Maine Field Guide to Invasive Aquatic Plants

and their common native look alikes

MAINE CENTER FOR INVASIVE AQUATIC PLANTS
MAINE VOLUNTEER LAKE MONITORING PROGRAM

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Maine Center for Invasive Aquatic Plants
Maine Volunteer Lake Monitoring Program

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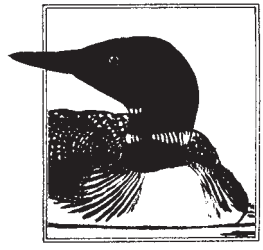

The Maine Volunteer Lake Monitoring Program (VLMP), formed in 1971, is the longest standing citizen lake monitoring program in the U.S., and the largest provider of scientific lake data in the State of Maine. Several hundred certified volunteers currently monitor more than 500 lakes through the VLMP. The VLMP mission is:

> *To foster stewardship of Maine's lakes and their watersheds, to insure high water quality and ecological integrity. This is to be accomplished by the collection of credible lake data by trained citizen volunteers, and by providing educational material to the citizens of Maine.*

The wide range of data collected by our volunteers is the cornerstone of the foundation of knowledge for Maine lakes. Data collected by the VLMP strengthens watershed education and conservation initiatives, and helps motivate positive action toward the protection and restoration of Maine lakes.

We have established many collaborative partnerships throughout Maine with entities and individuals who are focused on Maine lakes. Our partners include *state agencies*, such as the Maine Departments of Environmental Protection and Inland Fisheries and Wildlife, and the Maine Natural Areas Program, *public water utilities*, including the Maine Water Utilities Association, the Portland Water District and the Auburn Water District, *educational institutions*, including the University of Maine and Unity College, *regional lake conservation organizations*, including the Maine Congress of Lake Associations and Lakes Environmental Association and others including individual lake associations and watershed conservation groups, community planners, private citizens, and businesses.

In response to the growing threat to Maine waters by invasive aquatic flora and fauna, the VLMP formed the Maine Center for Invasive Aquatic Plants (MCIAP) in 2003. MCIAP was created to provide a citizen-based front line in the battle to protect Maine waters from aquatic invaders. MCIAP provides a wide range of training and networking opportunities, technical services and resources to support active public participation in the statewide effort to prevent the spread of aquatic invaders through prevention, early detection and rapid response to infestations. MCIAP's Invasive Plant Patrol Program (IPP) is widely recognized as one of the most comprehensive and successful training programs of its kind in the country. Nearly all of the aquatic invaders now known to be present in Maine were first detected by alert and informed volunteers. MCIAP has played a critical role in raising public awareness about the threat of aquatic invaders in Maine.

This Field Guide is one of several resources developed by the VLMP for public use in addressing the threat of aquatic invaders. We hope you find it helpful. Thank you for your efforts to protect Maine waters.

The Authors

ACKNOWLEDGEMENTS

Maine's Field Guide to Invasive Aquatic Plants is largely based upon a previous publication titled the *Field Guide to Invasive Aquatic Plants,* written by Amy Shnur and Scott Williams of the Maine Volunteer Lake Monitoring Program.

We thank the numerous volunteers, professionals, educators, students and others who have now put the original publication to test in the field, and have provided suggestions for revising and expanding this new edition. Readers will find many of these excellent ideas included in the new *Field Guide,* including: a simplified dichotomous key, spiral-bound format, more detailed plant descriptions, clearer images, several new identification aids, and more.

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We wish to thank all of those who so graciously contributed content to this project. (Please see page 140 for a complete list of sources.) Special thanks are owed to those whose work is found, or was heavily drawn upon, throughout this publication:
Don Cameron, Garrett Crow, C. Barre Hellquist, and the authors of *Through the Looking Glass, a Field Guide to Aquatic Plants*: Susan Borman, Robert Korth and Jo Temte.

The introduction of non-indigenous invasive aquatic plant and animal species to the United States has been escalating with widespread destructive consequences. The impacts of the spread of invasive aquatic plants are well known: habitat disruption, loss of native plant and animal communities, reduced property values, impaired fishing and degraded recreational experiences, as well as enormous and ongoing control costs.

With over 6000 lakes and ponds, and thousands of miles of stream habitat, the task of preventing the introduction and spread of invasive aquatic species in Maine waters is one of the greatest environmental challenges of our time. Invasive plants and animals are moved about in complex and often unseen ways. The speed at which a new introduction can explode into an ecologically and economically disastrous infestation is well documented. Once an invader is well established, eradication is extremely difficult and costly, if not impossible.

Early detection of an invasive aquatic organism ensures the highest probability of effective control. Though written for a general audience, the *Field Guide to Invasive Aquatic Plants* has been created most specifically to assist those directly involved in Maine's "early detection" effort: trained Invasive Plant Patrol volunteers, natural resource agency personnel and professionals, teachers and students, conservation groups, lake association members, anglers, and others. The guide is intended to serve as a convenient field reference; spiral bound for easy viewing, and printed on durable (tear-resistant and waterproof) paper.

The primary focus of the guide is the eleven invasive aquatic plants that are currently listed by Maine law as imminent threats to Maine waters. Also featured are some of the more common native aquatic plants that may be confused with these invasive species. Photographs, illustrations and narrative descriptions are presented for each of the featured species, with a variety of cross reference tools provided to facilitate comparison of similar species. *The guide does not include information on many of the most common native plant species found in Maine waters, because they do not resemble one of the eleven plants on Maine's invasive aquatic plant list.* Additional reference sources for identifying the broader array of Maine native plant species have been recommended in the *Sources* chapter.

Also included in the guide is a brief chapter titled *Other Invaders on Maine's Radar Screen.* Though not intended as a comprehensive listing, the chapter presents a quick visual guide to some of the other invaders (plants and animals) that users should be on the lookout for when out on Maine waters.

USING THE FIELD GUIDE

The primary purpose of this guide is to help users recognize the eleven invasive aquatic plants on Maine's invasive aquatic plant list, and to distinguish these invaders from their more common native look alikes. One does not need to have previous knowledge of aquatic plants to use this guide, or, for that matter, to successfully detect a suspicious aquatic plant. Indeed, most of the aquatic plant infestations known to date in Maine have been detected by those with limited experience in plant identification.

Though familiarity with the native plants is not a prerequisite for successfully screening waterbodies for invasive plants, it does provide some advantages. The more familiar one becomes with the plants that belong in a particular waterbody, the greater the likelihood that one will notice an "outsider" if and when it does appear. It is not unusual for one's familiarity with Maine's native aquatic plants to increase naturally during the survey process. This guide offers a starting point in this regard, providing useful information regarding some of the more common native plant species found in Maine waters.

Generally, only *common* native plants that share one or more notable characteristics with one of the eleven listed invaders are included in this guide. Less common species have been included only in cases where the rarer species is a very close look alike to one of the listed invaders. Recommendations for additional native plant identification resources are provided in the *Sources* section.

For those with some familiarity with aquatic plants, many of the more common plant species can be easily ruled out as being suspicious by observing them from a boat, using a viewing scope as needed. However, when one is starting out in unfamiliar territory, it is a good idea to plan on collecting representative specimens from suspicious or unknown plants for later, more-detailed observation. For some plant species, accurate identification is virtually impossible (even for the seasoned expert) without collecting specimens for closer scrutiny.

Tips For Using This Field Guide

1. Read through the *Background* section, especially the material on plant structure. If you have recently participated in Invasive Plant Patrol (or equivalent) training, a quick review of this section should be sufficient.

2. Use the simplified key provided on page 12 to determine a possible identification for the plant in question. Turn to the page(s) indicated, and compare your specimen to the featured plant(s). Also check your specimen against all of the look alike plants listed for each featured species. Plant names shown in colored fonts, where used, indicate native or invasive status: red indicates an invasive plant species and green indicates native plant species.

CAUTION: Even after one has ruled out all eleven invaders on Maine's invasive aquatic plant list, it still pays to be cautious. New invasive plants (plants that are not yet officially listed in Maine) may be introduced to our region at any time. If you notice a plant that seems to be spreading unusually fast, and you cannot identify it, please collect a specimen, and send it to MCIAP for identification, as described below. For more information on non-listed invaders, please see *Other Invaders on Maine's Radar Screen* on page 115.

3. Specimen collection should be done with great care. Select specimens for collection that are in relatively good condition (no major deterioration or insect damage), including any flowering or fruiting structures, winter buds, distinctly different leaf-types, or other features that may help with the identification. For floating-leaf plants, collect one or two floating leaves and a portion of the leaf stem, including any submersed leaves that may be present. For submersed plants, collect three or four small stem fragments (15 to 20 cm long), including the growing tips. For the diminutive bottom dwellers, select one or two individual stems or rosettes from the colony.

