# The Volunteer Aquatic Plant Survey (VAPS) protocol to monitor health of Great Lakes coastal marshes


Division between the Aquatic (Low Marsh) and Meadow (High Marsh) in a coastal wetland

by

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# INTRODUCTION

Coastal marshes occur at the interface between land and water and support high biodiversity since they contain both aquatic and terrestrial habitats and species. A large number of birds, turtles, snakes, frogs, fish, insects, and mammals use coastal wetlands at some point in their life cycle. Marshes are home to several vegetation types, some of which can only tolerate a short period of flooding, whereas others can tolerate no dessication. Since these wetlands form in shallow, protected embayments, they are also vulnerable to the destructive activities of humans, who have built homes and harbours near these protected environments on the shores of the Great Lakes. In fact, 75% of southern Ontario wetlands have been lost since colonial settlement, and majority of the remaining wetlands have been severely altered or impacted by human development.

Coastal wetlands consist of three main habitats: the ***aquatic*** portion (low marsh), which is largely flooded throughout the year, the ***meadow*** portion (high marsh), which extends from the edge of the aquatic environment to the tree line, and the ***upstream*** portion, which comprises forested wetlands that are located above the high-water mark; these upstream wetlands are hydrologically disconnected from the lake but may contribute flow into the wetland periodically (see **Figure 1**). The aquatic and meadow portions alternate their dominance according to the natural 7-10 y cycles of water-level fluctuations in the Great Lakes: when water levels are low, emergent and meadow vegetation dominate, and when water levels are high, submergent vegetation dominate. Without this inter-annual variation, either the aquatic or the terrestrial vegetation would dominate at the expense of the other.

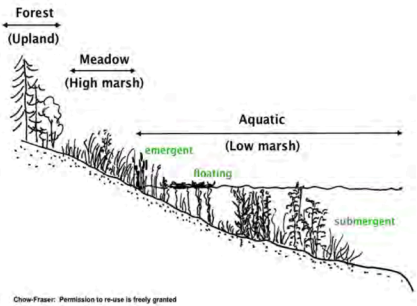


**Figure 1**: Schematic diagram of the three main wetland zones.

## The importance of good water quality

*Water quality* is a scientific term that we use to refer to a number of commonly measured parameters including the ionic properties of the water (conductivity, pH, salinity, total dissolved solids, dissolved macro and micro nutrients), the dissolved oxygen content or physical properties of the water (e.g. temperature, colour), the amount of suspended particles in the water (e.g. water turbidity, chlorophyll a content, total suspended solids) and the level of bacterial contamination. These parameters vary according to wetland geology and geomorphology, as well as the type of human activities in the watershed (e.g. agricultural, urban and industrial development). Pristine wetlands tend to have low nutrient levels, whereas human-disturbed wetlands tend to have high phosphorus and nitrogen inputs from watershed runoff that include manure and fertilizers from farmed land and lawn fertilizers and sewage from urban land. In 2006, Chow-Fraser developed the Water Quality Index (WQI) to assess the level of human disturbance in Great Lakes wetlands based on a suite of 12 water-quality parameters that *do not consider bacterial contamination.* The WQI allowed us to rank over 150 wetlands throughout the Great Lakes according to the degree of water-quality impairment. A pristine wetland, which has clear water, low nutrients and algal growth tends to have a score of >+2.0, while a degraded wetland, which has turbid water, high nutrients and high algal and macrophyte productivity tends to have a score of <-2.0 (see **Figure 2**).

**Figure 2:** Photo of a pristine wetland (top) and a degraded wetland (bottom)

## Why use aquatic plants?

The WQI was designed to allow environmental managers and scientists to monitor wetlands across the Great Lakes basin so that they can track changes in environmental quality through time (positive impacts as a result of restoration, or negative impacts as a result of urban and recreational development). Although the WQI is a good tool, it has several drawbacks as a routine monitoring tool. First, to measure the 12 variables is expensive and time-consuming and requires specialized equipment and chemical analyses that not readily available to environmental agencies. This led us to develop indices based on the presence or relative abundance of species in various water-quality conditions. The **W**etland **M**acrophyte **I**ndex (WMI) links the presence of certain groups of plants to the degree of human disturbance and assigns a low score (1 or 2) to certain plant taxa that are tolerant of high levels of human disturbance, and a high score (4 or 5) to taxa that are intolerant of human disturbance. The WMI score can range from 1 (highly disturbed) to 5 (pristine), and in practice, a score > 3.25 indicates good wetland conditions. As is the case for the WQI, WMI scores can be treated statistically, and used by environmental agencies to determine if the water-quality conditions in a wetland have changed significantly through time. Alternately, managers can monitor a number of wetlands at one time and compare their quality across the basin.

Compared to the cost and time required to measure water quality directly, surveying vegetation is fast and inexpensive. Even compare with other biomonitoring protocols that use fish or aquatic invertebrates, a plant-based protocol has an advantage because it takes only one field visit per year, when most aquatic plants have flowered (late July to early September), and it seldom takes more than 3 or 4 hours (usually less than 2 hours) to complete a survey, even in a very high-quality site with a diverse assemblage of wetland plants. There is no need to account for seasonality as is the case for fish and invertebrates, and there is no need to have any specialized equipment such as traps or nets. All the equipment required is a canoe, waders, and a garden rake, and an acceptable level of competence in identifying aquatic plants. Tests have confirmed that a WMI score that is representative of a site does not require all species of rare plants to be located and identified. In other words, even if only 60-70% of all plant taxa were identified for a particular site, an accurate WMI score would be generated. This led us to consider developing the **V**olunteer **A**quatic **P**lant **S**urvey (VAPS) protocol to extend the utility of the WMI so that citizens could participate in long-term monitoring.

## Development of the Volunteer Aquatic Plant Survey (VAPS)

VAPS is a rapid-assessment protocol based on the survey method we use to generate WMI scores for wetlands in our research program. In a pilot study, we compared WMI scores generated by experts (Mel Croft and Jon Midwood) with those generated by volunteers from Georgian Bay using the VAPS protocol, and we found no statistically significant differences. Therefore, we are confident that with proper training, volunteers can use VAPS to monitor the health of coastal marshes that they adopt.

## Main types of aquatic vegetation in the VAPS

It is important to keep in mind that the VAPS is primarily used to monitor the *aquatic* portion of the coastal wetland, which is important as fish habitat (see Figure 1); therefore, majority of the plants within the *meadow* and *upland* portions which are primarily terrestrial are excluded. Plants in the VAPS protocol are grouped into three main categories according to where the leaves and stems appear relative to the water surface, and we have organized the guide to help you identify species according to these three major groups:

**Floating plants** have leaves that are primarily floating on the water; **Submergent plants** have leaves primarily submerged while **Emergent plants** have leaves primarily emerging from the water surface.

NOTE: Some species change from floating to emergent, or from submergent to floating as they grow.

