Aquatic Plant Management Plan

For

Sandstone Flowage

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Sandstone Flowage Aquatic Plant Management Plan

Sandstone Flowage is a 153-acre impoundment on the Peshtigo River. The flowage is located 2.5 miles west of Crivitz in Marinette County, Wisconsin (figure 1).

The shoreline of Sandstone Flowage is heavily developed with many permanent and seasonal dwellings. One resort, and one private campground can also be found on the flowage. Public access is available at a boat landing on Hideaway Lane, a walk-in access at Sandstone Dam, and at several access points in the Peshtigo River State Forest immediately upstream from the flowage.

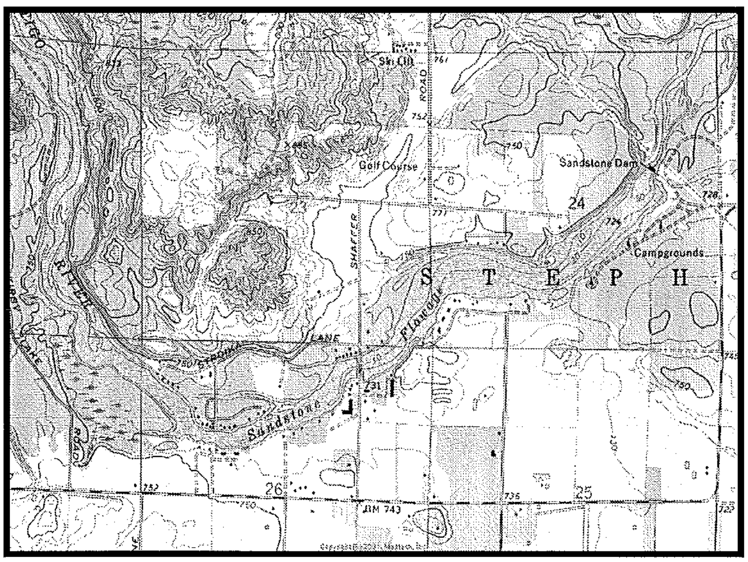


Figure 1. Sandstone Flowage

The purpose of this report is to develop a sustainable plan for the long-term management of aquatic plants in Sandstone Flowage with an emphasis on the control of Eurasian watermilfoil (*Myriophyllum spicatum*), an invasive exotic species, and wild celery (*Vallisneria americana*), a native plant that grows to nuisance levels in Sandstone Flowage.

Sandstone Flowage Landowners Association

The Sandstone Flowage Association formed in 2002 to preserve and protect Sandstone Flowage and to address the issue of excessive aquatic plant growth. Membership in the Association is voluntary and is open to all landowners within one mile of Sandstone Flowage. Association membership is currently 117 members representing 72 waterfront and 6 non-waterfront properties.

Physical & Chemical Characteristics of Sandstone Flowage

Sandstone flowage is formed by The Sandstone Rapids Dam, owned and operated by the Wisconsin Public Service Corporation (WPS). The dam is used for electricity generation and maintains a head of 42 feet. The dam is operated in run-of-the-river mode per Federal Energy Regulatory Commission (FERC) license. Run-of-the-river means that water is passed through the dam at the same rate it enters the flowage, limiting the amount of water level fluctuation in the flowage. The FERC license requires WPS to maintain the water level in Sandstone Flowage between 723.7 feet and 724.2 feet above sea level.

The Peshtigo River has a watershed area of 643 square miles where it enters Sandstone Flowage. According to WPS the average flow through Sandstone Flowage is approximately 615 cubic feet per second (cfs). The Flowage is approximately 2.4 miles long with a maximum width of 850 feet (0.16 miles). According to the Department of Natural Resources (DNR) the Flowage has a maximum depth of 39 feet and holds 2,230 acre-feet of water.

Using this data the flushing rate of Sandstone Flowage can be calculated. Flushing rate, or retention time, is amount of time it takes incoming water to replace the entire volume of a lake. Flushing rate is important because it impacts nutrient dynamics (how nutrients are stored, flushed, and recycled) within a lake or flowage. While most lakes have a flushing rate measured in years, the calculated flushing rate for Sandstone Flowage is only 1.8 days! That is, under normal conditions it takes less than two days to replace the entire volume of Sandstone Flowage with "new" water from the Peshtigo River.

Reservoirs with a high flushing rate often behave much more like a river than a lake. This usually means high turbidity and increased nutrient levels from runoff. Waters with a high flushing rate also tend to have fewer algae than might otherwise be supported by high nutrient levels.

Water chemistry data for Sandstone Flowage is rather limited. A search of DNR records found a single DNR monitoring event in the summer of 2003 and four sample sets collected during the fall of 1989 and summer of 1990 by WPS as part of their re-licensing process. From this limited data the water quality of Sandstone Flowage appears to be very good with an average total phosphorus concentration of 18 ug/l. This level is well below the average for Wisconsin impoundments (65 ug/l) and reflects the excellent water quality of the Peshtigo River. Without major changes in the upstream drainage area water quality in Sandstone Flowage should continue to remain good.

Sandstone Flowage has moderately hard water. Hardness, or alkalinity, is a measure of the amount of calcium in the water. Lakes and flowages with high alkalinity are better able to resist acidification and typically support a greater variety and increased quantities of aquatic plants.

Overview of the Sandstone Flowage Fish Community

The Wisconsin DNR has conducted fish surveys on Sandstone Flowage several times in the past 30 years including 1977, 1983, 1990 and 2003. The two most recent surveys included both spring fyke netting and summer electrofishing.

Results from the most recent surveys indicate good numbers of northern pike but few large fish in the population. Largemouth bass continue to outnumber smallmouth bass, and the walleye population appears to have fallen significantly since the 1990 survey. The DNR has recommended stocking to supplement the walleye population. The 2003 survey appears to show an excellent bluegill population with good numbers and size structure.

Muskellunge were found in both the 1990 and 2003 fish surveys. In each of the surveys fewer than 5 musky were captured but most of the fish were between 36 and 43 inches. Musky are not stocked in Sandstone but are likely coming from High Falls and Caldron Falls Flowages. Both have naturally reproducing populations and receive stocked fish as well.

A few rainbow trout were also captured in the 2003 survey. Trout likely spend winters in Sandstone Flowage and head up-river into the Peshtigo River fly-fishing area when water temperatures climb in the summer.

Aquatic Plant Community

An aquatic plant survey of Sandstone Flowage was completed in August 2005 using the Wisconsin DNR recommended point intercept sampling protocol. Approximately 500 locations were sampled for plant species, depth, and sediment type. Plant beds were also mapped using GPS and the overall plant density was described. In 2009 the plant community was again evaluated for plant density and mapped using GPS but no point intercept survey was completed. A complete survey report and detailed analysis of the aquatic community can be found in **Aquatic Plant Survey Report and Management Alternatives for Sandstone Flowage** (Druckrey 2006). Aquatic plant frequency data from the 2005 survey can also be found in appendix A.

Common Aquatic Plants

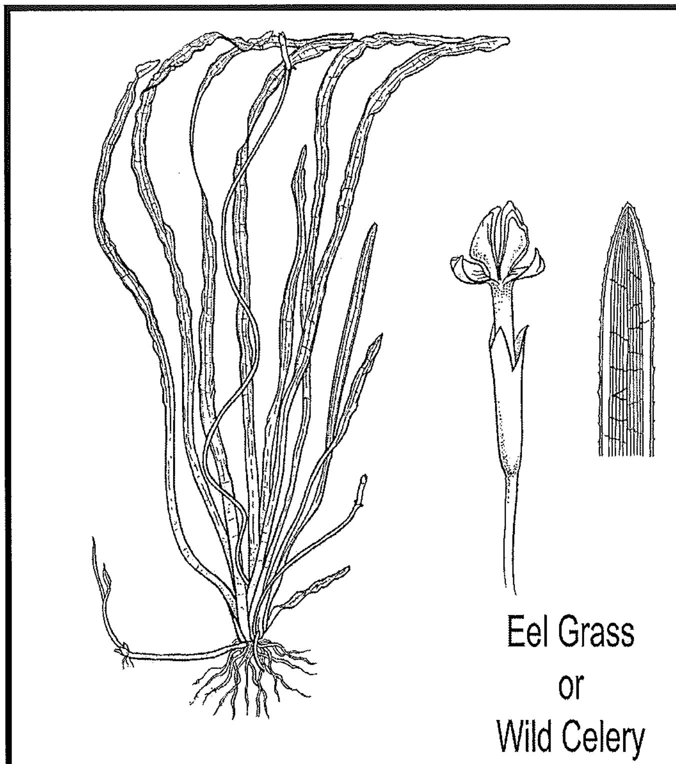
The 2005 aquatic plant survey identified twenty species in Sandstone Flowage. However, the plant population is clearly dominated by a handful of abundant species. The following plants were found at more than 10% of sample locations. Descriptions are taken from Through the Looking Glass A Field Guide to Aquatic Plants (2001).

Wild Celery

Wild celery (*Vallisneria americana*) is a native plant common to lakes and flowages throughout the state. It has long ribbon shaped leaves ¼ to ½ inch wide and up to 7 feet long that emerge from a central rosette on the bottom of the lake. The leaves have a prominent central stripe and a cellophane-like consistency. The leaves are mostly submersed with just their tips trailing on the surface of the water. Late in the summer water celery produces tiny male flowers (1 mm wide) under water that break free and float up to the surface. On Sandstone these floating flowers are so numerous on the surface of the water they are often mistaken for a noxious algae bloom. The white female flowers are found at the end of a long coiled stalk that extends the flower up to the surface. After pollination the female flower is withdrawn below the surface and a long narrow seed capsule develops.

Wild celery prefers hard substrate (sand or firm muck) and is quite tolerant of turbid water. The plant is common in the slow moving water of large river systems.