When collecting specimens, it is important to ensure that one's activity will not adversely impact the local plant populations. This is true whether the plants in question are suspicious of being invasive, or not. Native plant communities perform many functions that are vital to the ecosystem, and sometimes include rare or endangered species. For these, and many other reasons, native plants warrant our respect and protection.

But care must also be given when encountering invasive plants. Most invasive aquatic plants are easily spread by tiny plant fragments. Every effort must be made to minimize disturbance of such plants. Once an invasive species has been verified and the Maine Department of Environmental Protection has been notified a permit will be issued. The plants can then be carefully removed by those who have been *properly trained* to carry out such activity.

Plant specimens may be spread out in a tray of water (a white or light-colored tray works best) and observed. A good 5X to 10X hand lens is helpful for observing minute features. If multiple specimens are being collected, individual specimens may be placed (with enough water to float) in labeled zip-lock bags and stored in a cooler for later observation.

If you think you have found an invasive plant, mark the location of the plant with a weighted buoy and carefully collect a specimen for species confirmation. Place the specimen in a sealed container of water and store in a cool place. Alert the *Maine Center for Invasive Aquatic Plants* (207-783-7733 or mciap@mainevlmp.org) immediately. You will be given directions for shipping the specimen. Also, see *If You Find a Suspicious Plant* on page 113.

PLEASE DO NOT ATTEMPT TO REMOVE THE ENTIRE PLANT!

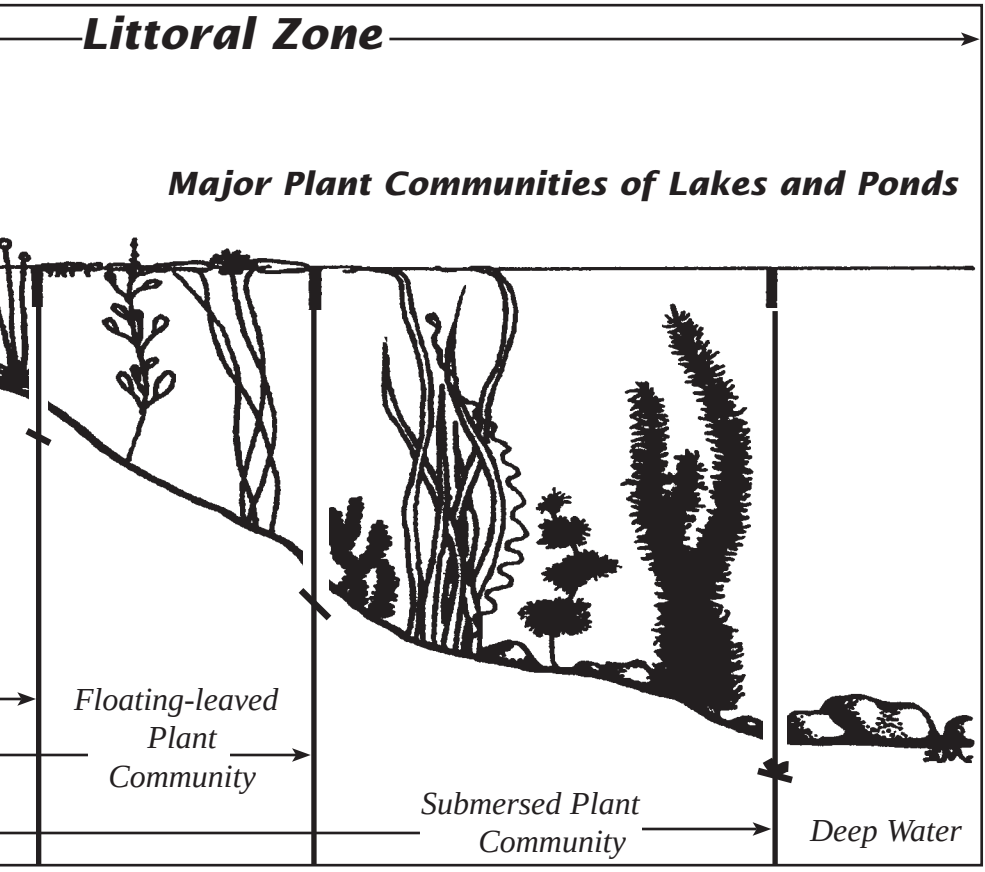
PLANT COMMUNITIES

Most aquatic plants are found in the near shore portions of the waterbody where sunlight penetrates to the bottom sediments. This portion of the lake, pond or stream is called the *littoral zone*. As water clarity and the bathymetry vary widely from one waterbody to another, the outer depth of the littoral zone also varies. The plants that grow in the littoral zone can be conceptually grouped into distinct communities. In reality, however, there is a good deal of overlap between communities.

EMERGENT PLANT COMMUNITY: This area extends from the wet shoreline soils into relatively shallow (knee-deep) water. With stiff but buoyant leaves and tough interlocking roots, emergent plants are well adapted to life at the water's edge where wave action and fluctuating water levels are common. The plants in this community play an important role in protecting water quality by preventing shoreline erosion and the resuspension of fine bottom sediments. They also provide important food and cover for insects, fish and waterfowl. Native plants commonly found in the emergent plant community (also referred to as "wetland" plants) include: cattails, arrowheads, pickerel weed, sedges and rushes.

Though there are invasive emergent plant species that threaten Maine's wetlands, none is currently prohibited by law as are the eleven aquatic plants on Maine's invasive aquatic plant list. Information on three of these invasive wetland species is presented on page 123.

FLOATING-LEAVED PLANT COMMUNITY: This area extends from the wet shoreline to chest deep water. Plants in this group are distinguished by tough, waxy leaves adapted to float on the surface of the water. Some floating-leaved plants have long, elastic leaf stalks extending to the bottom sediments. Others are free-floating. Native plants commonly found in this community include: fragrant waterlilies, watershield, spatterdock, and little floating heart. *Three of the eleven invasive aquatic plants on Maine's list are found in this community: European frogbit, yellow floating heart, and water chestnut.*



SUBMERSED PLANT COMMUNITY: This area extends from the shallowest depths to the deepest waters of the littoral zone. Plants in this community are adapted to life below the water surface, though many produce emergent or floating flowers that appear at or above the surface later in the growing season. Native plants found in this community may include: coontail, bladderworts, pondweeds, and the native water-milfoils. *Eight of the eleven invasive aquatic plants on Maine's invasive aquatic plant list are found in this community: Brazilian waterweed, curly-leaf pondweed, Eurasian water-milfoil, European naiad, fanwort, hydrilla, parrot feather, and variable water-milfoil.*

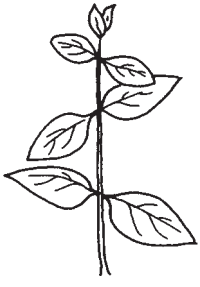
Water Marigold

PLANT STRUCTURE

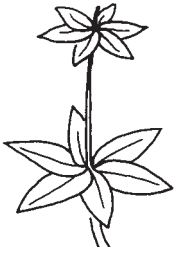
In order to identify an aquatic plant, begin by observing how the leaves are arranged on the stem. Then look carefully at a single leaf. Observe the leaf margins (outside edges) and the overall shape of the leaves. Next observe any additional features, such as flowers, fruits, and root structures.

Leaf Arrangements

Alternate



Opposite



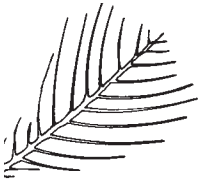
Whorled

Leaf Margins

Entire

Toothed or Serrated

Pinnately Lobed



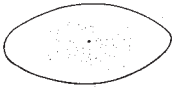
Finely Divided

Leaf Shapes

Triangular

Heart

Strap or Elongate

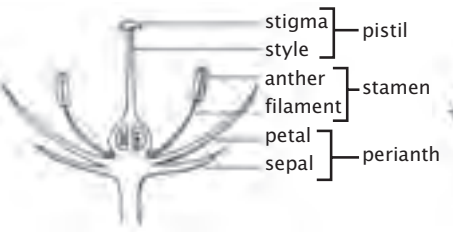


Oval

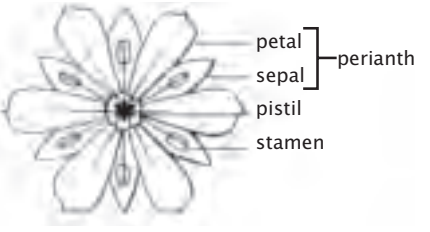
Elliptical

Lance or Blade

Flower Structures

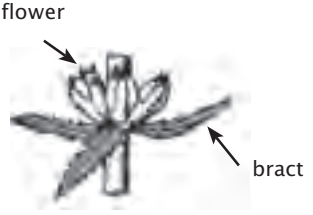


Flower parts (side view)

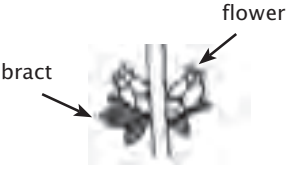


Flower parts (top view)

Bracts are specialized leaves associated with flowers. Note the "leaf-type" of the bracts and their size in relation to the flowers.