They can also be grouped according to ***growth forms*** as follows:

| | |
|---|---|
| Rosettes: | plants that have whorls of leaves arising at the base |
| Canopy: | submergent plants that have leaves growing up to the surface |
| Free-floating: | plants that are not rooted in the sediment |
| Macroalgae: | non-vascular plants that lack roots, stems and leaves and that tend to lie on or above the sediment, with at least parts of their stems, leaves and flowers emerging above the water surface |

## How to conduct VAPS:

A thorough survey of a site requires the selection of up to ten *quadrats* (sampling points) that will be surveyed by canoe or by wading (see **Figure 3**). At each location, you will survey plants within one meter on either side of the canoe or where you stand. You may need from 15 to 30 minutes at each quadrat. Try to choose sections that contain a variety of wetland plants: some in deeper open water, some along the shore, others within the lily pads, etc. If you are a novice, it may take 6-8 hours to complete the survey of the whole wetland, and it is alright to break this up into two days or two weekends during a single year.

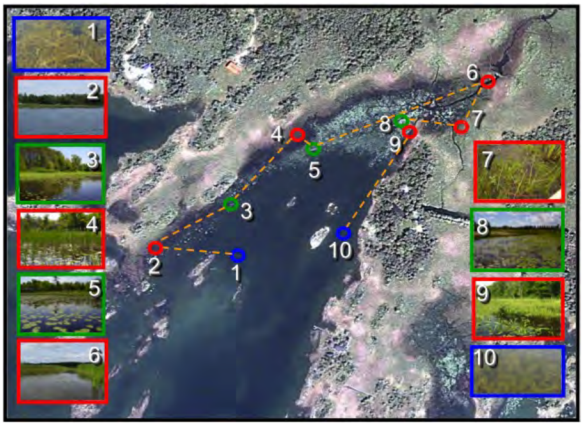


**Figure 3**: Location of quadrats during a survey. Points 1 & 10 (blue) were in deep, open water where submergent vegetation were sampled. Points 2, 4, 6, 7, & 9 (red) were in shallow water along the shoreline where emergent vegetation were sampled, and the remaining points (green) were sampled at intermediate depths where floating vegetation were identified.

**Minimum equipment you will need:**

- Canoe, kayak or row boat to get from quadrat to quadrat
- Chest waders or rubber boots to walk along the edge to see the shoreline species, where the canoe is not very useful.
- Survey Data Sheet (downloadable from http://urbanmonitoring.ca/)
- A pencil (ball-point pen may not write well on wet paper)
- If the water is too deep or murky to identify some plants, you may need a garden rake or pike pole to bring the plants to the surface

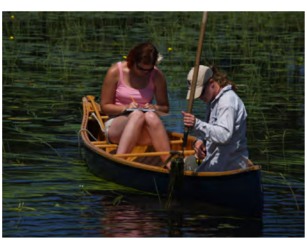

**Figure 3:** Gear commonly used to survey vegetation in Georgian Bay coastal wetlands.

**Optional equipment:**
If you have one, a digital camera to photograph any unidentified specimens is useful. In addition, a GPS unit to record the geographic coordinates of the sampling locations for future reference would also be useful.

The survey is best conducted in a canoe (see **Figure 3**). We recommend that you have at least one other person to help with identifying the plants and entering your data on the sheet.

**Website for additional assistance:**
For further information, please visit http://urbanmonitoring.ca/ and follow links to "VAPS". You can also use the ***WMI calculator*** located at the WIRENet website to calculate a score for your wetland:
http://wirenet.mcmaster.ca/indicators/calculator.php

## Concern about non-native invasive species:

Very often, when a wetland becomes enriched, one or two competitive species may start to grow more quickly than the others. This seems to happen more often when the species is not native to the Great Lakes, because they do not have natural predators and competitors here. An example of a submergent species that has this invasive behaviour is the Eurasian Milfoil (*Myriophyllum spicatum*), a species from the Baltic region that tends to take over areas it colonizes. An invasive emergent plant that has recently become a problem in the Great Lakes region is a strain of the common reed, *Phragmites australis*. It is important to eradicate these early in its invasion history, because once they have established, it is exceedingly difficult to eradicate them. In this guide, two asterisks in the Table of Contents means that the species is not native to the Great Lakes, regardless of whether it has an invasive behaviour or not.

## Frequently Asked Questions

***Whom do I call if I can't identify the plant?***

If you are having trouble identifying a plant, please take some photographs of the leaves, stem and flower and email them to chowfras@mcmaster.ca. If you have a scientific background, you can also use one of the complete guides for identifying wetland plants such as: A Great Lakes Wetland Flora, by Steve W. Chadde and Wetland Plants of Ontario by Newmaster, Harris and Kershaw.

***Is it important that I identify everything I see?***

No. In the VAPS Protocol, you will only find a portion of all species present in most Great Lakes wetlands. Remember that you do not need to identify all plant species in order to come up with a WMI score that is representative of the quality of your wetland.

***Is it unusual to spend more than an hour at each quadrat?***

If you are a novice at plant identification, you may find that it takes considerable time to identify all the plants found in one quadrat. Please do not be discouraged; it will get easier with practice!

***How much time should I spend in total?***

The survey shouldn't take much more than 4-6 hours in total but there is no need to complete the survey all at once. You can spread your sampling out over several weeks. If you adopt a very degraded wetland, then you may only find 4 or 5 species, and you may finish within an hour.

***I keep finding plants that are not in the guide, what should I do?***

As mentioned earlier, you do not need to identify every plant you come across in your transects. If you would still like to know what the plant is, you can email us with photos or consult A Great Lakes Wetland Flora, by Steve W. Chadde.

***How can I find out what the WMI score is? What do I do with the plant information I collected?***

Once you have completed the VAPS for your wetland, you can send us the data at the address indicated or go to our website: http://wirenet.mcmaster.ca/indicators/calculator.php where you will find a link to the "***WMI Form***", which you can use to enter your data and calculate a score for your wetland. Simply input your name, the wetland's name and its latitude and longitude (any GPS coordinate within your wetland is acceptable). Below this you can check off each of the species you have identified. At the bottom of the form, there is a box that will display the WMI score calculated for your wetland. Remember, a score of "1" is a very low score and a score of "5" is a very high score. A wetland in relatively good health will have a score > 3.25. Once everything is completed on the form, click the submit button and your information will be sent to us to add to our ever expanding database.

You can also send us the raw datasheets and we will then generate scores for your site. We would also love to have your feedback. Please direct your data, comments or concerns to **Dr. Pat Chow-Fraser.**


| | |
|---|---|
| **Mailing address** | McMaster University, 1280 Main St. West, LSB 224, Hamilton, ON L8S 4K1 |
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| **FAX:** | 905-522-6066 (Please make sure you direct it to my attention) |
| **Email:** | chowfras@mcmaster.ca |


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We wish to acknowledge the generous support of the GBA Foundation for past financial support in piloting the VAPS program, and especially Mary Muter and Roy Schatz for their encouragement and on-the-ground assistance. We are very grateful to the RBC Foundation for supporting the URBAN project, and believing that citizens can contribute meaningfully to long-term monitoring of our streams and wetlands. We especially thank the volunteers who gave up their summer afternoons to participate in VAPS and for offering suggestions to improve the protocol.