Wild celery is a perennial plant that spreads by seed and by vegetative means. Vegetative growth occurs primarily by underground rhizomes, which produce "offsets" along their length, some of which can detach and float to new locations. The plant also produces abundant tubers that overwinter in the sediment.



Graphic courtesy of WI Geological & Natural History Survey - Bulletin 96 - 1999

The State of Wisconsin lists wild celery as a "high value species" in NR 107. It is known as an important food source for ducks and geese, which eat the vegetation, rhizomes, tubers, and fruit. The starchy tubers are especially prized and canvasback ducks which are almost completely dependent on them during their migration flights. Due to its importance as food for waterfowl, wild celery is often encouraged to grow and most of the scientific literature focuses on increasing its spread.

In Sandstone Flowage wild celery certainly does not need help or encouragement. It was found growing at nearly 70% of the survey points shallower than 10 feet deep and was dense to moderate in an area covering more than 45 acres. Wild celery showed no clear sediment preference in Sandstone Flowage and was abundant over a large range of depths.

Common water-weed

Graphic courtesy of Wisconsin and Natural History Survey Bulletin 96 1999

Common waterweed
Common waterweed (*Elodea canadensis*) was the next most abundant plant, found growing at 35% of the vegetated sample points. Common waterweed has slender branching stems with small lance shaped leaves attached in whorls of three. Leaves are typically spread out at the bottom of the plant and crowded together near the top. In early summer it produces small white flowers at the surface but very few fruits are ever produced. Like many aquatic plants, common waterweed spreads primarily by stem fragments that settle to the bottom and take root.

Common waterweed prefers soft sediment with lots of organic matter. It is very tolerant of low light conditions and is often one of the most abundant plants in deep water.

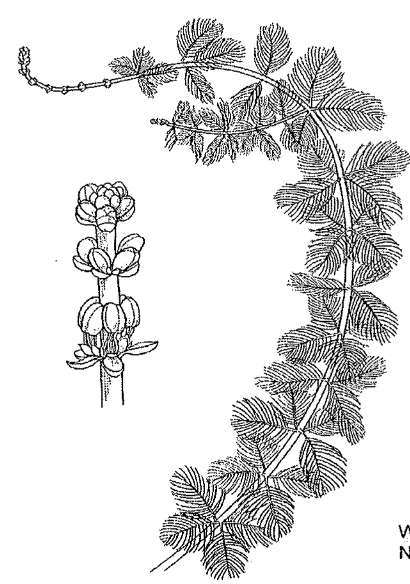
Common waterweed can overwinter green and begin growing again soon after ice out. It is used by waterfowl as a food source and provides general fish habitat. It typically does not grow to the surface in deep water so its nuisance potential is limited to shallow water areas.

Eurasian Water Milfoil (EWM)
Eurasian water milfoil (*Myriophyllum spicatum*), is an invasive exotic species with soft feather-like leaves arranged in groups of four along a thin stem. The plant can grow more than 6 feet long. When the stems reach the surface they branch profusely and spread out to form a canopy that shades the water beneath.

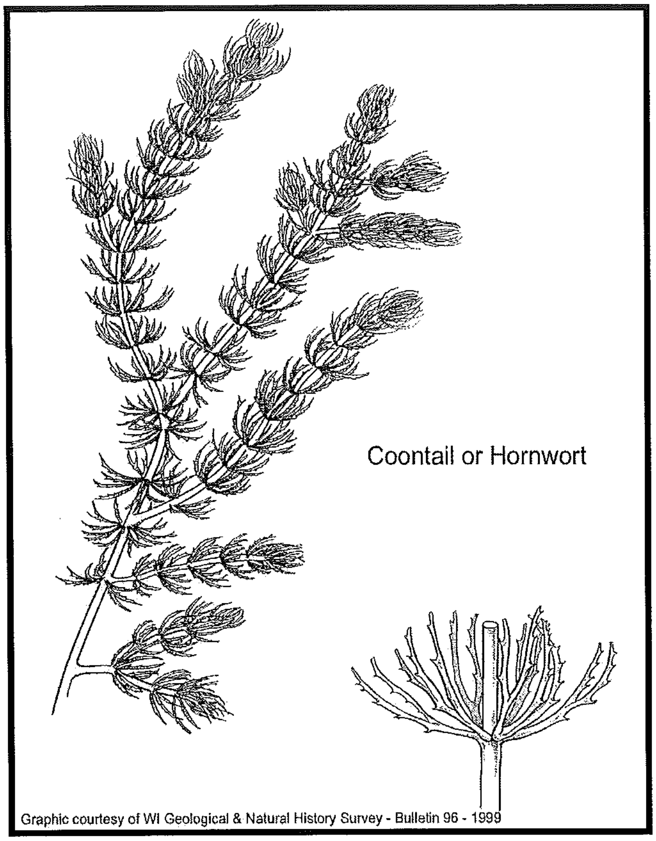
EWM can overwinter green or survive as sprouts on the rootstock. The plant begins rapid growth at a low water temperature and quickly reaches the surface. EWM spreads primarily by fragmentation, a process where even small fragments of the plant separated by boats or wave action drift to a new place and take root. The rapid growth, ease of spread, and its canopy forming habit, allows EWM to out compete many of the slower growing native plants.

While EWM provides some fish and wildlife habitat, studies show that native pondweeds support a higher diversity and greater numbers of beneficial aquatic insects (Engel 1990).

Eurasian water-milfoil



Graphic courtesy of Wisconsin Geologial & Natural History Survey Bulletin 96 1999



EWM was first identified in Sandstone Flowage in 1995. By 2005 it was found at 25% of sample locations. However, the distribution of EWM in the flowage is far from uniform. West of the Shaffer Road Bridge it was found at only 3% of the sites less than 10 feet deep. East of the bridge EWM was found at 45% of sites less than 10 feet deep. EWM was most abundant immediately west of the boat landing on Hideaway Lane in 2 to 5 feet of water where the bottom is primarily muck.

Coontail

Coontail (*Ceratophyllum demersum*) is the most common aquatic plant in Wisconsin. Like milfoil, coontail has long stems with leaves arranged in whorls around the stem. Unlike milfoil the leaves of coontail are very stiff and spiny, and tend to be dense near the ends of the stem, giving them the appearance of a bushy raccoon tail.

Coontail has no true roots but anchors to the sediment by modified stems wherever it touches the bottom. Due to its poor "rooting" ability, coontail prefers soft organic sediment. It rarely produces seed but spreads by fragmentation.

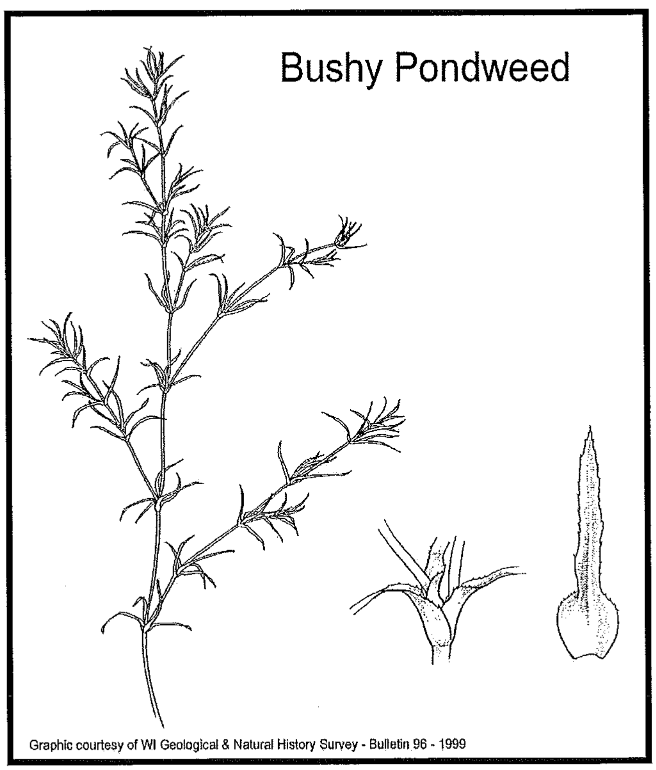
In Sandstone Flowage coontail was found at more than 23% of vegetated sites. It shows a strong preference for muck sediment but no strong depth preference.

Coontail is important for fish habitat since it is slow to decompose and often stays alive under the ice. This habit makes it excellent winter habitat, attracting aquatic insects and the fish that feed on them.

Bushy Pondweed

Bushy pondweed (*Najas flexilis*) was found at 18% of vegetated sites in Sandstone Flowage. This plant varies greatly in growth form, compact and bushy in shallow water, long and wiry with widely scattered leaves in deep water. The leaves are very narrow (1/16th inch wide) with a broad base where they attach to the stem. Plants generally grow no more than 2 feet tall and prefer a firm substrate.

In Sandstone bushy pondweed shows no distinct sediment preference. It was found primarily in



Small Pondweed

Graphic courtesy of WI Geological & Natural History Survey - Bulletin 96 - 1999

water less than 2 feet deep. Since the plant does not grow very tall it is seldom considered a nuisance species.

Bushy pondweed is rather unique in that it's one of the few annual aquatic plants. It dies each winter and depends on seed to grow new plants each year. The plants and the seeds, which are produced in great number each year, are important food for waterfowl. The plant also provides shelter for fish, particularly in very shallow sandy areas where it is often the only available cover.