Bracts are serrated and larger than flowers (variable water-milfoil)

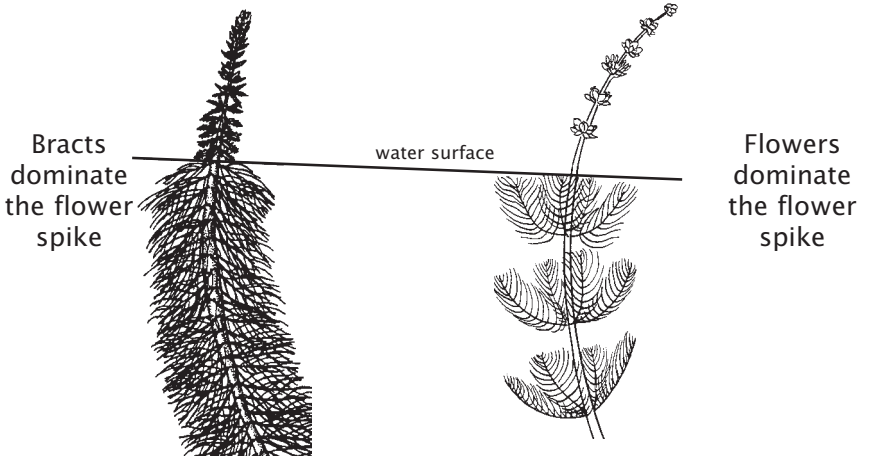


Bracts are entire and smaller than flowers (Eurasian water-milfoil)

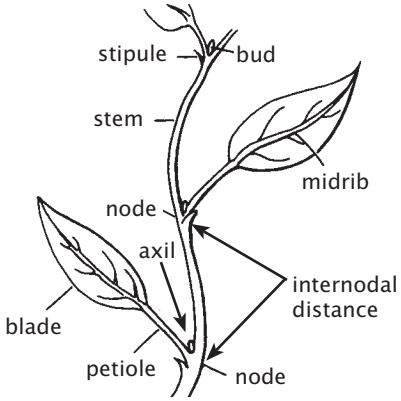
The illustrations below show the emergent flowering spikes of the invasive variable water-milfoil and Eurasian water-milfoil. Not all milfoil species flower above the surface.

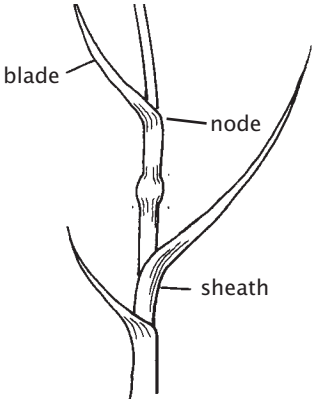
Variable water-milfoil

Eurasian water-milfoil

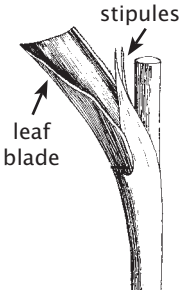


Stem and Leaf Structures

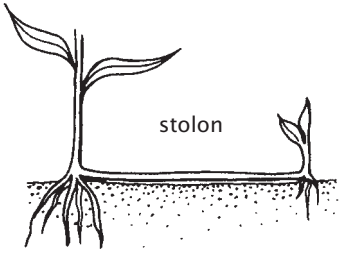




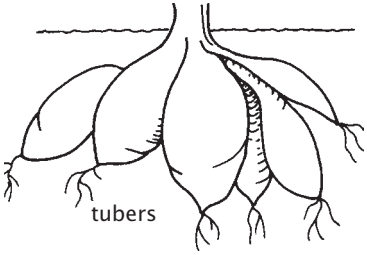
Turions, also called winter buds, are compacted vegetative buds produced along the stem that can overwinter and form a new plant

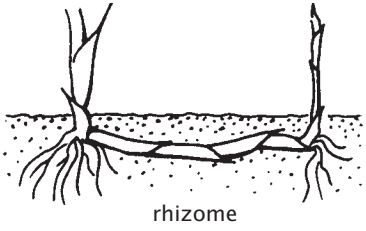


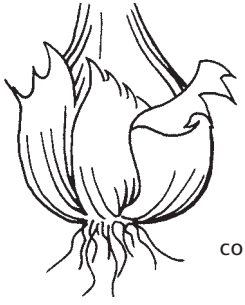
Stipules are sheath-like tissues associated with the leaf bases of some species

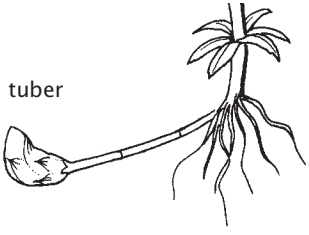


Root Structures



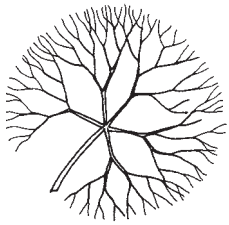






Finely-divided Leaf Patterns

Fork-divided

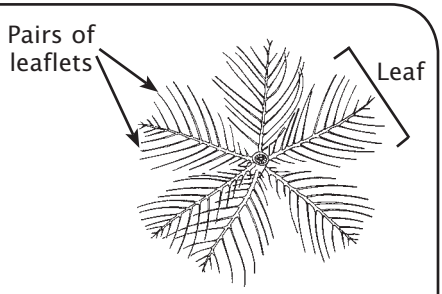


Branch-divided

Feather-divided

TIP: When identifying water-milfoils, check:

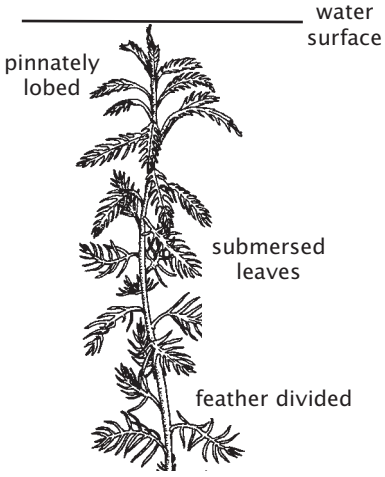
- The number of leaves in the whorls
- The number of paired leaflets on each leaf



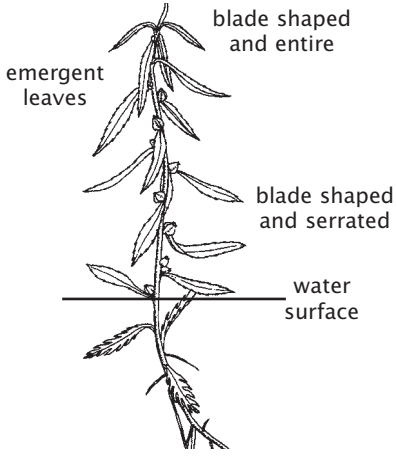
Milfoil stem cross-section showing a whorl of six feather-divided leaves

Leaf Heterophylly

Some plants have two or more distinct leaf types. Mermaid weed (illustrated below) is a good example.

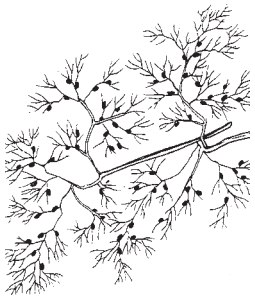


Submersed leaves are feather divided to pinnately lobed



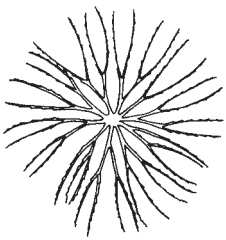
Emergent leaves are blade shaped, and serrated to entire

The four plants depicted below are all submersed plants with finely divided leaves. When seen in the water, these plants may appear similar. Closer observation of structure, however, will reveal the distinctions needed to identify each plant.



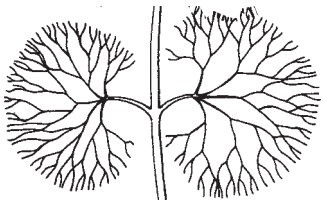
Side view

Common Bladderwort (NATIVE)
Leaves are finely branch-divided and arranged alternately along the main stem of the plant. Small bladders occur along the margins of the leaves.



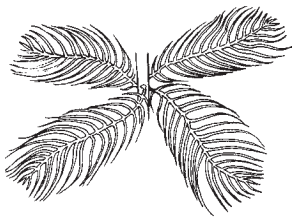
Cross-section

Coontail (NATIVE)
Fork-divided leaves are arranged in whorls along the stem. The leaves may be forked once or twice, and the leaf margins are finely serrated.



Side view

Fanwort (INVASIVE)
Finely branch-divided leaves are arranged in strict opposite pairs along the main stem. The leaves have slender leaf stems (petioles), and resemble tiny fans with handles.