# Floating Leaves


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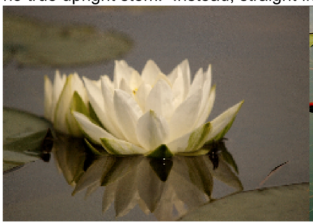
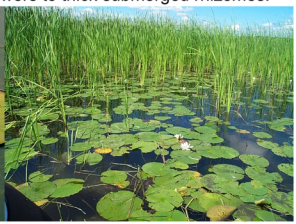
** Could be found in more than 1 growth form* ***Non-native to Great Lakes*

# Fragrant water lily *Nymphaea odorata*

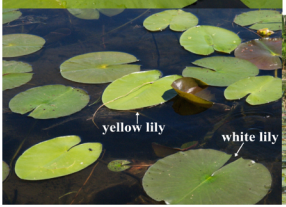
**Description:** This is one of the most common floating-leaved plants in wetlands, and has become a symbol of marshes. It is immediately recognizable by its round leathery leaves, with upper green and lower reddish coloration. It has numerous veins and the leaf stalk is attached to the leaf center at the base of a slit. There is no true upright stem. Instead, straight flexible stalks attach leaves and flowers to thick submerged rhizomes.

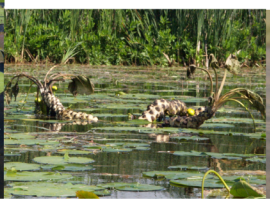
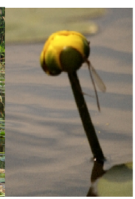




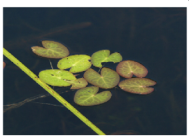
# Common yellow pond lily *Nuphar variegata*

**Description:** This is the familiar yellow pond lily that we have all seen with yellow, cup-like flowers, and heart-shaped leaves. The flower has 6 showy petals. The leaves are more oval-shaped than those of fragrant water lily. It tends to grow in protected, quiet areas of wetlands. It overwinters as rhizomes and seeds, and new leaves often have to emerge from the rhizomes in early summer and they bloom all summer long.



# Little floating hearts *Nymphoides cordata*



**Description:** Very small heart-shaped leaves 1.5-5 cm wide, with smooth outer margin. Each leaf is attached to the bottom by a long slender petiole (stalk). There are small white flowers with 5 petals. Sometimes, there are clumps of tiny roots growing at the base of the stem below the leaf, resembling a cluster of bananas. It is distinguished from the yellow lily by its distinctive leaf colouration, venation and small size. Pick up the leaf and see the dark red/purple colouration.

## Floating pondweed *Potamogeton natans*

**Description:** Stems slightly compressed 0.8-2.0 mm thick, simple, and **rarely branched.** Up to 2 m long. Submersed leaves are very reduced, nearly linear with bladeless stems, and disintegrate with age. Floating leaves are the only obvious ones, and are ovate, 3-10 cm long, 1-5 cm wide, rounded at the base. Flowers occur in dense clusters on cylindric spikes that are 2-5 cm long and are a dull green-yellow. Veins on leaves are parallel and converge at the tip. When enriched with nutrients, can grow in dense cover and crowd out other submergent plants. Since most of the leaves occur above the water surface, this species tends to be commonly in more eutrophic wetlands. In some lakes, this species can be considered a nuisance.

## Watershield *Brasenia schreberi*

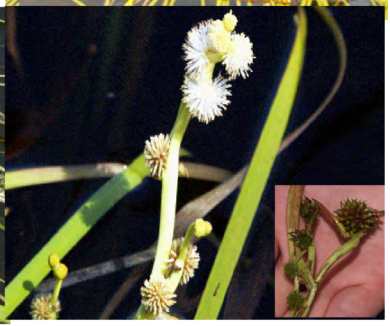

**Description:** Watershield is identified by the thick coating of gelatinous slime covering the young stems, buds, and the under-side of young leaves. The underside of leaves are reddish, as is the stalk, which is attached to the leaf at the centre, giving them a "shield" like appearance. Their flowers are small and purplish, and rise slightly above the water, but are not very showy. They are very different in size compared with the larger "heart-shaped" yellow water lily, and have much more fleshy leaves than the little floating heart. Roots are slender, branched and they also have creeping rhizomes. Can grow in water up to 3.0 m deep.

## Water smartweed *Polygonum amphibium*


**Description:** Stems tend to be reddish and have pink clusters of flowers on oblong spikes that are stalked. They are woody and stiff, unlike the broad-leaved pondweed. Can form mats on the edge of wetlands. Leaves float and are alternately arranged, large, up to 35 cm long and 6 cm wide with rounded or pointed tip. Leaf is stalked up to 5 cm long. In our surveys, this species has tended to occur primarily in Lakes Erie and Ontario.

# Floating burreed *Sparganium fluctuans*

**Description:** Compared with the wild rice leaf, that of the floating burreed is brighter green, and more fleshy. It lays flat on the water surface, and grows well in brown-coloured water. They grow from long rhizomes, with leaves that are alternate, limp, and floating like ribbons on surface of the water. It doesn't tolerate pollution and grows well in low nutrients, extending up to 2 m in length, but usually less. This plant occurs through N. America in lakes, ponds and wetlands, wherever there is slow moving water.

# Wild rice *Zizania palustris*

**Description:** Wild rice is a grass that grows in shallow water, slow-flowing environments. It also requires very clear water because it grows from seeds annually, and the stems and leaves must reach to the surface very quickly. It tends to disappear when there is too much nutrients and sediment, and therefore, it is a good indicator species of relatively pristine conditions. This species is native to the Great Lakes, while there is another species, *Z. aquatica*, that occurs in the St. Lawrence River and on the Atlantic and Gulf coasts. The seeds of wild rice can be harvested as a grain and eaten. The leaves of wild rice will first float, then eventually become emergent.Can be confused with floating burreed, but leaves of wild rice have a waxy texture. (see Emergents for more photos).

*This section is contributed by Dr. Lyndsay Smith-Cartwright*

## Lesser duckweed
*Lemna minor*

Robert H. Mohlenbrock. USDA NRCS

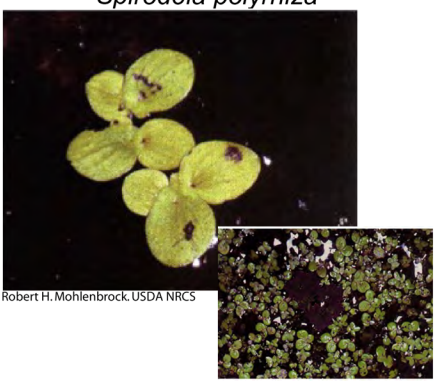
**Description**:This floating species is one of the smallest plants in the world. The plant is composed of a small, flat, green frond structure which floats on the water's surface. The frond is stalkless, can be round to oval in shape and is 2-4 mm in diameter. The underside of the frond is often slightly red in colour. A single unbranched root descends from the center of frond's underside. Generally found in still, calm waters such as ponds and ditches, in groups of 2-5.

## Star-duckweed
*Lemna trisulca*

Robert H. Mohlenbrock. USDA NRCS

**Description**: This species is similar to the Lesser Duckweed. The plant is composed of a small, flat, green frond structure which floats just below the water's surface. This species only floats on the water's surface when it is flowering. This stalked frond is branched, with several lance shaped fronds joining to create star shaped colonies. The fronds taper to a point, are flat on both sides and are 5-20 mm in length. A single unbranched root descends from the center of frond's underside. This species can also be rootless. Generally found in still calm waters, such as ponds and ditches, in colonies.

