paint the stump tops with herbicide. The herbicide can be applied with a small drip bottle or spray bottle, which can be adjusted to release only a small amount. Try to cover the entire cut portion of the stem but not let the herbicide drip onto other plants since it is non-selective and can kill any plant it touches.

Glyphosate herbicides: Currently, glyphosate is the most commonly used chemical for killing loosestrife. Roundup and Glyfos are typically used, but if there is any open water in the area use Rodeo, a glyphosate formulated and listed for use over water. Glyphosate must be applied in late July or August to be most effective. Since you must treat at least some stems of each plant and they often grow together in a clump, all stems in the clump should be treated to be sure all plants are treated.

Another method is using very carefully targeted foliar applications of herbicide (NOT broadcast spraying). This may reduce costs for sites with very high densities of PL, since the work should be easier, and there will be few other plant species to hit accidentally. Use a glyphosate formulated for use over water. A weak solution of around 1% active ingredient can be used, and it is generally necessary to wet only 25% of the foliage to kill the plant.

You must obtain a permit from WDNR before applying any herbicide over water. The process has been streamlined for control of purple loosestrife, and there is no cost. Contact your regional Aquatic Plant Management Coordinator for permit information.

BIOLOGICAL CONTROL

Conventional control methods like hand pulling, cutting, flooding, herbicides, and plant competition have only been moderately effective in controlling purple loosestrife. Biocontrol is now considered the most viable option for more complete control for heavy infestations. The WDNR, in cooperation with the U.S. Fish and Wildlife Service, is introducing several natural insect enemies of purple loosestrife from Europe. A species of weevil (*Hylobius transversovittatus*) has been identified that lays eggs in the stem and upper root system of the plant; as larvae develop, they feed on root tissue. In addition, two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) are being raised and released in the state, and another weevil that feeds on flowers (*Nanophyes marmoratu*s) is being used to stress the plant in multiple ways. Research has shown that most of these insects are almost exclusively dependent upon purple loosestrife and do not threaten native plants, although one species showed some cross-over to native loosestrife. These insects will not eradicate loosestrife, but may significantly reduce the population so cohabitation with native species becomes a possibility.

ZEBRA MUSSELS *(Dreissena polymorpha)*

The zebra mussel is a tiny (1/8-inch to 2-inch) bottom-dwelling clam native to Europe and Asia. Zebra mussels were introduced into the Great Lakes in 1985 or 1986 and have been spreading throughout them since that time. They were most likely brought to North America as larvae in ballast water of ships that traveled from fresh-water Eurasian ports to the Great Lakes. Zebra mussels look like small clams with a yellowish or brownish D-shaped shell, usually with alternating dark- and light-colored stripes. They can be up to two inches long, but most are under an inch. Zebra mussels usually grow in clusters containing numerous individuals.

Zebra mussels were first found in Wisconsin waters of Lake Michigan in 1990. They are now found in a number of inland Wisconsin waters. Zebra mussels are the only freshwater mollusks that can firmly attach themselves to solid objects. They are generally found in shallow (6 to 30 feet deep), algae-rich water.

Zebra mussels feed by drawing water into their bodies and filtering out most of the suspended microscopic plants, animals, and debris for food. This process can lead to increased water clarity and a depleted food supply for fish and other aquatic organisms. The higher light penetration fosters growth of rooted aquatic plants, which although creating more habitat for small fish, may inhibit the larger, predatory fish from finding their food. This thicker plant growth can also interfere with boaters, anglers, and swimmers. Zebra mussel infestations may also promote the growth of blue-green algae, since zebra mussels avoid consuming this type of algae but not others.

Once zebra mussels are established in a water body; very little can be done to control them. It is therefore crucial to take all possible measures to prevent their introduction in the first place. Be sure to follow the Clean Boats, Clean Waters procedure in preventing the spread of aquatic hitchhikers. In addition to these measures, boaters can take specific precautions in protecting their motors from zebra mussels.

No selective method has been developed that succeeds in controlling zebra mussels in the wild without also harming other aquatic organisms. To a certain extent, ducks and fish will eat small zebra mussels, but not to the point of effectively controlling their populations. As of yet, no practical and effective controls are known, again emphasizing the need for research and prevention.

GIANT KNOTWEED (*POLYGONUM SACHALINENSE)*

Giant knotweed is a perennial that can reach up to 20 feet tall with erect, hollow stems that resemble bamboo. Plants die back each year; the dried stalks remain standing into winter. Stems are smooth and arching with swollen nodes and twigs that zigzag from node to node.