Cross-section

Eurasian Water-milfoil (INVASIVE)
Finely feather-divided leaves are arranged along the stem in whorls of three to six leaves. Each leaf is comprised of 12 to 24 pairs of thread-like leaflets. The tips of leaves may be blunt, as if snipped off.

PLANT IDENTIFICATION KEY

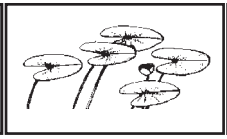
All eleven invaders on Maine's invasive aquatic plant list have characteristics that place them in one of four categories depicted below.

If the plant in question ***does not*** fit into at least one of these categories, you may rule out all eleven invaders! (This also means that you have likely found a native plant that is not featured in this guide.)

If the plant in question ***does*** fit into one of these categories, go to the numbered section indicated and choose between the optional descriptions presented. Continue making choices until you arrive at a page number where a possible match for your plant is featured. In some cases, you will be referred to more than one plant.

Compare your specimen to the plant or plants indicated. Also check your specimen against all of the look alike plants listed for each featured species.

1 	2 
Floating leaf plants *page 13*	Submersed plants with small (< 5 cm) undivided leaves arranged along stems *page 14*
3 	4 
Submersed plants with larger (> 5 cm) undivided leaves alternately arranged along stems *page 15*	Submersed plants with finely divided leaves *page 16*

1  Floating Leaf Plants

1. Floating leaves occur on long stems that are rooted to the sediment.

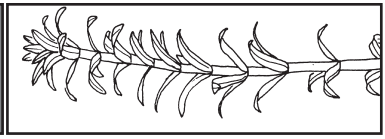
    a. Floating leaves are oval, with stems attached to the center of the leaf. (See **watershield**, page 94)

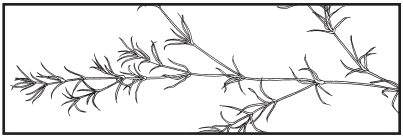
    b. Floating leaves are distinctly cleft, lobed and/or heart-shaped. (See **little floating heart**, page 92, **spatterdock**, page 90, **fragrant water lily**, page 88, and **yellow floating heart**, page 24)

    c. Floating leaves are conspicuously serrated and somewhat triangular, arranged in a loose whorl or rosette. (See **water chestnut**, page 22)

2. Floating leaves occur in bouquet-like clumps that are not attached to the sediment by stems and roots. (See **European frogbit**, page 20)

2





Submersed Plants with Small (< 5 cm) Undivided Leaves Arranged Along Stems

1. Leaves are arranged along the stem in strict whorls.

    a. Lance-shaped leaves; consistently 3 leaves per whorl. (See **waterweeds**, page 50)

    b. Generally more than three lance shaped leaves per whorl. (See **Brazilian waterweed**, page 36, **hydrilla**, page 44, and **mare's tail**, page 54)

    c. Whorls of thin, needle-like "leaves.” “Leaves” may appear barbed. (See **stoneworts**, page 104)

2. Leaves are strictly arranged in opposite pairs along the stem. (See **water starworts**, page 52)

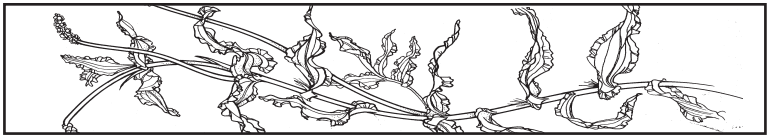
3. Leaves are alternately arranged. (See **pondweeds,** page 96)

4. Slender leaves occur in a mixed arrangement. (including opposite, whorls, and clusters)

    a. Leaves are finely but conspicuously serrated. Serrations are easily seen with a hand lens. (See **European naiad**, page 42)

    b. Leaves appear to be entire. Serrations are not easily seen, even with a hand lens. (See **native naiads**, page 100)

3



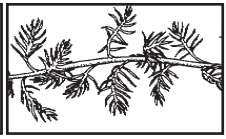
Submersed Plants with Larger (> 5 cm) Undivided Leaves Alternately Arranged Along Stems

1. Submersed leaves have distinct leaf stems. (See **large-leaf pondweed**, page 58)

2. Submersed leaves have no distinct leaf stems (are directly attached to main stem).

    a. Leaf margins are finely but conspicuously serrated. Serrations are easily seen with a hand lens. (See **curly-leaf pondweed**, page 38)

    b. Leaf margins are entire, not serrated. (See **clasping-leaf pondweeds**, **red pondweed**, **variable pondweed**, and **white-stem pondweed**, pages 56 - 65)

4  Submersed Plants with Finely Divided Leaves

1. Leaves are fork or branch divided.

    a. Leaves are (or *appear* to be) arranged in whorls. (See **hornworts**, page 70, **water marigold**, page 74 and **large purple bladderwort**, page 66)

    b. Leaves have conspicuous leaf stems and are strictly arranged in opposite pairs. (See **fanwort**, page 26)

    c. Leaves are alternately arranged. (See **bladder-worts**, page 66, and **water crowfoots**, page 76)

2. Leaves are feather divided.

    a. Submersed leaves are strictly arranged in an alternate pattern along the stem. (See **mermaid weeds**, page 72)

    b. Submersed leaves are radially scattered around the stem (like a bottle brush, but not strictly whorled). (See **Farwell's water-milfoil** and **low water-milfoil**, page 84)

    c. Submersed leaves are arranged in strict, or nearly strict, whorls. (See **Eurasian water-milfoil**, **northern water-milfoil**, **parrot feather**, **variable water-milfoil (and invasive hybrid)**, and **whorled water-milfoil**, pages 28 - 35 and 78 - 85)

Invasive Plant Patrol On-Lake Training

MAINE'S ELEVEN MOST UNWANTED INVASIVE AQUATIC PLANTS

This section covers eleven invasive species that are listed by law as posing a threat to Maine waters. Following the description of each plant is a list of possible look alike plants that may be confused with the invader.

INVASIVE AQUATIC PLANTS

Variable water-milfoil

EUROPEAN FROG-BIT

Hydrocharis morsus-ranae

NOT NATIVE TO MAINE - INVASIVE

Habitat: European frog-bit (or frog's bit) is found in the floating-leaved plant community. It is a free-floating plant that thrives in open marsh habitat and quiet backwaters, forming dense floating colonies.

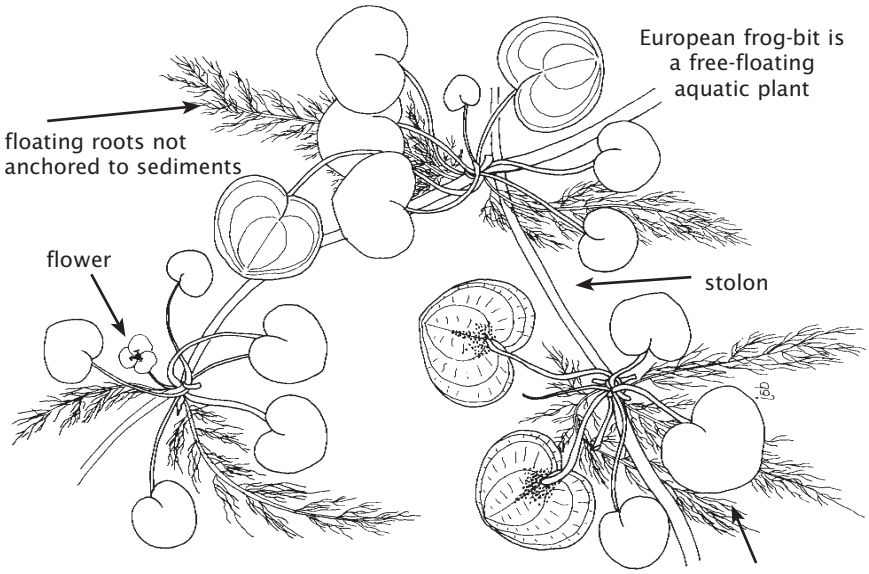
Description: European frog-bit is a small free-floating aquatic plant. Its small kidney or heart shaped leaves (1.5 to 6.5 cm long) are not anchored to the bottom sediments. The leaves have elongated stalks (4-6 cm long) and occur in clumps, forming a bouquet-like rosette. Unbranched root-like tendrils (resembling slender bottle brushes) dangle below. The flowers of European frog-bit have three white petals with a yellow center.

Origin and US Range: European frog-bit is native to Europe. It is not native to New England and is considered invasive to this area. Nearby populations occur in Vermont and New York.