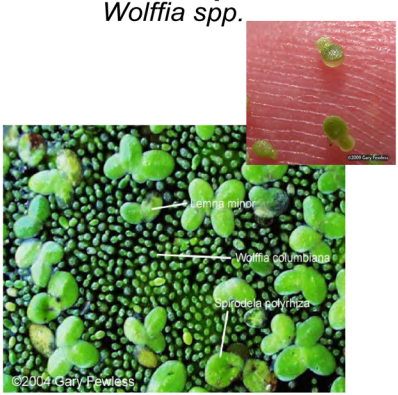
## Greater duckweed
*Spirodela polyrhiza*



Robert H. Mohlenbrock. USDA NRCS

**Description**: Similar to other duckweed species except the leaves are larger (5-8 mm across) and the undersides of the leaves are reddish-purple as opposed to the green of other species. Each frond (leaf) has multiple roots.

## Watermeal species
*Wolffia spp.*

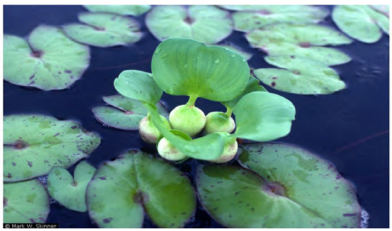


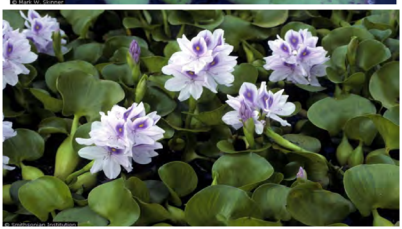

**Description**: Watermeal species are a floating species that are most often only 0.5-1.5 mm long, therefore making them smaller than duckweeds. They are also different from duckweeds because they lack roots.

*This section is contributed by Dr. Lyndsay Smith-Cartwright*

# Water hyacinth *Eichhornia crassipes*

**Description:** Free-floating wetland plants with circular, oval or elliptical leaves. Flowers are violet-blue with yellow streaks. Reproduces vegetatively through stolons. This plant is native to S. America and is an exotic invasive species in N. America. It grows rapidly and can form such dense mats that it blocks canals, river systems, and chokes out all other forms of life.



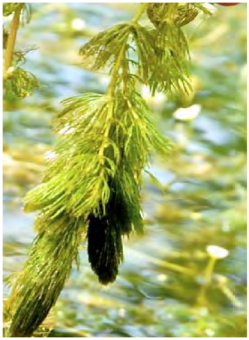


# Water lettuce *Pistia stratiotes*

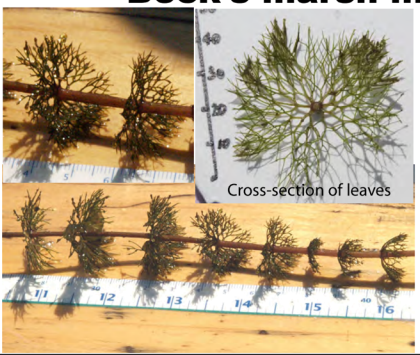
**Description:** An exotic species that is spongy and free-floating, resembling lettuce. It has very thick leaves, that are a dull green colour, hairy and ridged, up to 15 cm long. There are no leaf stalks present. The roots are feathery and light in colour, extending below the leaf. This species can occasionally form dense colonies.

## Coontail *Ceratophyllum demersum*

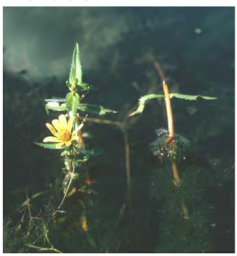

**Description**: smooth stem with 0-3 branches per node. Leaves are stiff, coarse, and curve slightly upwards. Leaves more crowded near branch tips giving it a "coontail" appearance. Retains shape when out of water. Roots absent, but anchored by white root-like leaves. Flowers if present are minute, inconspicuous and submsersed. Can grow at low light intensities and tolerate shade.



## Beck's marsh marigold *Bidens beckii*



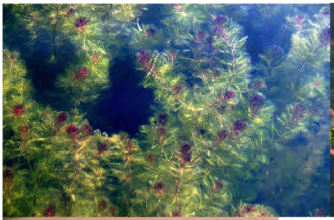

**Description:** Little branched, submersed leaves that are opposite or whorled, dissected into threadlike segments.These leaves have a branching pattern that radiates out like a fan. The flower has yellow petals, about 1-inch wide, at the end of a sturdy stalk. Most of the time, you will see only the submersed leaves. They exist in relatively clear water, in soft sediment.

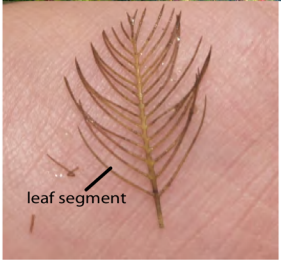


## Common Waterweed *Elodea canadensis*

**Description:**
Unbranched 20-100 cm long stems, round in section. Leaves are firm, with lower leaves opposite, but reduced in size. Upper leaves in whorls of 3, crowded in the uppermost. Flowers are found at ends of thread-like stalks, and float on top or are detached. Aggressive colonizer if light and nutrients provided.

# Eurasian milfoil *Myriophyllum spicatum*



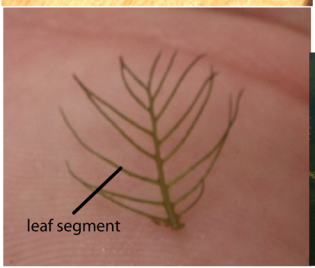



**Description:** Stems have many branches near water surface, and the distance between leaf nodes is about 1-3 cm long. There are **12-20 leaf segments** per side, more than the native milfoil (Below). Flowers float on surface in dense mats. This is an invasive exotic species to the Great Lakes. When it is present in dense mats, it usually signifies human disturbance because it needs a great deal of nutrients. However, because of its need for light, when wetlands become very degraded and turbid, Eurasian milfoil will disappear, and will be replaced by more turbidity-tolerant species such as the sago pondweed. It sometimes takes on a **red coloration near the tip** (Top left photo), and loses its shape when pulled out of water. Branches can be torn and carried from place to place (via boats or bird feet) and is a common way for this species to colonize without having to produce seeds (process referred to as fragmentation).

# Common water-milfoil *Myriophyllum sibiricum*

**Description:** Very similar appearance to Eurasian milfoil (above), and will often compete directly with it. Stems up to 1 m or longer, with leaves in whorls of 3-4; only **5-10 leaf segments** and fewer than Eurasian milfoil. Flowers occur in spikes, with whorled flowers and bracts, raised above water surface. They are pinkish red, clearly different from the underwater stems.

There are several other species of native milfoils in Great Lakes wetlands. These include *M. alterniflorum, M. tenellum, M. verticillatum,* but these do not occur commonly in our surveys. If you think you have a species of milfoil that is neither the Eurasian or the common milfoil, you should collect a specimen (preferably with flowers), and get it identified later. Note that each leaflet branches from central stalk.





# Common bladderwort *Utricularia vulgaris*

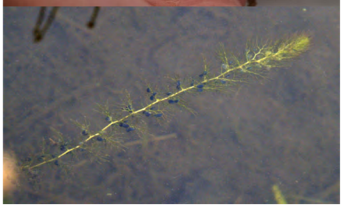
In water, the common bladderwort often appears as a ribbon of "stars" as shown in above photo. It is very flimsy and feathery, and because they have no roots, they seem to just float around. When taken out of water, they do not retain their shape, so best viewed in water.