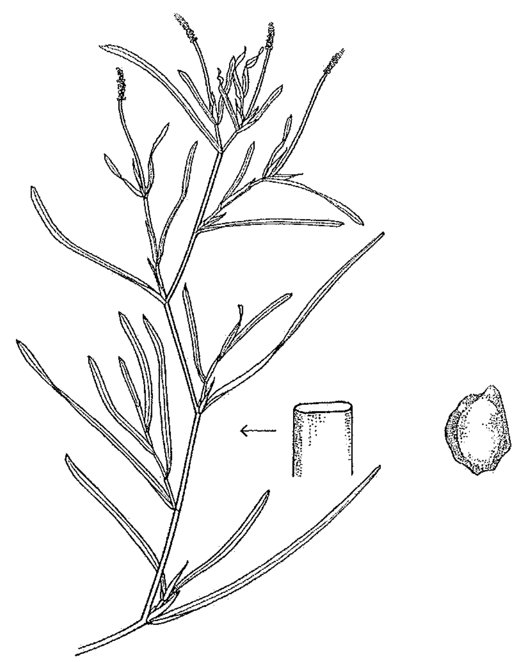
Small pondweed
Small pondweed (*Potamogeton pusillus*) is the most common species in a large group of narrow-leaf pondweeds that are notoriously difficult to identify. They are differentiated based on floating leaves, winter buds, seed shape and other factors. Small pondweed has very fine stems that branch profusely as they rise towards the surface. The leaves are typically much longer ($3/8^{th}$ –2 1/2 in) than they are wide ($1/16^{th}$ -$1/8^{th}$ in).

Small pondweed was found at 12% of vegetated sites in Sandstone Flowage. It showed no distinct sediment preference but did show a preference for water less than 4 feet deep. Many of the small pondweeds have similar sediment and depth preferences to EWM but cannot compete with the larger, more aggressive invader.

Flat-stem Pondweed
Flat-stem pondweed (*Potamogeton zosteriformis*) is identified, as the name implies, by its strongly flattened stems. The leaves are long (4"-8"), narrow (1/8"-1/4") and very stiff. The plant produces no floating leaves.

Flat-stem pondweed is a perennial that rarely reproduces by seed. Typically the entire plant dies back each year and re-grows from the root system. Like many of the pondweeds, flat-stem pondweed spreads by producing winter buds, specialized leaves packed in a tight cluster that form at the end of the season on some side branches. When the plant dies back the winter buds detach and fall to the sediment where they take root.

Flat-stem Pondweed



Graphy courtesy of WI Geological & Natural History Survey - Bulletin 96 - 1999

Water Star-grass

Graphic courtesy of WI Geological & Natural History Survey Bulletin 96 1999

Flat-stem pondweed was found at 11% of the sample locations where it shows an affinity for muck sediment (61%). It shows no noticeable depth preference.

Flat-stem pondweed provides important foraging habitat for panfish and edge cover for gamefish. It also serves as a food source for waterfowl that graze on its leaves and eat the seeds.

Water Stargrass
Water stargrass (*Zosterella dubia*) has slender freely branching stems with long (up to 6 inches) narrow (1/8 inch) alternate leaves. The leaves attach directly to the stem without a leaf stalk and lack a prominent midvein. In shallow water they sometimes produce small yellow star-shaped flowers that are held at the surface.

In Sandstone Flowage it was found at 10.6% of the sites, primarily in water less than 3 feet deep. It showed no obvious sediment preference.

Water stargrass overwinters and spreads by hardy rhizomes. Flowering is uncommon and reproduction by seed is rare. Water stargrass is an important food source for ducks and geese that forage on the vegetation and rhizomes.

Minor species
Twelve additional aquatic species were found at fewer than 10% of the sample locations. Many of these plants have specialized habitat requirements, such as long-leaf pondweed, which prefers flowing water, or are found scattered widely throughout the flowage.

Some species may also be more common than the survey suggests. Point intercept surveys typically under sample plants that grow in very shallow water next to the shore. Plant collection methods also tend to under sample very small species and species such as water lilies.

Aquatic Plant Distribution

Each species of aquatic plant has habitat preferences that determine where it grows or potentially can grow. These include such factors as depth, light exposure and sediment type.

Depth
The maximum depth of plant colonization in Sandstone Flowage is approximately 10 feet. Between 8 and 10 feet deep the number of species is limited and overall plant density is sparse. The maximum depth of plant colonization is determined by how deep light can penetrate (transparency). In Sandstone Flowage color, not suspended sediment or algae is responsible for limiting transparency. The light brown color is typical in the Peshtigo River and all its flowages and is caused by tannins. Tannins are naturally occurring dissolved organic compounds from decomposing plants in wetlands throughout the drainage area.

Of the major aquatic plant species, Eurasian water milfoil shows a strong preference for shallow water with nearly 85% of the milfoil found in water less than 5 feet deep. Wild celery, coontail, and common waterweed all have a more uniform distribution. For all species there is a sharp decline in aquatic plant abundance beyond the 8-foot depth.

Sediment

Sediment type also plays a major role in aquatic plant distribution and abundance. Sediment preference can be related to physical properties of the sediment (coarseness, grain size, compaction) or in the chemical properties of the sediment such as pH, or nutrient availability.

The graph in figure 2 shows the sediment preference of the four most abundant plants in the flowage. The graph shows that Eurasian watermilfoil, coontail and common waterweed all show a preference for growing in muck. Wild celery, the most abundant plant in the flowage, is found growing in sand and gravel almost as often as it is found in muck. Literature reports indicate that water celery has a preference for firm substrates. No plants are especially abundant in rocky areas.

Water flow

Aquatic plants also differ in their response to flowing water. Some plants are intolerant of flowing water, some are resistant to its effects, and others prefer it. When water flow is very high sediment scouring can be sufficient to prevent all plant growth.

In the upper end of the flowage the effects of water flow can be seen on the distribution of plants. The center of the channel where current is greatest is often free of plants even where the water is less than 8 feet deep. Long-leaf pondweed (*Potamogeton nodosus*) was also found exclusively in the upper reaches of the flowage. This plant is adapted to growing in flowing water and is found primarily in rivers.

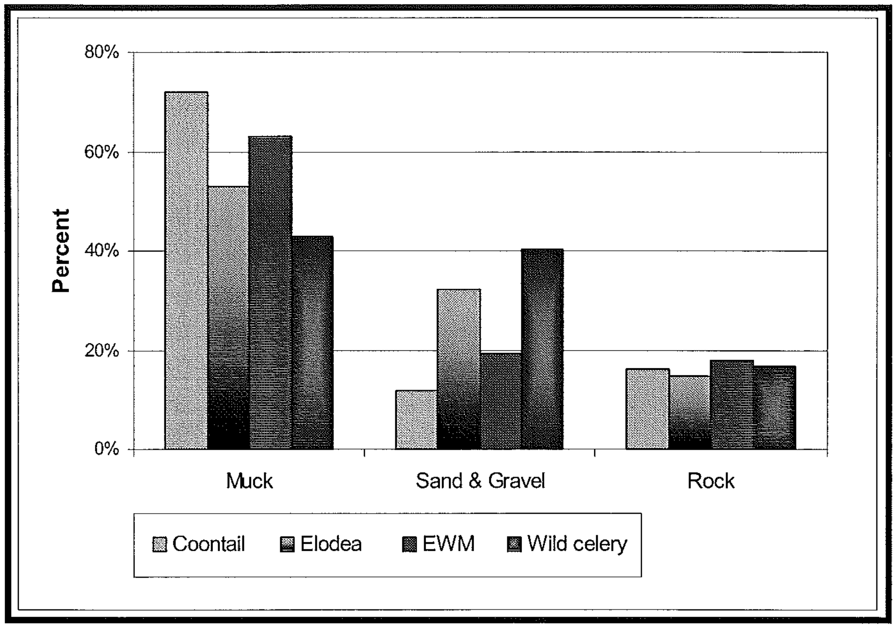


Figure 2. Sediment preference of major aquatic plants in Sandstone Flowage.

Water celery, the most abundant aquatic plant in the flowage, is also adapted to flowing water and is the dominant plant upstream from the Schaffer Road Bridge where the flowage is more "riverine" (like a river).

The effects of flow and sediment type can be hard to separate. Generally where there is considerable flow the sediment will consist of sand & gravel or rock. The fact that Eurasian water milfoil and coontail are uncommon upstream from the bridge may be a function of flow or it may be a lack of the preferred sediment type (muck).

Aquatic Plant Density

The aquatic plant survey methodology recommended by the Wisconsin DNR determines the frequency with which different species occur in the flowage but does not include any measurement of plant density. This is unfortunate since a plant can be present but of little concern if its growth is sparse. Understanding plant density is critical to comprehending the scope of the problem and managing aquatic plants on the flowage.

In an effort to more accurately describe the plant population areas supporting aquatic plants were mapped in 2005 and again in 2009 (Appendix A). Plant density was mapped using a Trimble Geo XT Explorer GPS receiver by slowly navigating the edge of plant beds with a boat. Individual plant beds were described as dense where plants were abundant at the surface and motorboat use was severely restricted. Plant growth was described as moderate where plants only intermittently reached the surface and it would be possible to boat through them. These areas typically supported 100% plant coverage but the plants remained below the surface. Areas with sparse plant growth had scattered aquatic plants.

In 2005 approximately 74 acres of plant beds were mapped. 52 acres (70%) were dense and 22 acres (30%) supported moderate plant growth. Areas supporting dense plant growth were typically shallow with muck bottom on the inside bends of the old river channel. Moderate plant density was typically found in deeper water or areas with stronger current in the upper reaches of the flowage. While no data was collected concerning species dominance, the aquatic plant survey indicated EWM was most prevalent adjacent to Hideaway Lane and rare above the Shaffer Road Bridge.

In 2009 aquatic plant density was again mapped and it was noted whether EWM or wild celery was the dominant species. Approximately 68 acres of plant beds were mapped with 40 acres (59%) supporting dense plant growth and 28 acres (41%) with moderate growth (figure 3).

It's clear from this effort that plant growth patterns and density have remained consistent in the flowage. During both surveys it was noted that virtually all of the aquatic plant beds contained abundant growth and had an abrupt boundary where they met open water. The reduction in dense aquatic plant growth in 2009 was primarily due to aquatic plant management efforts (herbicide use) adjacent to Hideaway Lane and a cool summer that left some of the wild celery beds short of the surface in deeper waters.