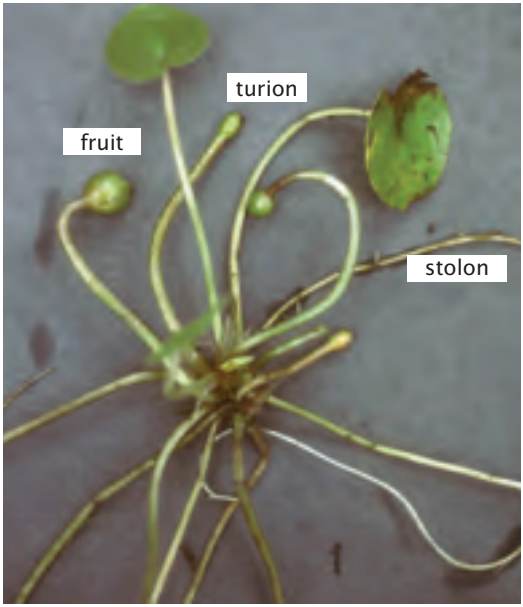
Annual Cycle: European frog-bit is an aquatic perennial that propagates primarily by vegetative means. Mature plants send out multiple offspring on trailing runners (stolons). Winter buds (turions) form during the summer, and fall to the bottom as plants begin to decay at the end of the growing season. In the spring the turions break dormancy, bob to the water surface, and sprout new growth. Flowers, followed by fruits, occur during the summer.

Look Alikes: May be confused with fragrant water-lily, little floating heart, spatterdock and watershield.

European frog-bit



Flower has three white petals and a yellow center



Reproductive structures

Heart shaped leaves occur in clumps

WATER CHESTNUT

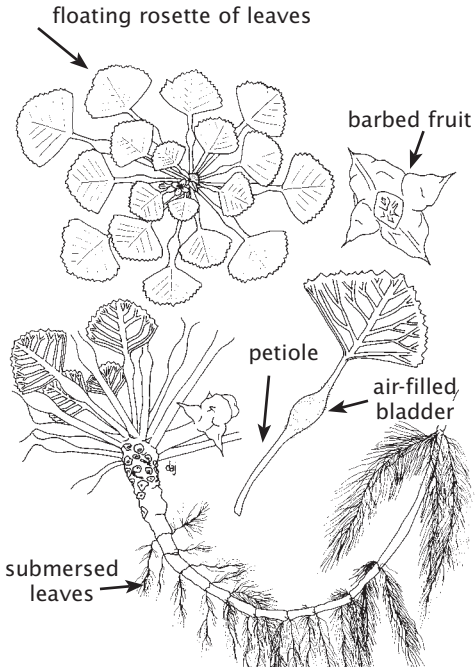
Trapa natans

NOT NATIVE TO MAINE - INVASIVE

Habitat: Water chestnut grows in the floating-leaf and submersed plant community. It thrives in the soft sediments of quiet, nutrient rich waters in lakes, ponds and streams. The plant is well adapted to life at the water's edge, and prospers even when stranded along muddy shores.

Description: Water chestnut has two distinct leaf types. The floating leaves are somewhat triangular (or fan shaped) in form, with conspicuously toothed margins along the outside edges. The upper surface of the leaf is glossy, the undersides covered with soft hairs. The leaves are arranged in a loose, radiating pattern or rosette and joined to the submersed stem by long leaf stems, or petioles (up to 15 cm long). Spongy inflated bladders in the petioles provide buoyancy for the rosette. The rosettes are anchored to the sediments on stems reaching lengths of up to 5 meters. The first submersed leaves to emerge are alternate, linear and entire, but these give way as the plant develops to feather-like finely divided, leaf-like roots (or root-like leaves—there is ongoing debate as to which is correct). The upper leaf-roots contain chlorophyll, causing them to be greener. When water levels drop, those lower down anchor the plant to sediments. Small white flowers appear above the rosettes in mid to late July, each emerging from its own stalk from the axils of the floating leaves. When the fruits form they submerse and dangle beneath the rosette. The fruits are woody and nut-like, typically with four sharp barbs.

Water chestnut has two distinct leaf types



Water chestnut (*Trapa natans*)

Small white flowers occur among floating leaves

Fruits have four sharp barbs

Origin and US Range: Water chestnut is native to Europe, Asia and tropical Africa. It is cultivated in Asia and other parts of the world where the fruit is eaten. It was brought to this country in the late 1800s as a showy botanical garden specimen and later escaped to become a noxious aquatic invader. Nearby populations occur in New Hampshire, Connecticut, Massachusetts, New York, Vermont and Rhode Island.

Annual Cycle: Unlike most aquatic plants, water chestnut is a true annual. Plants sprout anew each year from seeds overwintering in the sediments. Submersed stems grow rapidly to the surface, where the floating rosettes form and the flowers and fruits develop. During the growing season rosettes may become detached and float to new areas. Water chestnut flowers from July to September. The fruit, or nuts, begin to appear by late summer. Each water chestnut seed can produce 15 to 20 new rosettes and each rosette can generate up to 20 seeds. At the end of the growing season, frost kills the plants and decomposition is rapid. The nuts fall and sink into the sediment where they over-winter and sprout in the spring. The nuts may remain viable for up to 12 years but most germinate within 2 years. The nuts have sharp barbs that readily attach to boating gear and wildlife and are easily dispersed by natural and human processes.

Look Alikes: Water chestnut is not easily confused with other aquatic plants.

YELLOW FLOATING HEART

Nymphoides peltata

NOT NATIVE TO MAINE - INVASIVE

Habitat: Yellow floating heart is found within the floating-leaved plant community. It can grow in various substrates (sand, mud, gravel, etc.), in littoral areas ranging from the damp mud along the water's edge to water depths of 4 meters.

Description: Rounded to heart-shaped floating leaves emerge on long stalks from rooted stems. Each rooted stem supports a loosely branched group of several leaves. *Note that all heart-shaped floating leaved plants that are native to Maine produce only one leaf per rooted stem.* The leaves are typically wavy (shallowly scalloped) along the outer edges and have purplish undersides. Leaves average 3 to 10 cm in diameter. The flowers are showy (3 to 4 cm in diameter), bright yellow with five distinctly fringed petals. They are held above the water surface on slender stalks with 1 to 5 flowers per stalk. The fruit capsule is 2.5 cm long and contains numerous seeds. The seeds are oval and flat (about 3.5 mm long) and hairy along their outer edges.

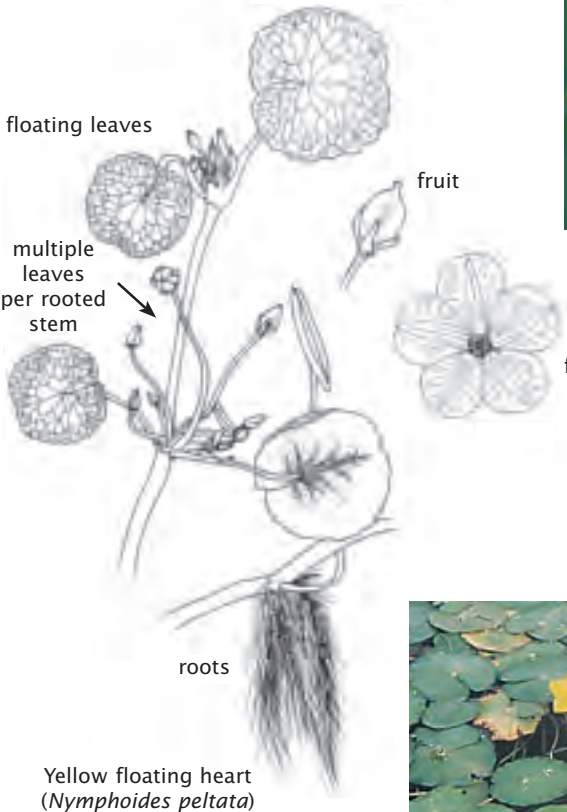
Origin and US Range: Yellow floating heart is native to parts of Europe and Asia. It is not native to North America and was introduced to this country as an ornamental pond species. Nearby populations occur in Massachusetts, Vermont, Connecticut and New York.

Annual Cycle*:* Yellow floating heart is an aquatic perennial that propagates by seeds, fragmentation, and spreading rhizomes. Most floating leaved plants lack the ability to propagate by fragmentation, but in the case of yellow floating heart broken leaves with attached stem parts will form new plants. Viable seeds are produced abundantly and germinate readily. Seed hairs help the seeds float and aid their attachment to waterfowl, increasing possibility of spread to new areas.

Look Alikes: May be confused with European frogbit, fragrant water lily, little floating heart, spatterdock, and watershield.

Floating leaves often have wavy margins

Yellow flower has five delicately fringed petals



Yellow floating heart (*Nymphoides peltata*)

Yellow floating heart

FANWORT

Cabomba caroliniana

NOT NATIVE TO MAINE – INVASIVE

Habitat: Fanwort is found in the submersed and floating-leaved plant communities, growing in a variety of substrates including sand, mud and gravel. It thrives in stagnant or slow moving waters of lakes, pond and streams in depths of up to 2.5 meters. Large mats of drifting fragments may occur.