**Description:** There are no roots and are free-floating. Sparsely branched stems that live submersed in water. Leaves can be up to 5 cm long, finely divided. There are many **bladder-like traps**, scattered among the leaflets, and they turn black when they are filled with prey (see photo to left). The flowers are 1-2 cm long, are yellow with two equal lips. They sit elevated above water surface on long stalks.

The common bladderwort is the species that you are most likely to encounter in these wetlands. However, in very high-quality sites such as those in Georgian Bay, you may find 5 other species: *U. gibba, U. minor, U. geminiscapa, U. purpurea,* and *U. cornuta,* which is an emergent species. There is also a species that is indicative of less pristine conditions called *U. intermedia.* If you find these species, you should collect a specimen, and have them identified at a later time.

The photo on to the left of the text shows a vegetative bud called a "turion" which helps to keep the plant alive through the winter.

Below you can see some photos of other bladderwort species. These are difficult to identify to species in the field.



These are examples of some of the rare species of *Utricularia* that we have found in some of the Great Lakes marshes.

It may take a trained eye to see them among other species of submergent plants, except when they flower in late sumner. The characteristic small yellow petals are catchy. Once you pull them out of the water, you will see the bladders that distinguish this genus from other submergent taxa.

*U. cornuta* is an emergent species

## Water lobelia *Lobelia dortmanna*

**Description:** This species is usually under water but sometimes can be found on exposed, sandy shores. The stems are upright, hollow, smooth, with milky juice. The leaves are in dense rosettes at base the of the plant, and are fleshy, hollow, stiff, 3-8 cm long. The flowers are pale-blue or white, about 1-2 cm long. Roots are white, forming large clumps. They are able to take up virtually all its carbon dioxide needs from the slightly acidic and low-nutrient sediments and release a substantial amount of oxygen during photosynthesis. This leads to close to saturation conditions at the root zone, and helps to ensure efficient aerobic degradation of organic matter. They grow in sandy sediments and are well adapted to the soft and dystrophic (tea-stained) water of wetlands that occur on the Canadian Shield. They are good indicators of high-quality sites of Georgian Bay, and are often associated with pipewort and quillwort.

## Quillwort *Isoetes sp.*

**Description:** Quillworts are a relative of ferns and have an ancient pedigree. They are last the remnant of the fossil tree lycopod. Leaves are dark green, grass-like and elongated, up to 30 in number, up to 20 cm long. The stem has much starch storage, and is very reduced. Roots are more like modified leaves than actual roots of higher plants. These plants are always submersed, and are indicators of excellent water quality. When a leaf is removed, a pouch can be found at the base of the leaf that holds small spherical spores used in reproduction.

## Pipewort *Eriocaulon aquaticum*

Segmented Roots

Pipewort is simlar to Lobelia except that it has a leaf-lessstem, and also has very narrow leaves.

**Description:** Pipewort is a tiny species that you may find at the edge of wetlands in clear water. Leaves are very thin, translucent, about 0.5-4.0 in long, in basal rosette. The stem is single, and typically less than 30 cm, but may extend 2-3 m in deep water. Flowers are white, with typically a wooly appearance and a 4-6 mm globe at the tip of the stem. You cannot mistake its identification when in bloom, because of its tiny white pinhead flower (bottom right image) sticking out of the water. The roots have a distinctive banded or segmented appearance.

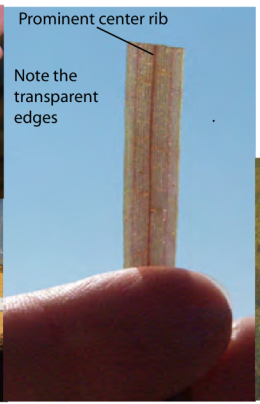
# Grassy arrowhead *Sagittaria graminea*

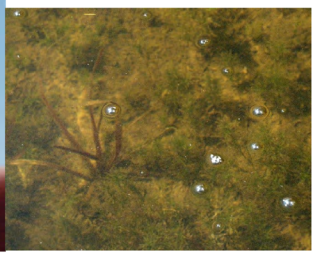
Different varieties of this species are recognized, and they may have leaves of different widths, and different lengths of pedicels (short supportive stalks for the flowers). The distinguishing feature for all of these is the grass-like basal rosette.

**Description:** Grassy arrowhead starts growing as tiny rosettes in shallow clear water where there is ample light. Therefore, they tend to grow near the edge of wetlands, in water < 60 cm deep. By the end of the season,it may appear as an emergent plant with 3-petalled white flowers (characteristic of all arrowheads). This species has long, narrow, needle-shaped leaves that are much smaller than the common arrowhead, which has broad leaves (see Emergents). Although it is described as submergent, it can also grow out of the water in damp soil.

# Tape-grass, water celery *Vallisneria americana*

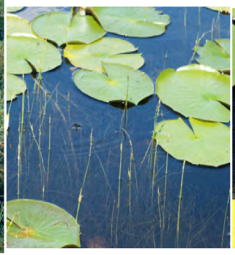
**Description:** Tape-grass is almost completely underwater, growing in green to reddish ribbon-like rosettes. They tend to grow from rhizomes (underground stems), and can be distinguished from other similar plants by the prominent center mid-rib on each leaf. They also have coiled, corkscrew-like flowers on stalks, and these are very different in appearance than other ribbon-like aquatic weeds. Tape-grass is a very common plant found in most healthy marshes. Although they may appear as small rosettes in shallow water, they also have a ribbon-like appearance in deeper water. In fact, some of the leaves can be very long, appearing as very long ribbons (see Submergents: ribbons). Hence, its name of "tape-grass" is quite appropriate. Regardless of size, though it still has the prominent mid-vein.

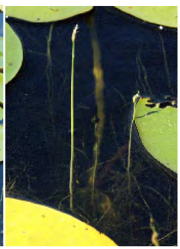


# Water-bulrush *Schoenplectus subterminalis*

**Description:** Unlike other species of bulrush that have stiff stems, water bulrush have weak, limp and, hair-like stems and leaves. The leaves and stems grow entirely under water, except for the flower spike, which rises above the water.



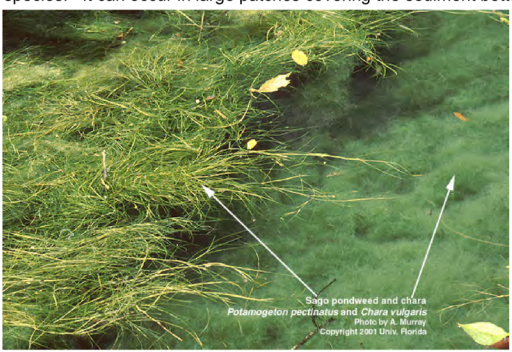


The solitary flower spikes are short, light brown in colour and appear to grow out of the side of the stems. Under the right kind of conditions (clear, quiet water), water bulrush can grow profusely and carpet the bottom of the wetland.

**Note:** Water-bulrush can be confused with sago pondweed (below) but water-bulrush occurs as single leaves emerging from the sediment while sago pondweed is highly branched.