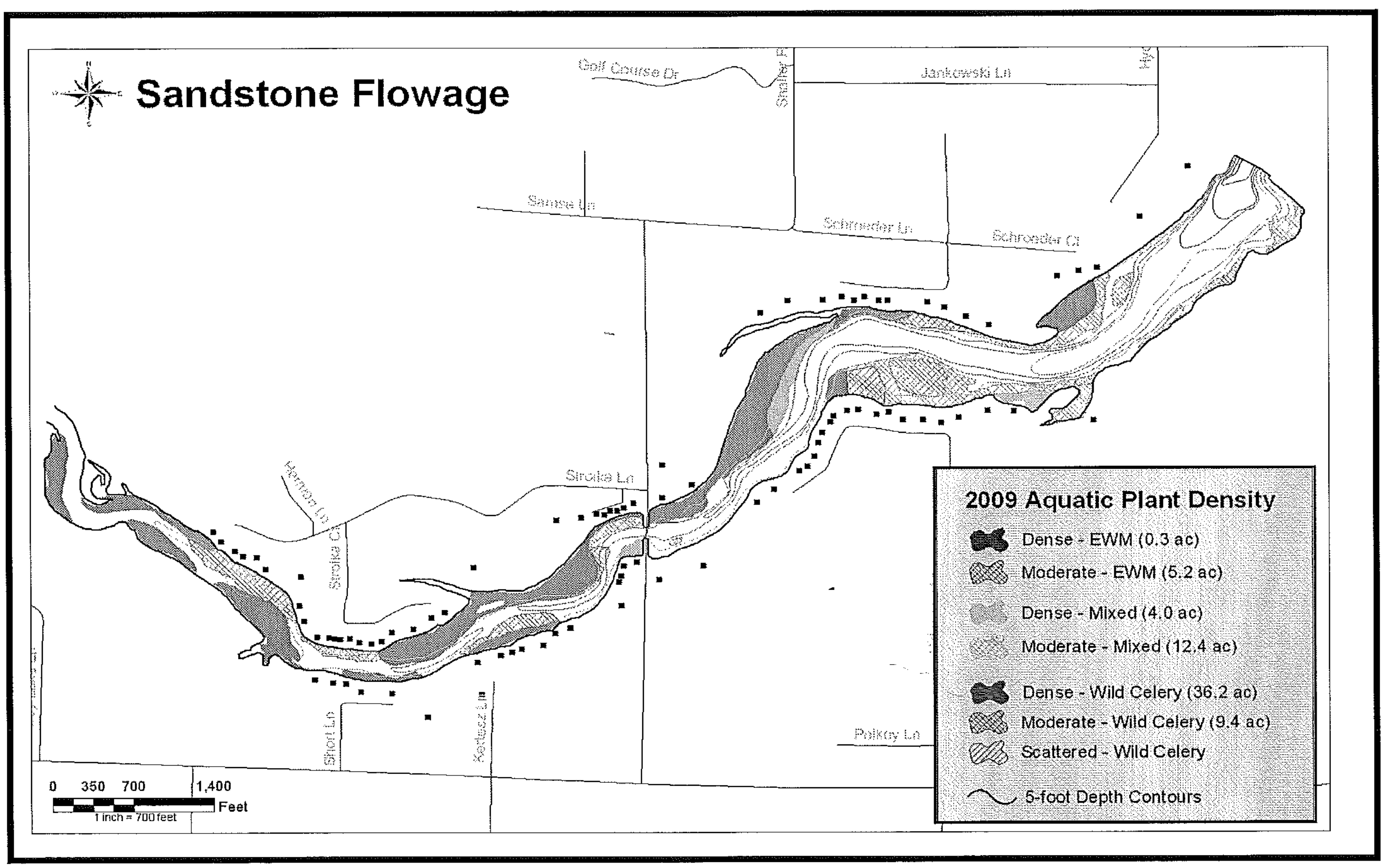


Figure 3. 2009 aquatic plant stand density map for Sandstone Flowage.

Nuisance Plant Growth & Changes in the Aquatic Plant Community

When surveyed, 91% of landowners on Sandstone flowage reported that aquatic plant growth limited their access to parts of the flowage and diminished attractiveness. A third (33%) reported that excessive plant growth limited their ability to swim and restricted their access to open water. When asked about changes in the plant community, 65% reported that, in their experience, aquatic plant growth has increased substantially.

It is clear from the aquatic plant surveys that both EWM and wild celery are responsible for nuisance conditions in Sandstone Flowage. Currently EWM is found in abundance primarily at the Hideaway Lane site, although it appears to have spread somewhat since 2005 and is now found mixed with wild celery at the edge of some plant beds east of the bridge. West of the bridge wild celery is the dominant plant, forming nearly impenetrable beds along much of the shore.

In the Aquatic Plant Survey Report (Druckrey 2006) a considerable effort was made to explain the increase in aquatic plant growth witnessed by landowners. Throughout the planning process landowners, at public meetings and in written surveys, questioned whether the change in operating mode of Sandstone Dam might be responsible for increasing aquatic plant density in the flowage. Prior to November 1998 the dam was operated in a peaking mode. In the peaking mode water is preferentially stored in the flowage during off periods of electrical use (mid day and at night) and released in the morning and late afternoon during periods of peak electricity use. According to WPS the daily fluctuation averaged 0.5 ft per day up to a maximum of 1 foot per day.

When the Sandstone dam was re-licensed in 1998 the operation was changed to run-of-the-river mode. In run-of-the-river water is passed through the dam at the same rate at which it enters the flowage. Surface water elevation must be maintained between 723.7 and 724.2 feet. WPS reports that daily water level fluctuations are typically less than 1/10 ft per day with a maximum allowable fluctuation of 0.5 ft per day.

As detailed in the plant survey report, there is little support in the scientific literature to suggest that changes in hydropower operations would be responsible for a drastic increase in wild celery. To the contrary, most of the research points to wild celery's preference for flowing water. Wild celery also grows in abundance in many fresh and brackish water estuaries where water levels fluctuate daily with the tides. Other research indicates wild celery populations fluctuate considerably in large river systems due to changes in turbidity (water clarity) and water temperature.

A more likely explanation for the recent increase in wild celery is long-term changes in climate and runoff. A review of discharge data from the Peshtigo River shows that during the twenty-year period of 1968 to 1988 the average daily discharge of the river was 1005 cfs. Between 1988 and 1998 the average discharge fell 10%. Over the last 10 years discharge has fallen drastically, to an average of 740 cfs, a 26% decrease. This reduction in discharge has likely resulted in increased water clarity and daytime water temperatures, factors known to stimulate wild celery growth.

History of APM Efforts

Wisconsin DNR records show that since 2000 several landowners along Hideaway Lane have attempted to control EWM and other nuisance vegetation using aquatic herbicides. Most applications occurred in mid to late June using Reward (Diquat) or Aquathol and Cutrine plus. Reward and Aquathol are both fast acting contact herbicides that kill exposed vegetation but not the root system. Cutrine is a copper compound used to control filamentous algae. Navigate (2,4-D), a systemic herbicide that targets exposed vegetation and the roots system, was used in 2000 and in 2008. Most applications covered less than 4 acres and included areas around docks and navigation channels through the dense plant beds out to open water.

During the 2005 aquatic plant survey the effects of a recent herbicide treatment was clearly visible as a channel through otherwise very dense vegetation. In 2009 EWM density was only moderate at the Hideaway Lane site. This may be due to the 2008 treatment with Navigate, which kills the root system of EWM and provides some measure of long-term control.

Likely Impact of EWM Expansion in Sandstone Flowage

Despite its presence in Sandstone Flowage for nearly 15 years, EWM has not dominated the plant community as is has in many lakes. This is probably due to limited suitable habitat and competition from wild celery. A review of the aquatic plant survey data confirms that, as expected, EWM was found almost exclusively in areas with muck sediment and seemed to prefer water 2-5 feet deep.

Left to its own, it is likely that EWM will increase its spread and may come to dominate the plant community in areas with a muck bottom. A review of the sediment map shows this area includes much of the flowage east of the bridge. Even areas currently dominated by wild celery will likely succumb to EWM eventually if the area has a muck bottom. As EWM expands native pondweeds and other beneficial aquatic plants will decrease in abundance.

Wild celery will likely continue to dominate the plant community in areas with a sand bottom. This includes most areas west of the bridge. EWM may spread to these areas but it is not expected to flourish or displace the wild celery.

Identification of Problems and Threats to Sandstone Flowage

Landowners and resource managers have clearly identified excessive aquatic plant growth as the most pressing concern on Sandstone Flowage. Looking deeper, there are basically two separate but related problems, the expansion of the exotic EWM and an overabundance of the native wild celery.

Eurasian watermilfoil
The most pressing issue confronting Sandstone Flowage is the continued expansion of EWM and the threat it poses to the native plant community, navigability, and recreational potential of the flowage. Without a long-term management effort the EWM problem will likely get worse.

Wild celery
In much of the flowage, particularly west of Shaffer Road, wild celery is the dominant species, responsible for restricting navigation and recreation. Environmental conditions (flowing water and sediment type) make it likely that wild celery will continue to be a problem in these areas. Predicted climatic changes such as warmer & drier summers will only exacerbate the problem.

Other aquatic invasive species
Future threats to Sandstone Flowage include new introductions of aquatic invasive species. Marinette County already has one inland lake (Noquebay) infested with zebra mussels (*Dreissena polymorpha*) and the Bay of Green Bay is home to numerous invasive aquatic species, all of which have the potential to impact Sandstone Flowage. The risk is compounded by the fact that Sandstone is downstream from some of the most heavily used waters in Northeast Wisconsin where transient boaters are the rule.

Aquatic Plant Management Goals & Objectives

The goal of the Sandstone Flowage Association is to: **Develop and implement a sustainable aquatic plant management program for Sandstone Flowage to prevent EWM dominance and control excessive aquatic plant growth where it restricts navigation and recreational use.** To achieve this goal specific management objectives have been identified and targets have been set to gauge success and guide selection of management options.