Description: Stems emerge at intervals from slender roots. Fanwort has two distinct leaf types. Submersed leaves are finely divided, widely branched, and held apart from the stem on slender leaf stems, or petioles, and resemble tiny fans with handles. The leaves are strictly arranged in opposite pairs along the main stem. The orderly formation of leaves and stems gives the plant a tubular appearance underwater. Plants range in color from grass green to olive green to reddish. Small oval to elliptical floating leaves, 1 cm long, occur at the surface. They are alternately arranged on slender petioles attached to the center of each leaf. Small white flowers (1 cm in diameter) develop among the floating leaves.

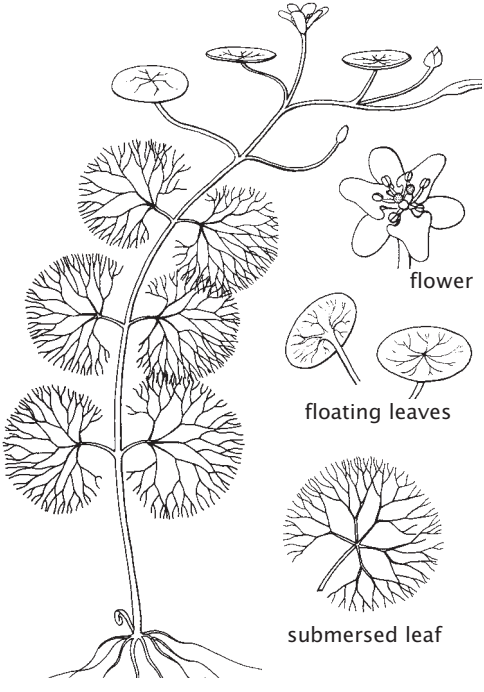
Forming a mat at the surface the submersed leaves may appear robust and resilient; notice the small clusters of floating leaves located near the two flowers

The small flowers have six white petals

Origin and US Range: Fanwort is native to Europe. The previously held belief that this plant is also native to some parts of the southeastern United States is now under debate. It is not native to New England. An attractive plant, fanwort has long been popular in the aquarium trade. Release from aquaria into the environment is considered to be one of the ways this plant has spread beyond its natural range. Fanwort occurs, and is considered invasive, in many parts of the United States including the nearby states of New Hampshire, Massachusetts, New York, and Rhode Island.

Annual Cycle: Fanwort is an aquatic perennial that propagates primarily from stem fragments and root expansion. In the spring, new growth emerges from buried roots and over-wintering stem fragments. Plants grow rapidly to the surface, often forming dense mats. Flowers are produced from May to September. Although fanwort is self-pollinating, seed germination in areas beyond its natural range does not appear to be significant. Both the roots and stems are easily broken as the season progresses, facilitating vegetative spread to new areas.

Look Alikes: May be confused with bladderworts, hornworts, mermaid weeds, water crowfoots, and all leafy water-milfoils.



Fanwort has two distinct leaf types

Long leaf stems and strictly opposite arrangement are key features

EURASIAN WATER-MILFOIL

Myriophyllum spicatum

NOT NATIVE TO MAINE – INVASIVE

NOTE: All leafy milfoils display a wide range of vegetative variability. Any milfoil found in Maine waters should be considered "suspicious" until a positive identification has been confirmed by someone with the appropriate expertise.

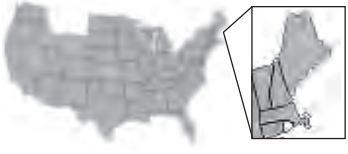
Habitat: Eurasian water-milfoil is an extremely well adapted plant, able to thrive in a wide variety of environmental conditions. It grows well in still and flowing waters, tolerates mild salinities and can survive under ice. Eurasian water-milfoil grows rooted in water depths from 1 to 10 meters, generally reaching the surface in depths of 3 to 5 meters. Though adapted to a wide variety of substrate types, this species seems to favor fine-textured, inorganic sediments.

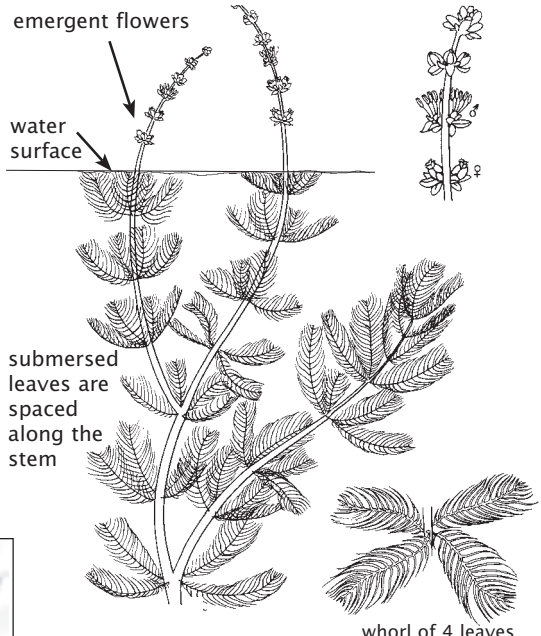
Description: Branching stems of Eurasian water-milfoil emerge from dense, spreading roots. The leaves are arranged in whorls of 3 to 6 leaves (4 leaves per whorl is common). The whorls are openly spaced along the stem, with 1 to 3 cm between nodes. The leaves are finely feather-divided, typically with 12 to 24 pairs of thread-like leaflets on each leaf. Since the leaves of other milfoil species generally have fewer than 14 leaflet pairs, counting leaflets can provide helpful clues to identifying Eurasian water-milfoil. (Note that the occasional Eurasian milfoil leaf may have as few as 5 leaflet pairs. For this reason it is always advised to count leaflet pairs on several leaves, taken from various points along the stem.) The tips of the leaves often have a blunt, snipped-off appearance. Flowers and bracts occur in whorls on slender flower spikes that rise above the water surface. The bracts have smooth margins and the flowers are generally larger than the bracts. Eurasian water-milfoil does not form winter buds.

Whorls are openly spaced along much of the stem

Whorl of leaves; typically greater than twelve leaflet pairs per leaf

Origin and US Range: Eurasian water-milfoil is native to Europe and Asia. It was introduced to North America in the 1940s. Spreading rapidly since its introduction, Eurasian water-milfoil is now present in most states, *including Maine*. It also occurs in most Canadian provinces including Quebec.





Eurasian water milfoil (*Myriophyllum spicatum*)

Annual Cycle: Eurasian water-milfoil is an extremely hardy aquatic perennial that propagates through root division, fragmentation, and seeds. Flowering spikes typically emerge from the water in mid to late summer, but not all colonies produce flowers. Auto-fragmentation may occur during the growing season with stem sections developing roots even before they separate from the parent plant. Toward the end of the growing season some plants break apart and die back to their rootstalks; others overwinter intact. New growth sprouts from roots and overwintering plants and plant fragments as the water begins to warm in the spring, growing rapidly toward the surface. Certain milfoils are able to hybridize with other, closely related, milfoil species. Eurasian water-milfoil is known to hybridize with Maine's native northern water-milfoil.

Look Alikes: May be confused with bladderworts, hornworts, mermaid weeds, water crowfoots, and other leafy water-milfoils.

Eurasian water milfoil forms dense, tangled stands

Flowers and bracts are arranged in whorls on the emergent flower spike; the flowers are larger than the bracts

VARIABLE WATER-MILFOIL

Myriophyllum heterophyllum

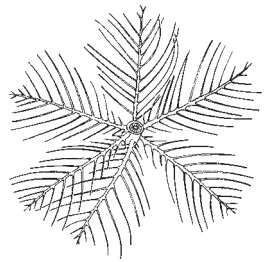
NOT NATIVE TO MAINE - INVASIVE

NOTE: All leafy milfoils display a wide range of vegetative variability. Any milfoil found in Maine waters should be considered "suspicious" until a positive identification has been confirmed by someone with the appropriate expertise.

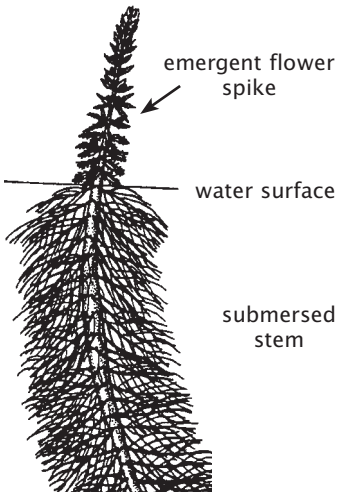
Terrestrial morphs

Habitat: Variable water-milfoil is an extremely well adapted plant, able to thrive in a wide variety of environmental conditions. It grows well in still and flowing waters, and can survive under ice. Variable water-milfoil grows rooted in water depths from 1 to 5 meters on various substrates including organic muck, silt, sand and gravel. Plants stranded on dewatered shorelines form erect spikes known as "terrestrial morphs." The morphs, resembling miniature pine trees, will remain in this land-adapted form until the waters return, at which time they will "morph" back into submersed aquatic plants.