# Sago pondweed *Stuckenia pectinatus*

**Description:** These are robust pondweeds that have narrow stems and leaves that are all submersed (3-10 cm) and only 1 mm wide. They have stipules (right photo) that are 2-5 cm long and are attached to the leaf. Flowers grow on spikes 1-4 cm long. Despite its narrow shape, it is very stiff to the touch and resembles tall underwater grass, unlike muskgrass *(Chara)* that is more like short grass (left photo). It is one of the most turbidity-tolerant species found in Great Lakes wetlands. Often in highly degraded sites it is the only submersed species. It can occur in large patches covering the sediment bottom.




Sago pondweed had earlier been called a species of *Potamogeton,* but is now known as *Stuckenia.*


**Note:** Water-bulrush can be confused with sago pondweed but water-bulrush occurs as single leaves emerging from the sediment while sago pondweed is highly branched.

# Slender pondweed *Potamogeton pusillus*

**Description:** These pondweeds have very slender, round stems, freely branched up to 1 m in length. The leaves are all submersed, linear, tapered to a stalkless base (1-7 cm long x 0.4-2 mm wide). They have a slighlty brown-green colour. Flowers are in short spikes, grouped in whorls on slender, upright stalks of 1-5 cm (see photo below). Very difficult to identify in water except when in shallow clear water.

Small size and slender form. Only one type of leaf is a diagnostic feature.

Slender pondweed is a common species, and may be confused with the northern snailseed pondweed (see below). The latter has short branches and also has two different type of leaves, and tends to be found only in pristine conditions.

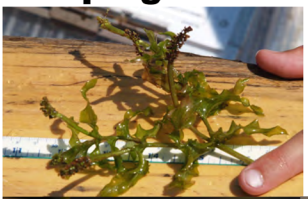
# Northern snailseed pondweed *Potamogeton spirillus*

**Description:** This is one of a few species that have two different forms of flowers and leaves. Some clusters have many flowers and cylindrical erect spikes, while others have few flowers, and are submersed in rounded flower heads. Tends to be found in undisturbed wetlands and can grow up to 1 m in length. It tends to have short branches that are often curved. Floating leaves are small and leathery (1-4 cm long x 5-12 mm wide). Submersed leaves are slender and can resemble those of the slender pondweed (1-8 cm long x .5-2.0 mm wide), but they are stalkless and rounded at tips. Leaves appear to droop down when viewed from above.

## Curly-leaf pondweed *Potamogeton crispus*

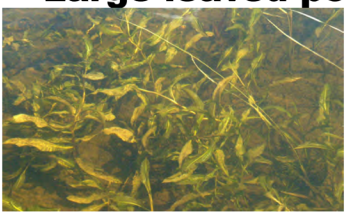
**Description:** This pondweed was introduced to N. America and is therefore referred to as an "exotic" species. It has a compressed stem, with few branches. It has stalkless, submersed, oblong leaves that are 8-9 cm long and 5-10 mm wide. They are rounded at the tip and have characteristic wavy margins. They flower in dense, cylindrical spikes that are 1-2 cm long. Along with sago pondweed, it can be found as one of a few submersed species that tolerate degraded conditions in urbanized marshes.

## Clasping-leaved pondweed *Potamogeton richardsonii*



**Description:** Stems are brown to yellow-brown, and round in section, and can have few to many branches. They are flexible, about 1.25 cm thick. Leaves are submerged, alternate and usually less than 10 cmm long x 2 cm wide. Lance to egg-shaped with prominent, parallel veins. Leave have a wavy edge and clasp onto the stem (wrap almost all the way around). There are no floating leaves. Flowers are small and are in clusters at stem tip (about 1.5-3 cm long). This species can grow in very deep water, and in dense patches.

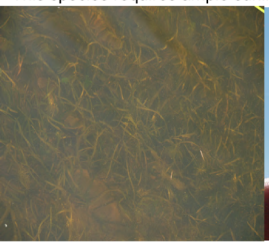
## Large-leaved pondweed *Potamogeton amplifolius*



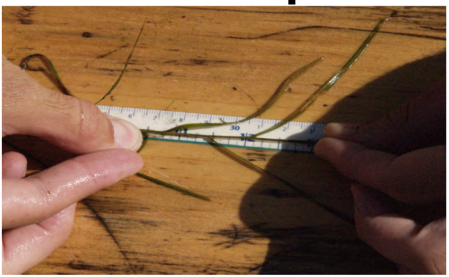
**Description:** Stems are round in section, usally unbranched, and can grow to 5 m long, 2-4 mm wide. Leaves are alternate, and have two types. Submersed types are bright to dark green, translucent, 8-20 cm long, 2-7.5 cm wide, folded along the midrib, curved backwards into a banana shape and sometimes with wavy margins. These have short stalks and lengthwise veins. There are also opaque leaves that are leathery, oval and tapered at both ends and are 5-10 cm long x 2.5-5 cm wide. They have 25-45 veins and 3-10 cm long stalks. Flowers occur as tight clusters arranged on a spike up to 5-cm long, rising above the water. Flower stalks are thicker than stems. Plant develops early in the season and may be well developed by mid-summer--sometimes starts to decay by August. Grows in clear, deep water--as deep as 6 m in some lakes.

# Tape-grass, water celery *Vallisneria americana*

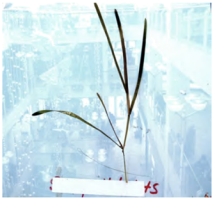
**Description:** Tape-grass is almost completely underwater, growing in green to reddish ribbon-like rosettes. They tend to grow from rhizomes (underground stems), and can be distinguished from other similar plants by the prominent center mid-rib on each leaf. They also have coiled, corkscrew-like flowers on stalks, and these are very different in appearance than other ribbon-like aquatic weeds. Tape-grass is a very common plant found in most healthy marshes. It can also appear as small rosettes as young plants (see Submergents: Other Rosettes). This species requires ample sunlight as well as nutrients, and are therefore not found in poor-nutrient sediment.




# Flat-stemmed pondweed *Potamogeton zosteriformis*



**Description:** Flat-stemmed pondweed has a characteristic flattened stem (see left photo). It also has long slender leaves, that are longer than the two species shown here. This species can be found in slightly disturbed conditions. The leaves of the flat-stemmed pondweed are more stiff than those of the ribbon-leaf pondweed, and they tend to hold their shape when removed from the water.



# Ribbon-leaf pondweed *Potamogeton epihydrus*

**Description:** This pondweed has both floating and submerged leaves. It differs from broad-leaved pondweed (above) in that there are long, thin, ribbon-like submersed leaves that have a broad light green central stripe. The floating leaves are oval-shaped and leathery. They may have a few branches under water, and the stem is somewhat flattened. These are widely distributed throughout N. America, and tend to be found in the shallower portions of the wetland. Note that the dominant leaf found in wetlands tend to be the submergent ones rather than the floating ones. See p. 19 to see comparison of this species with the variable pondweed.


These species are very robust forms that tend to retain their shape when taken out of the water. Variable pondweed has several types of leaves, including a floating one, but the most prominent form is the submergent.