Goal: Develop a sustainable aquatic plant management program.

A sustainable aquatic plant management program will be cost-effective and should, as much as possible, be relatively easy to repeat as needed. In determining cost effectiveness the Association needs to consider both management cost and duration of control. In the final analysis management efforts that cost more may be preferable if they provide multi-year control. Permitting requirements should also be considered and figured into the management cost.

Objective: *Place emphasis on aquatic plant management methods that provide multi-year control and reduce annual management costs.*

An aquatic plant management program that is sustainable over the long-term also needs to adapt as environmental conditions and the aquatic plant population changes. To make the required adjustments those responsible for making management decisions need current information upon which to base their decisions.

Objective: *Track changes in the aquatic plant population so changes can be documented and past management efforts evaluated.*

The recommended frequency of plant surveys depends on the frequency of changes in management methods. When new management methods are adopted surveys should be completed to track changes and determine management effectiveness. Management activities funded through DNR grants typically require pre and post treatment aquatic plant monitoring.

Target - *Conduct pre and post management aquatic plant surveys to evaluate effectiveness of new management tools.*

When management is routine, providing no unexpected changes in the plant community are noticed, the amount of time between plant surveys can be lengthened considerably.

Target - *Conduct a full point/intercept survey of the Flowages every 5 years unless conditions "on the ground" call for more frequent surveys*

In addition to formal point/intercept surveys landowners should be routinely monitoring the Flowage for early detection of new invasive species.

Target - *Conduct annual surveys of the Flowage for new aquatic invasive species according to DNR AIS monitoring protocol.*

With some training in aquatic plant ID and a handheld GPS, volunteers should be capable of collecting usable aquatic plant data.

Target – *Provide for two or three Association volunteers to be trained in aquatic plant ID and survey methods. Purchase equipment needed to conduct aquatic plant surveys.*

For any management program to be sustainable Association members also need to understand and take ownership of the program. Good communication is essential so Association members are realistic about the expected outcomes and understand what they as landowners can do to help.

Objective: *Communicate effectively with Association members.*

While important, effective communication will require more than reports at the annual meeting. The Association should use other avenues to communicate information, goals and outcomes to its members.

Target *- Publish a regular newsletter to keep members informed about management practices and outcomes, and to share success stories.*

Target *- Provide aquatic invasive species educational materials to members.*

Goal: Prevent EWM dominance in Sandstone Flowage.

There are no management tools currently available that will allow for the eradication of EWM in Sandstone Flowage. The most realistic objective is to minimize its nuisance potential.

Objective: *Reduce the frequency and abundance of EWM so that it does not dominate the aquatic plant community or restrict navigation and recreational use.*

Since EWM has many competitive advantages that allow it to quickly exploit disturbed areas and suppress native plant communities, control methods that cause widespread disturbance in the aquatic plant community may be counterproductive. Therefore, control methods should be carefully chosen to selectively control EWM where possible.

While EWM has made fairly serious inroads into the Flowage it still does not dominate the aquatic plant community. In 2005 EWM was found at 45% of survey sites east of the bridge. An appropriate target is to:

Target *– Maintain EWM frequency of occurrence to less than 50% of sample locations.*

Survey methods should be modified in future surveys to measure relative abundance. Relative abundance is estimated based on the rake fullness and give some measure as to which plants are dominant in an area.

Target *- Reduce the abundance of EWM so that it's not the dominant submersed plant where found as measured by average rake fullness.*

Target *- Control EWM abundance in areas where it restricts navigation and recreational use.*

Goal: Control excessive aquatic plant growth where it restricts navigation and recreational use.

Landowner concerns and results of the aquatic plant survey clearly show that EWM is not the only "problem" species in Sandstone Flowage. Wild celery is the dominant species west of the Shaffer Road Bridge and along much of the north shore east of the bridge as well. In many areas nuisance vegetation consist of a mix of EWM and wild celery. Restoring beneficial uses of the Flowage requires managing aquatic plants in these areas as well.

Unfortunately, since maintaining a healthy native plant community will help prevent EWM expansion, the desire to reduce the abundance of wild celery may run counter to the primary goal of reducing EWM dominance. Extra care must be taken in selecting management tools that will meet both goals.

Objective: *Selectively control native species where it does not promote EWM growth.*

In high use areas such as swimming beaches and around docks where intensive physical removal is possible all plants can be controlled. Manual removal with specialized weed cutters and weed rakes is common. Regular maintenance cutting is required to prevent re-colonization. Cut plants and plant fragments must be removed from the water. In the case of EWM this will help prevent its spread.

***Target** – Manually remove aquatic plants around docks and swim areas.*

In limited cases the growth of native species that do not typically produce nuisance conditions can be promoted.

***Objective:** Choose control methods which will promote the growth of low-growing native plants.*

Submersed aquatic plants that are common in Sandstone Flowage but seldom grow to nuisance levels include bushy pondweed and common waterweed.

***Target** - Increase the frequency and abundance of bushy pondweed, common waterweed and other species where experience shows them to be beneficial (or at least less of a nuisance).*

Aquatic Plant Management Alternatives

A successful aquatic plant management strategy must be tailored to the plants and water body in question and will typically utilize multiple control methods as appropriate. A comprehensive review of aquatic plant management alternatives follows. While each of the alternatives may be beneficial in certain situations, not all are currently applicable to managing aquatic plants in Sandstone Flowage.

Do Nothing

Doing nothing is inexpensive, easy to do, and relatively uncontroversial. However, it is rarely effective. Lakes and flowages are complicated ecosystems and aquatic plant populations fluctuate within them due to a variety of factors. Large-scale climactic conditions and local weather cycles can impact flow, temperature, and clarity, all of which effect aquatic plant growth. Plant populations also vary because of disease, species introduction, competition and other internal processes. Left to its own devices the plant community in Sandstone Flowage will continue to change over time.

In the case of Eurasian watermilfoil, doing nothing typically leads to EWM domination of the aquatic plant community. While the EWM dominance is often thought to be permanent, the history of EWM in Wisconsin shows this is not always the case. Carpenter (1980) reported that the duration of peak abundance in some lakes is approximately 10 years after which EWM may experience a significant decline. While the reason for these "natural" declines in EWM abundance is poorly understood some attribute it to a native milfoil weevil (*Euhrychiopsis lecontei*) which feeds on milfoil species. Unfortunately this natural decline has not been seen everywhere and is often temporary. In some lakes EWM populations experience quite a bit of natural variability with periodic declines and subsequent increases without any active management.

The downside to doing nothing is that the result may be nothing. This option will result in a continuation of the problem in the short term. In the long term doing nothing will most likely result in expansion of EWM and a worsening of the situation.

Chemical Control

When properly planned and executed, chemical control of aquatic plants can be effective. However, if care is not taken in the selection timing, and application of aquatic herbicides the results can be less than desirable, or worse, have unintended consequences.

There are several herbicides approved for aquatic use in Wisconsin. Each differs in its mode of action and in the species it controls. Contact herbicides kill exposed plant material but can leave the root system intact, allowing for rapid recovery and plant growth. Systemic herbicides are transported to the roots and kill the entire plant. Systemic herbicides provide longer-term control but may act more slowly than contact herbicides.

Herbicides can also be grouped into two general groups, "broad-spectrum" and "selective". Broad-spectrum herbicides control a broad range of plants. Selective herbicides, as the name implies, are more-or-less selective and control fewer species while leaving many others unharmed. Often selectivity is a function of timing of application and/or concentration of the herbicide.

Eurasian watermilfoil (EWM) is susceptible to several common aquatic herbicides. Selective control can typically be achieved using 2,4-D, a systemic herbicide that many pondweeds are resistant to. The DNR typically requires 2,4-D applications be conducted prior to May 31 or before the water temperature at two feet reaches 65° F. In Marinette County excellent control has been achieved by treating with 2,4-D as early as May 1.

Chemical control of EWM is a popular and effective control measure where the goal is to shift the plant community to a more natural mix of native species. When used in a selective manner it is also possible to get multi-year control from herbicides. This is most likely to be achieved when the native community is relatively vigorous and can resist EWM reestablishment. Eventually EWM will return so even selective management will have to be repeated on a regular basis.

Wild celery is reported to be one of the more difficult plants to control. According to the U.S. Army Corps of Engineers (1988) none of the aquatic herbicides registered for use in Wisconsin offer more than fair control of the plant. According to two different aquatic plant control contractors Hydrothol 191 is the only chemical recommended for the control of wild celery. However, the DNR has not approved Hydrothol 191 for use in Wisconsin waters since it is toxic to fish and other aquatic organisms even when applied at label rates.

Improper or excessive use of aquatic herbicides can have unintended consequences. Widespread use of broad-spectrum herbicides can leave large areas of suitable habitat exposed to colonization by nuisance species. Many of the more common nuisance plants, such as EWM, are aggressive pioneer species that can quickly invade disturbed areas. The decomposition of tons of aquatic plants also releases large amounts of nutrients to the water column. These nutrients can trigger algae blooms and fuel additional aquatic plant growth

Chemical treatment cost depends on the chemical formulation and application rate, the distance a certified applicator has to travel, and the time and equipment involved. Currently (2010) EWM treatment with Navigate granular 2,4-D could be expected to cost between $500.00 and $900.00 per acre depending on the water depth and size of the treatment area. In some instances the State of Wisconsin can provide funding for chemical treatment of Eurasian watermilfoil or other lake restoration activities recommended in a lake management plan approved by the DNR. Pre and post-treatment monitoring of the aquatic plant community is required when state cost-share dollars are used to support aquatic plant management efforts. Even without state funding it is a good idea to conduct pre and post-treatment monitoring to evaluate treatment effectiveness.