Description: Variable water-milfoil is a submersed, aquatic plant with branching stems emerging from dense, spreading roots. Feather-divided leaves are arranged in densely packed whorls. (Leaves along lower portions of the stem may not be in perfect whorls, i.e., some leaves may be slightly offset.) There are generally 4 to 6 leaves per whorl and 5 to 14 pairs of thread-like leaflets on each leaf. The dense leaf arrangement gives this plant a bottle brush appearance. Stems may be green and slight, but most often they are thick, robust and reddish in color (even bright red). Flowers and bracts are arranged in whorls on an emergent flower spike. The tiny white flowers occur in the axils of the bracts. The bracts are blade-shaped, serrated, and more than twice the length of the flower. Winter buds (or turions) are formed in the fall at the base of the stems or on the rhizomes.



Stem cross-section showing whorl of 6 leaves



Variable water-milfoil (*Myriophyllum heterophyllum*)

Origin and US Range: Variable water-milfoil is native to parts of the United States, but *not native to New England.* Variable water-milfoil is present in Maine and all New England states except Vermont. A hybrid of this species (*M. heterophyllum* x *M. laxum*), depicted on the following page, has also been confirmed in Maine.

Annual Cycle: Variable water-milfoil is an extremely hardy aquatic perennial that propagates through root division, fragmentation, turions and seeds. Flowering spikes typically emerge from the water in mid to late summer, but not all colonies produce flowers. Auto-fragmentation may occur during the growing season with stem sections developing roots even before they separate from the parent plant. Toward the end of the growing season some plants break apart and die back to their rootstalks; others overwinter intact. New growth sprouts from turions, roots, overwintering plants and plant fragments as the water begins to warm in the spring, growing rapidly toward the surface. Certain milfoils are able to hybridize with other, closely related, milfoil species.

Look Alikes: May be confused with bladderworts, hornworts, mermaid weeds, water crowfoots, and other leafy water-milfoils.

Whorls of submersed leaves are densely arranged, giving plants a "bottle brush" appearance

Flowers and bracts are arranged in whorls on the emergent flower spike; the blade-shaped serrated bracts are larger than the tiny white flowers that occur in their axils

INVASIVE VARIABLE WATER-MILFOIL HYBRID

Myriophyllum heterophyllum X Myriophyllum laxum

NOT NATIVE TO MAINE - INVASIVE

NOTE: All leafy milfoils display a wide range of vegetative variability. Any milfoil found in Maine waters should be considered "suspicious" until a positive identification has been confirmed by someone with the appropriate expertise.

The invasive variable water-milfoil hybrid is not explicitly prohibited by Maine law. However, the hybrid is half variable water-milfoil and, as such, is treated as a prohibited invasive plant by The Maine Department of Environmental Protection.

Habitat: The invasive water-milfoil hybrid is an extremely well adapted plant, able to thrive in a wide variety of environmental conditions. It grows well in still and flowing waters, and can survive under ice. The hybrid grows rooted in water depths from 1 to 5 meters on various substrates including organic muck, silt, sand and gravel.

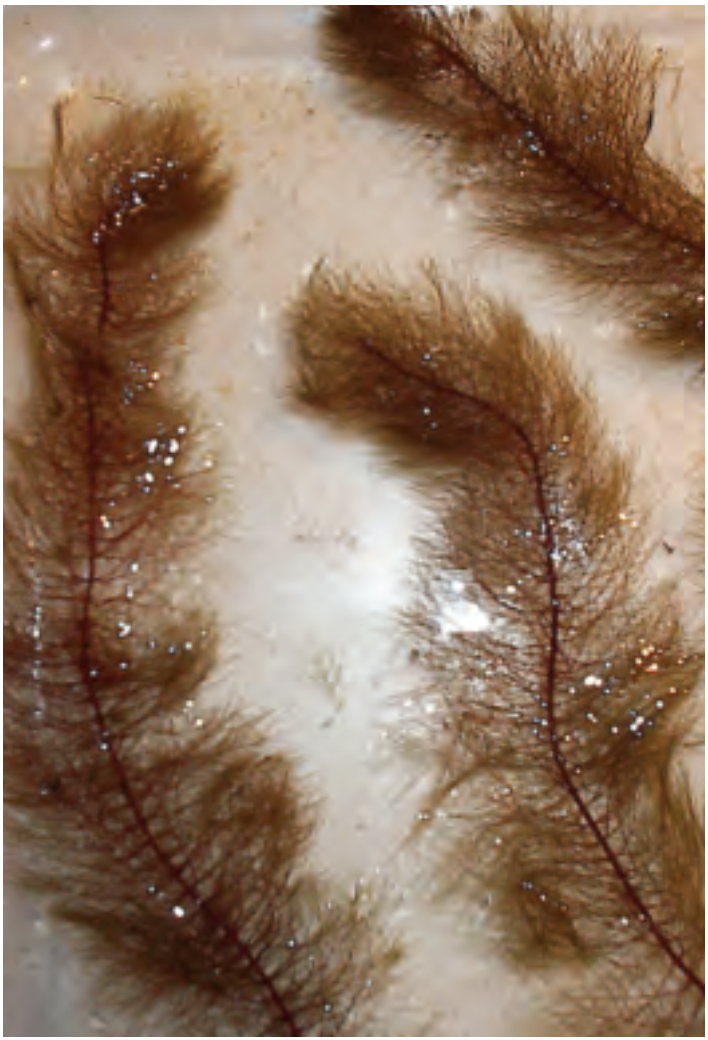
Description: This hybrid milfoil is a cross between variable water-milfoil (*M. heterophyllum*) and loose water-milfoil (*M. laxum*), a milfoil native to the southeastern United States. The hybrid is a submersed, aquatic plant with branching stems emerging from dense, spreading roots. Feather-divided leaves are arranged in densely packed whorls. (Some of the leaves in the whorl may be slightly offset.) There are generally 4 to 6 leaves per whorl and 5 to 14 pairs of thread-like leaflets on each leaf. The dense leaf arrangement give this plant a bottle brush appearance. Stems are typically reddish in color (even bright red). Leaves may also be red. Flowers occur on emergent spikes.

Two features (both present on the emergent flower spike) distinguish the hybrid from its invasive parent, variable water-milfoil (*M. heterophyllum)*: 1) The bracts and flowers of the hybrid are arranged both alternately and whorled, as opposed to the strictly whorled arrangement found on the flower spikes of *M. heterophyllum*. 2) The bracts of the hybrid range from pinnately lobed, to elongate and entire. (Bracts on *M. heterophyllum* are mostly serrated and blade-shaped.)

The hybrid does not produce winter buds; *M. heterophyllum* does.

Annual Cycle: The invasive milfoil hybrid is an extremely hardy aquatic perennial that propagates primarily through root division and fragmentation. Flowering spikes typically emerge from the water in mid to late summer, but not all colonies produce flowers. Toward the end of the growing season some plants break apart and die back to their rootstalks; others overwinter intact. New growth sprouts from roots and overwintering plants and plant fragments as the water begins to warm in the spring, growing rapidly toward the surface. Certain milfoils are able to hybridize with other, closely related, milfoil species. (See above.)

Look Alikes: May be confused with bladderworts, hornworts, mermaid weeds, water crowfoots, and other leafy water-milfoils.



Both leaves and stems may be reddish

Flowers and bracts are arranged both alternately and whorled along the emergent flower spike; bracts range from pinnately lobed, to elongate and entire; bracts are larger than flowers

PARROT FEATHER

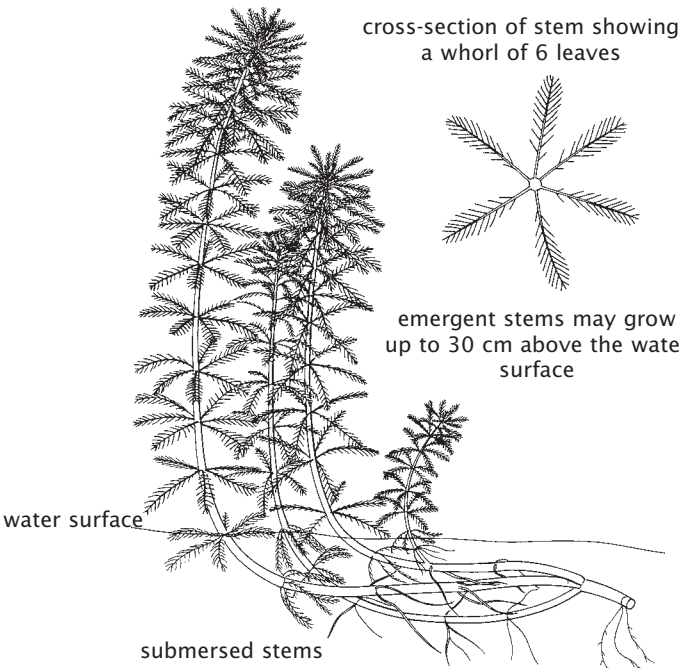
Myriophyllum aquaticum

NOT NATIVE TO MAINE - INVASIVE

NOTE: All leafy milfoils display a wide range of vegetative variability. Any milfoil found in Maine waters should be considered suspicious until a positive identification has been confirmed by someone with the appropriate expertise.