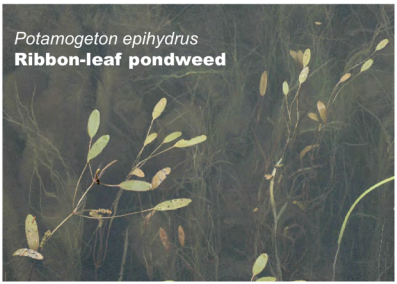
## Variable pondweed *Potamogeton gramineus*

**Description:** This pondweed has slender, slightly compressed and branched stems, up to 80 cm long and 1-mm wide. There are several types of leaves. Submerged leaves are linear, lance-shaped, or oblong (3-9 cm long x 3-12 mm wide) and are tapered to a stalkless base. There are also floating leaves (2-6 cm long x 1-3 cm wide) with a leathery texture. They flower in dense cylindric spikes, with stalks that are thicker than stems. Most often, these occur in shallow margins of wetlands, and are seen under water. See p. 19 to see comparison of variable pondweed and ribbon-leaf pondweed.

## Fern-leaf pondweed *Potamogeton robbinsii*

**Description:** Appears as a stiff, robust plant with underwater leaves only. They tend to have a dark green colour, with closely spaced leaves arranged in a rigid, flattened spray, giving it the appearance of a palm frond or fern. It is usually a low-growing plant, and approaches the water surface only when it is flowering. The flowering stalks have more widely spaced leaves that are less fan-like. Leaves can measure up to 12 cm long and 6 mm wide, and have many parallel veins. Said to prefer less alkaline water, and need very clear water because it grows as a low plant, and cannot tolerate any shading.

# Ribbon-leaf vs variable


Sometimes, it is difficult to distinguish between two pondweeds that both have floating leaves, but which also have submergent leaves. The best way to distinguish between ribbon-leaf and variable pondweed is to compare the shapes of the submergent leaves (see photo below). Ribbon-leaf pondweed have few narrow leaves that occur on rarely branched stems. By comparison, the variable pondweed tends to have shorter, oblong leaves that are more numerous and tend to occur on much-branched stems.

# Bluntleaf pondweed *Potamogeton obtusifolius*


**Description:** This pondweed has very slender stems that are highly branched, and can grow to be 1 m long. All of the leaves are linear, stalkless, and underwater, (3-10 cm long, 1-4 mm wide) and often have a red tinge. The leaves are rounded at the tip and have a broad midvein, with translucent glands at the base, and free, white stipules (1-2 cm). The flowers are thick and form a cylindric spike (8-14 mm) on upright stalks (1-3 cm).


# Vasey's pondweed *Potamogeton vaseyi*

**Description:** This pondweed has threadlike stems (20-100 cm long), that are highly branched, with short upper branches. Leaves that are submerged are linear and transparent (2-6 cm long, 1 mm wide) and tapered to a sharp tip. They are stalkless and usually have 1 vein, rarely 2. The stipules are free, linear and white (1-2 cm long), sometimes with 2 glands at the base. Floating leaves occur only on those plants that are flowering, and are obovate, opposite, and leathery (8-15 mm long, 4-7 mm wide), with 5-9 veins on each leaf. Flowers occur on top of 1-3 cm long stems, in cylindric spikes (3-8 mm long) and have 1 to 4 whorls of flowers.

**See this website for more pictures**: **http://www.maine.gov/doc/nrimc/mnap/features/potvas.htm**


Macro algae and Sponge

## Muskgrass *Chara sp.*

Green or gray-green in colour, growing entirely submersed in water. Individuals can grow to be very large (5 cm to 1 m in length).

**Description:** Muskgrass has a musky, pungent smell, often with a crusty texture. There are no true leaves, and it is not a vascular plant. Six to 16 leaf-like branchlets of equal length grow in whorls around the stem, never divided. Branchlets often bear tiny thorn-like projections. There are no flowers or fruits, and instead, they reproduce by spores through fruiting bodies. In some species, the fruiting bodies are orange and very conspicuous. Root-like holdfasts secure them to the sediment. They often carpet the bottom, but because they tend to be low-growing forms, they need clear water, and can grow in deeper water than vascular plants. There are many species, but we do not distinguish among them in this survey. Muskgrass tends to disappear in wetlands that become eutrophic and turbid.

## Stonewort *Nitella sp.*

**Description:** Stonewort is very similar in appearance to muskgrass. The main difference is the lack of a musky smell, and the crustiness. It has a bright green colour, again lying near the bottom of the wetland. They have 6-8 evenly forked branchlets that grow in whorls at regularly spaced intervals along the stem. Unlike the rough branchlets of muskgrasses, however, stonewort have a smooth texture. The best way to distinguish between the two is by smelling and touching them. They lack roots, flowers or fruits (same as *Chara*). Since they have no roots, they take nutrients directly from the water column. In our surveys, we do not distinguish between species of Nitella.

## Freshwater sponge

**Description:** Freshwater sponge is easy to recognize by its bright green colour. They are not plants, but are actually multicellular animals consisting of masses of cells embedded in a gelatinous matrix. The matrix is bound together by minute, spine-like calcium or silica spicules and an organic fibre called spongin. These can be very small, and can be missed if you are not looking out for them. About 150 species, but most of the 5,000 known sponges are marine. In wetlands, they appear as small projections (5-15 cm) near the sediment surface. The sponge lives together with green algae (which gives it the bright green colour). They feed by filtering large volumes of water through their pores, and capturing tiny food particles from the water. They are all free-swiminng in their larval stages, but then settle as they mature. They need well-oxygenated water and will not tolerate any kind of pollution. Therefore, they are excellent indicators of pristine conditions in wetlands. They take on various shapes and can have finger-like projections and/or irregular shapes. They are also surprisingly robust, and will retain their shape when pulled out of the water.

# Slender water nymph *Najas flexilis*

Slender water nymph grows completely submerged and is not an annual plant, like most of the other vascular aquatic plants such as the pondweeds, waterweeds, etc. They have only very short fibrous roots, and so can become dislodged and float to colonize new areas. They have opposite leaves that are often clustered near the tips of the stems. The leaf base is much wider than the rest of the leaf blade which has a tapered end (about 1-3 cm long). There is another water nymph which has blunt-tipped leaves, and are shorter and narrower (the common water nymph). The flowers are inconspicuous and tiny at the base of the leaves. If you find the fruit, it is oval-shaped and is located at the base of the leaves. Each fruit contains only one seed about 3-mm long. The entire plant is eaten by waterfowl, and therefore it is a highly desirable plant. This is a very common plant where water clarity is good. As long as the light penetration is good, it can grow to a depth of 4 m in lakes. In most of our wetlands, this is restricted to a depth of 1 m. Because of its low-growing form, it can sometimes be difficult to distinguish this from the water nymph, muskgrass and stonewort without pulling them out of the water with a rake, and looking at them close up.

## Common cattails
*Typha latifolia*


## Hybrid cattails
*Typha xglauca*


## Narrow-leaf cattails
*Typha angustifolia*


There are three cattails in Great Lakes wetlands. The N.American native species is the common cattail. The narrow-leaf cattail arrived from Europe several hundred years ago, and hybridized with the common cattail to produce the hybrid. Most of the cattails reproduce vegetatively. When they reproduce sexually, they need to have exposed shoreline to colonize. The species that can tolerate the deepest water is the hybrid, while the common cattail is most tolerant of dry-meadow conditions. The easiest way to **distinguish among the three is by looking at the distance between the male and female spikes.** The common cattail has almost no space between the two, while the narrow-leaf has the largest space, and the hybrid has intermediate distance. The common cattail also tends to have the widest leaf (>1 cm) and spike.