Chemical treatment of aquatic plants in Wisconsin always requires a permit from the Wisconsin DNR. This is to ensure that the proposed chemical treatment will use appropriate chemical(s), at the correct concentration and at the proper time of the year. In almost all situations the person applying the herbicide must be certified by the Wisconsin Department of Agriculture Trade and Consumer Protection.

Benthic Barriers

Benthic, or sediment barriers cover the sediment and prevent the growth of aquatic plants. The barriers work by physically disrupting plant growth or eliminating light at the sediment surface. When installed properly benthic barriers are very effective at eliminating all plant growth. However the difficulty of installing and maintaining these barriers prevent their widespread use.

Benthic barriers can be made of naturally occurring materials (sand and gravel) or artificial (synthetic plastic sheeting). Sand or pea gravel is commonly used to create weed free swim areas. However, there are several common problems with sand and gravel benthic barriers. If deposited on soft sediment it can sink in and mix with the native sediment. Also, over time new sediment is deposited on top of the barrier. All of these factors will lead to failure of the barrier.

Artificial barriers typically consist of sheets of polypropylene, polyethylene, fiberglass or nylon (Wagner 2004). All must be weighted to hold them in place against water currents, waves, and boat wake. If constructed of non-porous material benthic barriers will be subject to billowing and may float free of the sediment as gasses from decomposition build up beneath them. Porous barriers are less subject to billowing but plant fragments that settle on top are better able to root through them. Both types of barriers require annual maintenance since sediment accumulation on top of the barriers will build up and support new aquatic plant growth.

Artificial benthic barriers are also relatively expensive and difficult to install and maintain. Maintenance consists primarily of annually removing accumulated sediment, which typically requires removal and replacement of the barrier. The use of any type of benthic barrier requires a DNR permit.

Dyes and Floating Covers

Dyes are liquid chemicals that are applied to change the color of the water. Covers physically cover the water surface. Both control aquatic plants by reducing the amount of light reaching the sediment.

Dyes typically color the water a deep blue or even black. For small ponds they are relatively inexpensive, long lasting, and effective. Effectiveness is limited in shallow water (2 feet or less) where the light reduction is seldom enough to prevent plant growth. Dyes must stay in the water throughout much of the growing season so they are not appropriate for use in flowing water.

Floating covers also disrupt plant growth by reducing light levels at the sediment surface. However, unlike dyes the floating covers prevent virtually all water use while they are in place. Floating covers can be difficult to install and effectively anchor.

Both dyes and floating covers require DNR permits. The main permitting issue with floating covers is the disruption of public water rights (fishing and navigation) that they cause while installed.

Harvesting

Aquatic plant harvesting is a widely accepted aquatic plant management alternative that can be effective on a large or small scale. Individual landowners often manually clear small areas around their dock or swim area. Typically this is accomplished by using one of several specially designed non-motorized aquatic plant rakes and/or hand-held cutting implements. Under current Wisconsin Law landowners can manually harvest plants without a permit if the plant removal is not in a DNR designated sensitive area and is limited to a 30-foot wide area (measured parallel to shore). There is no limit on how far out into the lake a landowner can harvest by hand if they stay within the 30-foot wide corridor. The control area must be around existing piers, boat lifts, and swim rafts and the cut plants must be removed from the water.

Mechanical harvesting is typically accomplished using motorized equipment to cut and collect aquatic plants. The most common method is the use of specially designed harvesters that cut and collect aquatic plants in one operation. The size and capacity of these harvesters varies greatly but the largest can cut a 10-foot wide swath up to 6 feet deep and holds more than 16,000lbs of cut plants.

Like most aquatic plant management alternatives harvesting seldom eliminates plants. Much like cutting your lawn, harvesting leaves the root system intact and plants will re-grow. In some cases repeated harvesting close to the sediment surface can stress plants enough to cause mortality. Species that depend on seed production for their spread may be partially controlled by harvesting if seeds are repeatedly removed. Plants that spread by fragmentation such as EWM and coontail can actually be spread through harvesting when cut fragments escape the harvester and drift to other areas of the lake.

Repeated harvesting can have impacts on the aquatic plant community that go beyond the initial cutting. In Lake Noquebay repeated harvesting has led to measurable shifts in the aquatic plant community. When harvesting began in 1978 the lake was dominated by a variable watermilfoil, a native milfoil with growth habits similar to the Eurasian variety. After 28 years of harvesting the plant community has changed noticeably. Harvesting tonnage has gone down and the new dominant species in the lake is bushy pondweed, a low growing native that typically stays below the maximum cutter depth of 5.5 feet.

Harvesting can also provide benefits to the fish community. Dense aquatic vegetation provides important cover for minnows and small panfish. While this is clearly beneficial, too much cover can be a bad thing. Large predator fish such as bass and pike cannot feed efficiently in dense vegetation so they rely on the edges of plant beds to ambush their prey. When the plant beds are very large and dense, as in Sandstone, the amount of edge is limited and panfish can become overpopulated and stunted. Harvesting lanes through dense plant beds opens them up and increases the amount of edge habitat.

Large Scale mechanical harvesting can be an expensive proposition. Commercial harvesting is available in Wisconsin and can range from $400 to $600 per acre (2008 prices) plus travel costs. As with many services the unit cost is typically lower when the harvest area is larger. The Wisconsin Association of Lakes website has information regarding private commercial harvesting vendors.

Typically when a lake undertakes a long term harvesting program they purchase and operate their own equipment. Initial costs for a new harvester can range from $60,000 to $120,000 depending on the size of machine. Typically a truck is also required to transport plants to a disposal site and a shoreline conveyor to transfer cut plants from the harvester to the truck. Wisconsin does provide financial assistance for harvester and related equipment purchases through the Wisconsin Waterways Commission. Grants are awarded on a competitive basis and cover 50% of equipment purchase price. Operation and maintenance costs vary depending on the amount of use and the labor source. While volunteer operators are of course free, in the long run it may be best for the equipment and for the harvesting program to hire a dedicated worker to operate and maintain such expensive and complicated equipment.

According to WI. Administrative code NR109 A Wisconsin DNR permit is required to harvest aquatic plants using any mechanical device powered with a gas or electric motor. Large scale mechanical harvesting also requires a DNR approved aquatic plant management plan. An approved aquatic plant management plan is also a requirement for receiving a Waterways Commission grant for equipment purchase.

In lakes with EWM harvesting is typically recommended as a management tool only if the EWM is already widespread and well established. Since harvesting inevitably increases fragmentation, it can aid in the spread of EWM within the lake. If harvesting is used it will have to be repeated multiple times during the season to provide nuisance relief, especially in shallow water areas where re-growth occurs rapidly. Harvesting wild celery should also be viewed as a maintenance practice that would have to be repeated throughout the growing season.

As a control method for Sandstone Flowage, one of the major concerns is whether routine harvesting of wild celery would open up new areas for EWM invasion, trading one problem for another. Existing growth patterns and the history of EWM in Sandstone Flowage suggest this would not be the case. EWM has been present in the flowage for at least 15 years and still wild celery dominates the plant community in most areas. It appears the spread of EWM is controlled primarily by sediment type and flow regime. Since harvesting would not alter these factors it shouldn't result in a major expansion of EWM into areas now dominated by wild celery.

An illustrative example can be found in the experiences of Friendship Lake in Adams County, Wisconsin. Like Sandstone, Friendship Lake is a long narrow impoundment with a high flushing rate. The prevailing sediment type is sand and the plant community is dominated by wild celery. EWM has also been present in the lake for more than 20 years. As in Sandstone, wild celery grows to the surface and forms dense mats covering much of the lake. In many areas open water was limited to the main river channel. The landowners of Friendship Lake formed a management district in 1992 and began mechanically harvesting aquatic plants, targeting EWM and harvesting lanes through the wild celery beds to provide boating access to docks. An aquatic plant survey conducted in 2006 showed that, after 14 years of intensive harvesting, EWM had not taken over the plant community. In fact, EWM was not even in the list of 5 most abundant plants in the lake (Friendship Lake Management Plan 2009).

Dredging

Typically a practice known for increasing depth to aid in navigation, dredging can also be an effective aquatic plant control technique. As a plant control measure dredging has two primary modes of action: changing sediment type, and increasing the depth to sediment.

Where a layer of nutrient rich organic sediment overlies a nutrient poor layer of mineral soil the organic layer can be removed to expose the sand or gravel layer that is less capable of supporting plant growth. Typically such removal will change the plant community structure, not eliminate all plant growth. Removing the upper layers of sediment also eliminates plant roots and most viable seeds. Unfortunately, the result of organic sediment removal is seldom long lived since many plants will colonize mineral soil where they quickly begin the process of building new organic matter. Very little organic matter is needed to support dense plant growth.

Eliminating all submersed aquatic plants requires dredging the lake to a depth where light availability limits plant growth. In Sandstone Flowage the lower limit of aquatic plant growth is about 10 feet with sparse plant growth beyond the 8-foot depth.

There are two major types of dredging, hydraulic and mechanical. Hydraulic dredging is accomplished by pumping a sediment/water slurry out of the lake to a disposal/dewatering area. Hydraulic dredging is best suited to loose organic sediment. Mechanical dredging employs heavy equipment deployed on barge or shore to dig out the sediment and transfer it to trucks for removal. Mechanical dredging can be simplified if done in conjunction with a drawdown since less water is moved and conventional dry land excavating equipment can often be used.

It should come as no surprise that dredging is typically a very expensive alternative. Rough estimates for mechanical dredging range from $8.00 to $25.00 for each cubic yard (Wagner 2004). Much depends on the type of sediment, accessibility, and disposal costs.

Any type of dredging requires, at a minimum, a Wisconsin DNR and US Army Cops of Engineers permit. Permits must describe in detail the scope of the proposed dredging, dewatering and disposal of spoils, and the effects the project will have on fish, wildlife, and public water rights.