ECOLOGICAL THREAT

Invades riparian areas where it prevents streamside tree regeneration

- Increases soils erosion along streambanks
- Often found in floodplain forests, disturbed areas, roadsides, and vacant lots
- Plants forms dense stands that crowd and shade out native vegetation
- Plants alter soil chemistry and may be allelopathic (exude chemical compounds toxic to native vegetation)
- Plant fragments as small as one inch have the potential to resprout
- Japanese and giant knotweed are known to hybridize

Giant Knotweed is a prohibited species in Wisconsin.

DESCRIPTION

Leaves: Alternate, simple, dark green. Leaves are 6 to 14 inches long and have a heart-shaped base coming narrow to a point.

Flowers: Numerous small, greenish-white flowers appear in the leaf axils of the upper stems. Blooms are up to 4 inches long and occur during August to October. Giant knotweed blooms have both male and female parts in the same flower.

Fruits & seeds: Fruits are papery and broadly winged. Each fruit contains a 3-sided achene that is small, shiny, and brown. Small amounts of seed are viable and have no dormancy requirement.

Roots: Rhizomes that extend deeply into the soil creating a dense impenetrable mat.

Similar species: Japanese knotweed (*P. cuspidatum*) and Bohemian (hybrid) knotweed (*P. cuspidatum x P. sachalinense*) look very similar but can be distinguished by the type of hair on the veins on the undersides. Each species are equally as invasive. Japanese knotweed leaves are abruptly squared at base, and the flowers are dioecious. It has hollow stems with distinct raised nodes that give it the appearance of bamboo, though it is not related. Young plants are most commonly mistaken for rhubarb.

CONTROL

Mechanical Control: Hand pull, mow, or cut plants. Repeated cutting is needed to stimulate regrowth and exhaust root reserves. Digging up plants is difficult, because roots can extend so deeply into the soil. Discard plant debris cautiously as this plant aggressively reproduces vegetatively.

Chemical Control: Treat plants in the summer when there is a large amount of leaf surface to absorb and translocate systemic herbicides. Plants are more susceptible to herbicides if they are cut when 4 to 5 feet tall and the regrowth treated is around 3 feet tall. Foliar spray with 0.15% a.i. aminopyralid, 0.3 % a.i. Imazapyr, or either 2% a.i. glyphosate or triclopyr. Cut-stump treatment with 25% a.i. glyphosate or triclopyr.

APPENDIX A. WEB RESOURCES AIS IDENTIFICATION

AIS Identification Fact Sheets

https://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/programs/CLMN/AISfactsheets/AISfactsheetsALL.pdf

Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) Website

https://www.glerl.noaa.gov/glansis/

Wisconsin Lakes and AIS Viewer

https://dnr.wi.gov/lakes/viewer/

Minnesota Aquatic Invasive Species Research Center (MAISRC) Website

https://www.maisrc.umn.edu/

River Alliance of Wisconsin

https://www.wisconsinrivers.org/homepage/aquatic-invasive-species/

AIS Smart Prevention Tool

https://uwlimnology.shinyapps.io/AISSmartPrevention2/

U.S. Department of Agriculture AIS Webpage

https://www.invasivespeciesinfo.gov/aquatic-invasives

U.S. Fish and Wildlife Service AIS Webpage

https://www.fws.gov/fisheries/ANS/index.html

U.S. National Park Service AIS Webpage

https://www.nps.gov/subjects/invasive/aquatic-invasive-species.htm

UW-Extension Lakes AIS Monitoring

https://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/clmn/AIS.aspx

WDNR AIS Website

https://dnr.wi.gov/topic/Invasives/species.asp?filterBy=Aquatic&filterVal=Y

Wisconsin Sea Grant

https://www.seagrant.wisc.edu/our-work/focus-areas/ais/

APPENDIX B. ADDITIONAL WEB RESOURCES

Aquatic Plant Management in Wisconsin

https://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/Aquatic%20Plants/APMguideFull2010.pdf

Citizen Lake Monitoring Network (CLMN)

https://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/clmn/default.aspx

Clean Boats, Clean Waters (CBCW)

https://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/cbcw/default.aspx

Strategic Analysis of Aquatic Plant Management in Wisconsin

https://dnr.wi.gov/topic/EIA/documents/APMSA/APMSA_Final_2019-06-14.pdf

WDNR Aquatic Plant Management

https://dnr.wi.gov/lakes/plants/

WDNR Fish Stocking Database

https://infotrek.er.usgs.gov/doc/wdnr_biology/Public_Stocking/StateMapHotspotsAllYears.htm

WDNR Surface Water Grants Page

https://dnr.wi.gov/aid/surfacewater.html

Wisconsin Administrate Code

https://docs.legis.wisconsin.gov/code/admin_code/nr/100