## Softstem bulrush
*Schoenplectus validus*

**Stems are stout, round and smooth.** Spikes are red-brown, 4-12 mm x 3-4 mm. Single or in clusters of 2 to 5 at the end of stalks, that appear drooping. Stem is a lighter green colour than the hardstem bulrush.

## Hardstem bulrush
*Schoenplectus acutus*

**Stems are round,** about 1-3 m high. Flowers occur in clusters grouped up to 60 spikelets. The **branches are stiff** and will rebound when bent backwards. Stem is a darker green colour than the softstem bulrush.

## 3-square bulrush
*Schoenplectus americanus*

Also called *S. pungens*. This species is distinguished from the others in that the flowers are held on the erect stem without any stalk. **The stems are also triangular, smooth** and up to 1.5 m tall. Tends to occur along the shore.

## Pickerelweed
*Pontederia cordata*

Pickerelweed has very brilliant purple flowers and reversed heart-shaped leaves that taper to a point.

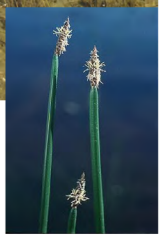
## Northern arrowhead
*Sagittaria cuneata*

Northern arrowhead has both emergent arrowhead-shaped leaves 5-15 cm long, narrow submersed leaves, and sometimes, also has oval-to-heart-shaped floating leaves. Stalks are usually triangular in cross section.

## Common arrowhead
*Sagittaria latifolia*

Common arrowhead has variable leaf shapes, but usually emergent and has the distinctive "arrow" shape. It is about 5-45 cmm long when mature. Flowers of this species are bigger than those of northern arrowhead. Sometimes leaves are much broader than shown here.

## Creeping spike-rush
*Eleocharis smallii*



Roots can fix nitrogen. They have creeping rhizomes.

Species is also known as common spike-rush (*E. palustris*). It has an erect, short stem that occurs at the edge of wetlands; can grow from 4-40 inches high. Distinctive single pointed spikelet at the tip of the stem. Leafless stems.

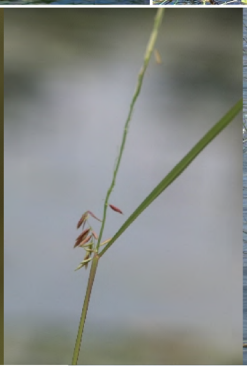
## Needle spike-rush
*Eleocharis acicularis*

Small, grass-like herbs that have oval-shaped brownish-flowering spikes at tips of smooth round stems. They grow individually or in clumps along shoreline or in shallow water, sometimes forming an ankle-high turf-like mat. Needle spike-rush looks hair-like when growing under water. The leaves are not very conspicuous and are located towards the base. There are usually slender, branching rhizomes and stolons rather than roots. They are adapted to highly fluctuating water levels. May resemble young sedge or rush, but doesn't grow larger than 15 cm.

## Giant burreed
*Sparganium eurycarpum*


Giant burreed has stout, smooth unbranched stems that can reach up to 5 ft high. Leaves are elongate, stiff and keeled, up to 2 cm wide. The fruits (achenes) are born in characteristic spherical clusters up to 4.5 cm in diameter. These are dull green-brown in colour, and are borne on stems without a stalk. The achenes are eaten by waterfowl.



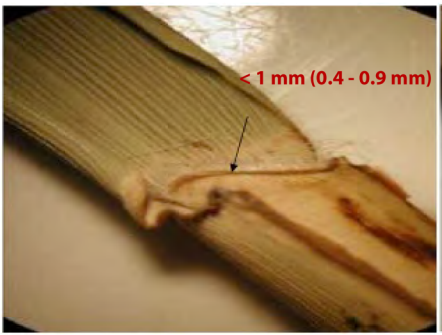

Wild rice is a species that starts out looking more like a floating plant, and can appear very similar in appearance to floating burreed (see Floating: ribbon-leaved on pg. 3) (top left photo). It then takes on an emergent growth form as it matures (see top right photo). It tends to grow in clear water, and is therefore a good indicator of water quality. Wild rice is an important food for waterfowl and wildlife.
The elongated grains of rice occur on the stem, and is harvested by N. American natives. They appear throughout eastern N. America wherever there is slow-moving water. This is an annual plant and is not a persistent species, even though they can tolerate some disturbance. Optimum depth for wild rice is about 1 m, although it can sometimes be found in deeper water. It needs to have a slight current to do well.
Its stems are thick and spongy,and its leaves are flat and strap-like. Leaf surfaces are smooth but they have rough margins and a waxy texture.

*This section is contributed by Dr. Janice Gilbert*

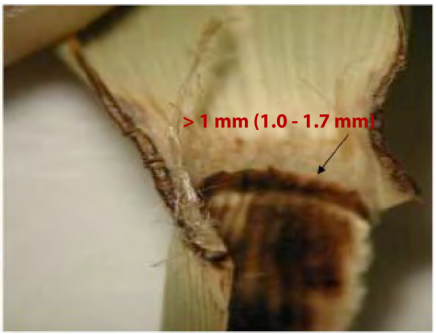
**Description**: Common reed, or the native Phragmites, is a tall perennial grass that is native to N. America. It is an important component in marshes, and unlike the invasive Phragmites strain, it does not tend to form large, dense monocultures that outcompete other native macrophytes. It is very difficult to tell the two strains apart, but it is possible by looking at the height, density, and seed head size, all of which are greater in the invasive. In addition, the native strain has smooth, reddish stalks whereas the invasive plant tends to have rough, brownish/yellowish stalks. Be careful when identifying species in sandy beaches or standing water however, as the invasive plants may have smooth, red-tinged stalks in these habitats. It is important to compare the glume size (native: 3.8-7.0 mm long; invasive: 2.6-4.2 mm long) and ligule of the middle leaf excluding the fringe (native: 0.4-0.9 mm high; invasive: 0.1-0.4 mm high).

**Ligule Width** (dark band indicated by arrow in photos below)

**Invasive**



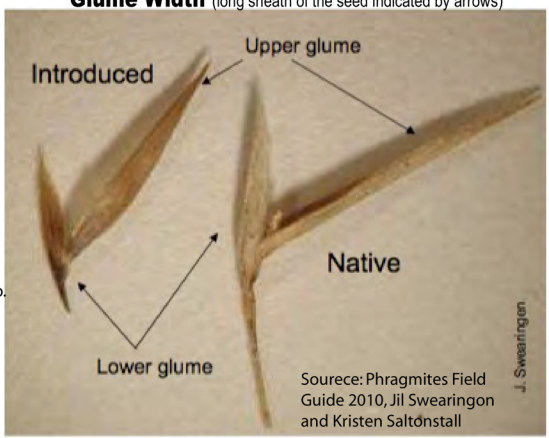

**Native**




**Glume Width** (long sheath of the seed indicated by arrows)

**Lower glume:**
2.5 - 5.0 mm
(most < 4.0)
**Upper glume:**
4.5 - 7.5 mm
(most < 6.0)

Note: measure from the base of the glume to its tip. Take measurements for at least 5 glumes (upper or lower) and then average.




Sourece: Phragmites Field Guide 2010, Jil Swearingon and Kristen Saltonstall

**Lower glume:**
3.5 - 6.5 mm
(most > 4.0)
**Upper glume:**
5.5 - 11.0 mm
(most > 6.0)

*This section is contributed by Dr. Janice Gilbert*


Examples of invasive strain in Lakes Huron and Erie are shown below