Drawdown

In impounded waters temporary drawdown can be a valuable aquatic plant management tool. Its effectiveness depends on the season and duration of the drawdown. Summer drawdown can kill some species of plants through desiccation of the root system but the duration of the drawdown has to be quite long to ensure adequate drying of the sediment. Organic sediment and untimely rains can make this process very difficult. Also, many plants are stimulated by changing water levels and actually increase with summer drawdown.

Winter drawdown controls plants by exposing their root systems to freezing conditions. In winter the duration of the drawdown is less important than the timing. It is important that frost penetrates to the root zone before snow insulates the lakebed. The response of aquatic plants to drawdown is well known for some species but not for others. To complicate matters, accounts in the scientific literature do not always agree. Table 1 lists the species found in Sandstone Flowage and their reported susceptibility to winter drawdown according to Cooke (2005) and local experience. As the table indicates, some aquatic plants are stimulated by winter drawdown, including wild celery.

The use of winter drawdown for EWM control in Wisconsin is very promising. The Wisconsin Public Service Corporation (WPS) conducted a drawdown of High Falls Flowage during the winter of 2001 specifically for the purpose of Eurasian watermilfoil control. In a plant survey conducted in 2002 no EWM was observed in 14 test plots that previously contained the plant. By 2005 the milfoil had re-colonized 5 of the plots but plant density was still much reduced (Shawn Puzen, pers. comm.). The duration of EWM control achieved by a single winter drawdown varies but has been reported as lasting 3 – 5 years. While winter drawdown of

Decrease	Variable/Unknown	Increase
Eurasian watermilfoil	Common waterweed (V) Flat-stem pondweed (V) Small pondweed (V) Leafy pondweed (U) Stiff water crowfoot (V) Large-leaf pondweed (V) Ribbon-leaf pondweed (V) Flat-leaf bladderwort (U) Variable-leaf pondweed (V) Water bulrush (U) Fries pondweed (U) Long-leaf pondweed (U) Northern watermilfoil (V) Water stargrass (U)	Wild celery Coontail Bushy pondweed Floating-leaf pondweed Water marigold

Table 1. Predicted effect of winter drawdown on aquatic plants found in Sandstone Flowage.

Sandstone Flowage shows promise for controlling EWM, the literature suggests it would not control wild celery and may even cause it to increase in density, if that is even possible.

The primary drawbacks to drawdown include loss of recreational use during the low water period (minimal with a winter drawdown) and potentially lowering water levels in shallow wells adjacent to the flowage. Other impacts may include unintended effects on fish and aquatic life. Since Sandstone Flowage has ample deep-water habitat a limited drawdown should have little direct impact on fish but may temporarily reduce the population of some aquatic insects and snails.

Based on literature reviews and local experience it appears that a periodic winter drawdown of 10 feet would be an effective tool for EWM management on Sandstone Flowage. It seems unlikely that wild celery could get any denser as a result of a winter drawdown but that remains to be seen.

While an effective aquatic plant management tool, water level drawdowns are typically only done for hydro dam maintenance and repair. They are seldom conducted strictly for aquatic plant management purposes. To conduct a drawdown for EWM management the Sandstone Flowage Association would have to work closely with the hydro dams owner, Wisconsin Public Service Corporation. The Federal Energy Regulatory Commission (FERC) licenses the Sandstone Dam and would need to issue a permit for any proposed water level fluctuations. The Wisconsin DNR would also be consulted for comment and conditions.

Control/Reduce Nutrient Inputs

Aquatic plant response to nutrient input varies by species and source of nutrients. For the most part, rooted aquatic plants absorb their nutrients through the root system so nutrient additions to the sediment are more important than dissolved nutrients in the water column. Studies have shown that many aquatic plants are particularly stimulated by nitrogen additions to the sediment. Rogers (1995) reported that nitrogen additions to sediment significantly increased wild celery growth. Nitrogen is a water-soluble nutrient. Septic systems, intensive irrigation and excessive nitrogen fertilizer use have all been shown to cause increased nitrogen concentrations in groundwater.

Increasingly the amount of fertilizer used in urban settings is seen as a major contributor of phosphorus and nitrogen to our surface waters. Recently the State of Wisconsin severely restricted the use of phosphorus in lawn and garden fertilizer and recommended reductions in the use of nitrogen fertilizer to protect surface waters. Restricting fertilizer use is especially important near lakes since nutrient rich runoff from these areas is more likely to be delivered directly to the water.

Reducing runoff volume is also important in controlling nutrient inputs to the lake. Since most of the increase in nutrient load is a result of increased runoff volume, it stands to reason that decreasing the amount of impervious surface and taking steps to increase the amount of infiltration will protect water quality. Many of the practices designed to decrease runoff volume also remove nutrients from the runoff.

Biological Plant Control

Biological control (biocontrol) typically utilizes bacteria, fungi, or insects to control an unwanted plant. Biocontrol of exotic species often involves finding the natural control mechanism in the exotic plants country of origin and importing it to the US. Since there is always a risk that introducing a new organism may lead to unintended impacts to non-target species a lot of study is required to approve the use of new biocontrol agents.

In a rather unusual twist, one of the most promising biocontrol agents for Eurasian watermilfoil is a native insect. The milfoil weevil (*Euhrychiopsis lecontei*) is a native species that normally feeds on northern water milfoil. The adult weevil lays its eggs on the growing tips of milfoil where the larvae feed and weaken the plant. Older larvae also burrow into the stems, often causing enough damage to cause the plants to loose buoyancy and sink. The stout stems and shoots of northern water milfoil typically show little damage from this feeding activity. Eurasian water milfoil however has relatively weak stems that are readily damaged by the insect. Studies have shown that milfoil weevils actually prefer EWM and increase in population when EWM is the dominant food source (Lillie, 1997). It's believed that the natural decline in EWM infestations in some lakes may be due to the native milfoil weevil that is reportedly widespread in Wisconsin lakes (Jester, 1998).

Since its discovery as a control agent "stocking" milfoil weevils to control Eurasian watermilfoil has been used with mixed results. In Wisconsin it was found that in twelve lakes where weevils were stocked a few experienced large-scale milfoil declines while others saw little or no change (Jester 1999). Several factors seem to affect the success of EWM biocontrol. Jester found better results when EWM had already reached its maximum distribution. The study also found that weevil density was positively correlated with increasing water temperature, distance of plant beds from shore (closer was better), and the percent of natural shoreline. The amount of natural shoreline is important because the adult weevils overwinter in leaf litter on the forest floor along the waters edge. Other studies have found that sunfish species (bluegill, pumpkinseed etc.) are very efficient predators of milfoil weevils and play a major role in reducing their effectiveness (Newman 2004, Ward 2006). Environmental factors such as winter severity, disease, etc. can also affect weevil abundance and may play a role in the inconsistent biocontrol results.

Where successful, biocontrol can reduce the abundance of EWM and allow the native species to better compete. However, the expense ($1.00 per weevil) and highly variable results make it hard to recommend weevil stocking as a control measure. Also, even in lakes were biocontrol has been effective the declines in EWM biomass have often been temporary. This may be due to natural cycles in weevil abundance or other natural environmental factors.

Little is known about the prevalence of milfoil weevils in flowages. While there is probably no historical population, they may have found their way into the flowage over the years since northern watermilfoil is native to the water. However, milfoil weevils are also reportedly poor swimmers so they may not find flowing water hospitable.

Exotic Species Monitoring and Prevention

As is often the case, an ounce of prevention is worth a pound of cure. With exotic species this is doubly true. In most lakes, and for most exotic species the primary mode of introduction is by boat, boat trailer, or bait bucket. While public access points are particularly susceptible, many exotic have been introduced on lakes without any public access.

Once established in a water body it is extremely difficult to eradicate an exotic species. In the few cases where eradication has been successful the introduction was detected early. For this reason routine monitoring to detect new invasive species is an important step in any aquatic plant management effort. The Wisconsin DNR and University of Wisconsin Extension have many good publications and websites to help the layperson identify exotic species. Periodically these agencies also offer exotic species identification and control training to landowners.

Aquatic Plant Management Recommendations

Since the EWM invasion of Sandstone Flowage is already well established it makes sense to consider all management options. Implementation will depend on landowner acceptance and commitment to funding a long-term management strategy.

Recommendation #1 – Form a Lake Protection District to stabilize funding and allow for continuity in management activities. Experience shows it is very difficult to undertake long-term lake management programs funded entirely by volunteer contributions. Forming a Lake District would allow the property owners of Sandstone Flowage to implement long-range plans with some assurance that funding would be available when needed. Lake Districts are also eligible for State Exotic Invasive Species Control Grants for EWM management and Recreational Boating Facilities grants for aquatic plant harvesters.

Recommendation #2 – Conduct early season 2,4-D treatments targeting areas of moderate to heavy EWM growth. Research shows that 2,4-D can selectively control EWM at relatively low application rates if applied early in the growing season. The application should occur prior to May 31 or before the water temperature reaches 65 degrees at a depth of 2 feet. This will limit damage to native pondweeds. Herbicide treatments have been effective at controlling EWM in water temperatures as low as 40 degrees F.

Treatment areas should be evaluated and mapped using GPS late in the summer prior to the year being treated. Map 1 identifies areas recommended for treatment in 2010. Herbicide applications will have to be repeated on a regular basis but not necessarily every year.

Several landowner surveys, and opinions expressed at public meetings, indicate that chemical control of EWM is fairly well accepted by shoreline property owners. Individually, a handful of landowners have been using this method for several years.

Recommendation #3 – Mechanically harvest wild celery and other native species where necessary for boat access. There are no aquatic herbicides that will <u>selectively</u> control wild celery. Those that will control it are very expensive ($1,800 – $2,900 per acre), cannot be used in flowing water, or are unlikely to be approved by the DNR because of fish toxicity issues. For this reason harvesting is the only viable management alternative.

Harvesting in areas dominated by wild celery or other native species should be limited to boat access lanes so property owners can reach open water, and limited cutting of lanes in dense plant beds where the local DNR fisheries biologist believes it will not harm the fish population (map 1).

Areas dominated by EWM can be harvested as well, perhaps negating the need to use herbicides at all.

Recommendation #4 – Work with WPS to conduct a drawdown of the flowage to test its effectiveness as tool for EWM control. The Association should contact WPS to explore the possibility of using periodic winter drawdown as a management tool. Its effectiveness in High Falls Flowage suggests it would be successful in Sandstone as well.

Ideally, as a private entity using a public resource (the Peshtigo River) WPS should be responsive to the needs of the public and should work in good faith to help manage the flowage for the public good. In reality, working with a large corporation is not always easy. The Association should also consult with federal (FERC) and state (DNR) regulators and keep them apprised of efforts to work with WPS.

Recommendation #5 – Reduce nutrient loading to the lake from developed shoreline properties. The Wisconsin Legislature recently banned the use of lawn fertilizer containing phosphorus except where soil tests show it is in short supply. Still the Association should promote the wise use of fertilizer (if any) on lakeshore properties. It is recommended that applications of nitrogen be limited to 3-4 lbs of nitrogen per 1000 square feet annually.
The Association should also promote the restoration of natural shorelines. These "shoreline buffers" reduce pollutant loading primarily by increasing infiltration. Additional benefits include improved shoreline habitat and less time spent mowing! The Marinette County LWCD has cost-share funds available to defray the cost of shoreline restoration.

Monitoring and Evaluation Plan

In order to evaluate and make changes to the management program the Association needs to track changes in the aquatic plant community. The management plan also needs to be evaluated on a regular basis and changed to meet evolving needs and address new challenges.

Recommendation #1 – Conduct aquatic plant surveys to evaluate management effectiveness and track changes to the lakes aquatic plant community. Surveys of the aquatic plant community should be completed with the application of any new management tool. For herbicide use, aquatic plant surveys should be completed before and after the treatment in and around areas to be treated. Pre and post-treatment plant surveys of the entire lake, or at least in representative areas, should be completed to evaluate the effect of any flowage-wide management tools such as winter drawdown.

Periodically the entire lake should be surveyed to evaluate lake-wide changes to the plant community. These routine surveys should be completed approximately every 5 years. Sooner if sudden changes in the plant community are noticed. All plant surveys should be completed using the same DNR point/intercept aquatic plant sampling protocol used in the 2006 plant survey. Dense plant beds should also be mapped using GPS and described.

Where grants are obtained to assist in aquatic plant management the cost of professional aquatic plant surveys can be included in the grant. Eventually however the Association should develop this capability from within its own ranks. The DNR and Wisconsin Lakes Partnership have many aquatic plant ID resources and offer periodic aquatic plant identification training. The Marinette County Land & Water Conservation Division can also assist.

Recommendation #2 – Appoint a committee to annually evaluate the aquatic plant management program and recommend changes to the Board. The Sandstone Flowage Association should appoint an aquatic plant committee to coordinate management activities, oversee data collection, and preserve aquatic plant management data. The committee should evaluate the management program and recommend changes to the Association Board.

Information & Education Plan

With aquatic invasive species (AIS) an ounce of prevention truly is worth a pound of cure. A strong information and education effort is an important part of any AIS prevention program. It is also important to effectively communicate with Association members when trying to implement a flexible aquatic plant management plan.

Recommendation #1 – Maintain signage at the boat landings and provide educational materials to visitors to Sandstone Flowage. Maintain educational signage at the Hideaway Lane boat landing and the WPS Campground landing to inform visitors to Sandstone Flowage about the danger of aquatic invasive species and how they can help prevent their spread. Signage should be clear and uncluttered. Handouts should be provided through the "Clean Boats, Clean Waters" program during busy periods. Signage and educational materials can be obtained from the Peshtigo DNR office or on line at Wisconsin Lakes Partnership or UW Extension Lakes Program websites.

Recommendation #2 – Publish a regular newsletter, provide educational materials, and update lake residents about AIS management efforts. The Association should publish a regular newsletter as a way of distributing educational materials and to keep members abreast of lake management issues. E-newsletters can be a cost effective alternative or supplement. The Association should also sign members up to receive the Lake Tides Newsletter, a free quarterly publication of the Wisconsin Lakes Partnership.

Recommendation #3 – Join the Wisconsin Association of Lakes and take advantage of their resources. The Wisconsin Association of Lakes (WAL) is a statewide lake organization that promotes sound lake policy and provides training opportunities for lake groups throughout the state. The Association should send a few members each year to the Wisconsin Lakes Convention, an annual event featuring numerous speakers, workshops and presentations concerning lake management, operating effective lake organizations, and other current issues affecting Wisconsin Lakes.

Aquatic Invasive Species Prevention, Monitoring and Rapid Response Plan

Unfortunately, Eurasian watermilfoil is not the only invasive aquatic species threatening our lakes. South of Marinette County curly-leaf pondweed (*Potamogeton crispus*) is an emerging problem. Other species including Hydrilla (*Hydrilla verticillata*), Brazilian waterweed (*Egaria densa*) and yellow floating heart (*Nymphoides peltata*) have been spreading north and may threaten our lakes in the future. Beyond the plant world we have Zebra mussels (*Drissena polymorpha*), Rusty crayfish (*Orconenctes rusticus*), exotic zooplankton, and fish diseases such as VHS to worry about. The best way to deal with these invaders is to be proactive and prevent their introduction. The Sandstone Flowage Association should also implement an exotic species prevention & monitoring plan to detect early invasions and a rapid response plan to deal with new invasive species if they are found.

Prevention

An effective AIS prevention plan should focus on the most common routes of AIS invasion, boats and water gardens. Boats traveling between lakes can carry plant fragments or zebras mussels attached to the boat or trailer. Water in the boat or bait buckets can carry plants, zebra mussels, zooplankton, algae, and disease causing organisms. While passive information and education materials can provide valuable information regarding the spread of AIS a more effective case can be made when delivering the message face-to-face.

Recommendation #1 – The Association should participate in the "Clean Boats, Clean Waters" watercraft inspection and information campaign. Volunteers should be trained to conduct watercraft inspections and talk to boaters about the danger of spreading invasive species. This is a good project in which to get youth involved. The CBCW program is sponsored by the Wisconsin Lakes Partnership. The County LWCD can assist in CBCW training. The Association should work with WPS to include CBCW inspections at their "private" campground landing as well.

Recommendation #2 – Education efforts should focus on the dangers of water gardening and the unintentional releases associated with the hobby. Mail order water garden plants are believed to be the source of hydrilla, an invasive exotic that was recently found growing in a Marinette County pond. It had been believed hydrilla could not survive this far north but the population was well established and expanding in the pond when discovered. On a positive note, the hydrilla was aggressively attacked and it appears to have been eliminated. A recent investigation of the water garden industry found that plants known to be invasive are available and routinely shipped around the country. Contamination of orders with other species, including invasive species, is also rampant (Maki, 2004).

Monitoring

Effective management of AIS is much easier when the invader is detected early. In some cases it may even be possible to eradicate an invasive species if it is discovered early enough.

Recommendation #1 – The Association should join the Citizen Lake Monitoring Network and train several members in AIS monitoring procedures. While the information & education program should equip all Association members with a basic knowledge of invasive species, several should be trained specifically for AIS monitoring. The Citizen Lake Monitoring Network holds training workshops to train volunteers in AIS monitoring protocol. They also provide a monitoring manual and laminated AIS identification sheets along with reconnaissance and reporting forms. The County LWCD can assist in AIS training, identification, and monitoring.

Recommendation #2 – Volunteer monitors should conduct annual AIS surveys of the lakes. Aquatic plant surveys, although very beneficial, are not designed to find many types of aquatic invaders and may even miss pioneer plant invasions. A better method is to look specifically for different invasive species at the optimal time and in the most likely habitats. The ideal monitoring time varies by species but all can typically be covered with one early and one late season survey. Trained volunteers should conduct annual invasive species surveys. Findings should be reported to the Association and the Citizen Lake Monitoring Network.

Recommendation #3 – Report any suspected aquatic invasive species to local resource professionals. If any suspected exotic species are found report it immediately to the Peshtigo DNR office and/or the County LWCD. Collect a sample of any suspected exotic species and keep it refrigerated in a zip-lock bag until it can be positively identified.

Rapid Response

When a new invasive species is positively identified the Association needs to act quickly. Depending on the species found, length of time since invasion, and where the pioneer colony is found, there may be a possibility for eradication. The following steps should be followed:

Step #1 – Notify local resource agencies and explore grant funding opportunities. The Association Board should immediately notify the Wisconsin DNR, arrange a meeting to explore control measures, and determine if an AIS Rapid Response grant is advisable. These grants were designed to deal with pioneer AIS infestations. The typical grant application process is bypassed so grant funds can be made available for quick action in hopes of eradication.

Step #2 – Notify membership of the discovery and what the Association plans to do about it. Notify Lake Association members of the discovery and explain what measures they can take to prevent its further spread within the lake or to other waters. Let them know how the Association plans on dealing with the invasion.

Step #3 – Conduct a thorough survey of the lake to determine the extent of the AIS infestation. Working with County and DNR staff, conduct a thorough survey of the lake to evaluate the extent of the invasion. Map location of the invasive species and record its density as well as any other physical data that may be important such as water depth, sediment type etc.

Step #4 – Determine if eradication is a possibility or if management is the only option. Work with local resource agencies and outside experts where necessary to determine if eradication is possible. Where eradication is not feasible begin revising the lake management plan to deal with the new species.

Step #5 - Develop an action plan based on species and extent of invasion. Work closely with the experts to develop a customized plan aimed at eradication or control.

If outside consultants are needed for things like herbicide treatment or scuba diving bring them into the process early. Many consultants can also help with things like mapping and planning.

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