Habitat: Parrot feather is found in both the emergent and the submersed plant communities of freshwater lakes, ponds, and slow moving streams. It is also adapted to waters with some salt intrusion. While it grows best when rooted in shallow water, it has been known to occur as a floating plant in the deep water of nutrient-enriched lakes. It is well adapted to life at the water's edge and can survive when stranded on dewatered river banks and lake shores.

Description: Long unbranched stems arise from roots and rhizomes. Unburied rhizomes function as a support structure for adventitious roots, and provide buoyancy for emergent growth. Emergent stems may grow to a height of 30 cm above the water surface. Slender, feather-divided leaves occur along the trailing stems in whorls of 4 to 6 leaves. Whorls are openly spaced toward the base, and more closely arranged toward the growing tip. Leaves are 2.5 to 5 cm long, with 10 to 18 leaflet pairs, flattened midribs and a short petiole. The emergent leaves are robust, vibrant green, and covered with a waxy coating. Submersed leaves, in contrast, are limp and brownish, and often in a state of deterioration. Small white flowers (female only) are inconspicuous, and borne in the axils of the emergent leaves.



Parrot feather (*Myriophyllum aquaticum*)

Origin and US Range: Parrot feather is native to South America, and is considered invasive in the United States. Nearby populations occur in New York and Rhode Island. Parrot feather is not known to be present in Maine waters.

Annual Cycle: Parrot feather is an aquatic perennial that propagates through root division and plant fragments. Plants usually flower in the spring but fall flowering also occurs. Male and female flower parts occur on separate plants, and male plants are only known to occur in the plant's native range. As a result, parrot feather populations in the United States do not produce seeds. Plants die back to their rhizomes toward the end of the growing season. New shoots begin to grow rapidly from overwintering rhizomes as water temperatures rise in the spring.

Look Alikes: When emergent stems and leaves are not present, parrot feather may be confused with bladderworts, hornworts, mermaid weeds, water crowfoots, and other leafy milfoils.

Tiny white flowers occur in the axils of the emergent stems

Thick growth creates the danger of entanglement

Leaves more closely arranged toward the growing tips

BRAZILIAN WATERWEED

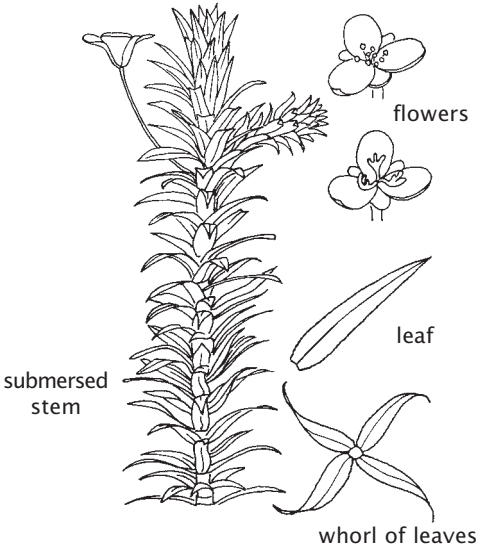
BRAZILIAN ELODEA, ANACHARIS

Egeria densa

NOT NATIVE TO MAINE - INVASIVE

Habitat: Brazilian waterweed is found in the submersed plant community. It may grow in substrates of sand, mud or stone to depths of 6.5 meters. A buoyant plant, most of its biomass is produced near the water surface. Infestations of Brazilian waterweed may occur in large densely rooted stands, and drifting mats.

Description: Submersed stems emerge from trailing, unbranched roots. Bright to dark green leaves are densely arranged in whorls of 4 to 6 leaves along slender stems. (Note: some lower leaves may occasionally occur in opposite pairs or in whorls of 3 leaves.) The leaves are robust and blade shaped, 1 to 3 cm long, and up to 5mm wide. Having generally more than 3 leaves per whorl, and leaves more than 1 cm in length help to distinguish this plant from Maine's native waterweeds. The leaf margins are very finely-serrated; magnification is usually needed to observe the serrations. Branches form irregularly along the stems in areas where two whorls appear to be joined (known as double nodes). The small flowers (2 cm in diameter) have three white petals and a yellow center, and emerge just above or at the surface on slender stalks projecting from leaf axils near the stem tips. Unlike its invasive look alike hydrilla, Brazilian waterweed does *not* produce tubers.



Brazilian waterweed (*Egeria densa*)

Larger form than Maine's native waterweeds; leaves typically longer than 1 cm

Origin and US Range: Brazilian waterweed is native to South America. It has been widely distributed in the United States (usually under the name "anacharis") as an aquarium plant and a beneficial oxygenator for water nurseries. Brazilian waterweed is currently present in many parts of the US including the nearby states of New Hampshire, Massachusetts, Vermont and New York.

Annual Cycle: Brazilian waterweed is a rooted, submersed perennial. Areas on the stems known as double nodes play an important role in food storage and reproduction. Adventitious roots and branches are both produced from double nodes on the stem. If a Brazilian waterweed fragment does not have a double node, it can not grow into a new plant. Regeneration of plant fragments containing a double node is the only means for reproduction. Only male flowers are present on plants found in the US, therefore no seeds are produced. Brazilian waterweed prefers moderate water temperatures, and optimum growth occurs in the spring and fall. During the summer growth may slow, or cease completely. Plants will die back to their roots in the winter.

Look Alikes: May be confused with hydrilla, native waterweeds, water starworts and mares' tail.

Brazilian waterweed forms dense, tangled mats at the surface

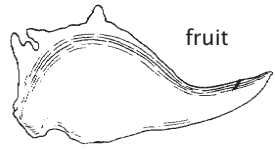
CURLY-LEAF PONDWEED

Potamogeton crispus

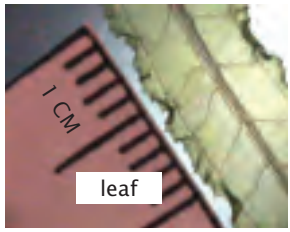
NOT NATIVE TO MAINE - INVASIVE

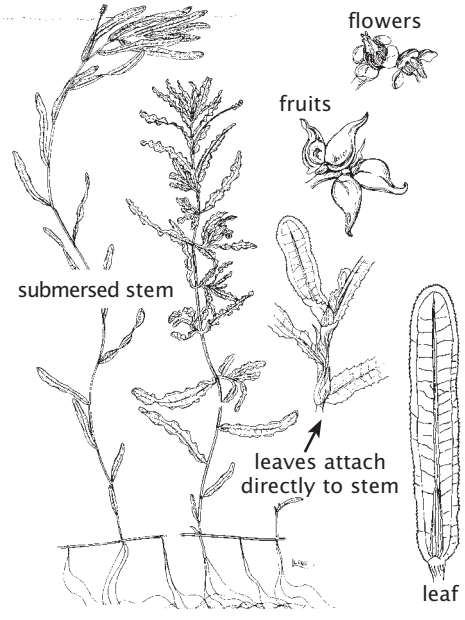
Habitat: Curly-leaf pondweed is found in the submersed plant community. Generally preferring soft sediments, it grows in waters that are shallow or deep, still or flowing. Curly-leaf thrives where many other aquatic plants do not, for example in waters that are shaded, disturbed, polluted or turbid.

Description: Curly-leaf pondweed has submersed leaves only. (Some pondweeds have two distinct leaf types: submersed leaves and floating leaves.) Slightly flattened stems emerge from slender rhizomes and sprouting turions, often branching profusely as they grow, giving the plants a bushy appearance. Mature stems may be several meters in length. The leaves of this plant are key to its identification. Though the leaves share characteristics with some native pondweeds, they also have three distinct characteristics that set this plant apart from any of its native look alikes. (See table on page 40.) Stipules, when visible, (they disintegrate early in the plant's growth cycle) are slightly joined to the stem at the leaf base and 4 to 10 mm long. Flower spikes appear above the surface of the water from June through September. The small flowers are tightly arranged at the end of a slender (often curving) stalk measuring about 7 cm in length. The fruits have a prominent cone-shaped beak and a bumpy, crown-like ridge. (The shape resembles the profile of a crested woodpecker.) Turions form in the leaf axils during the growing season. The turions are hard but flexible (like stiff plastic) and typically 1 to 2 cm long.



Alternately arranged submersed-leaves





Curly-leaf pondweed (*Potamogeton crispus*)

Leaves resemble small lasagna noodles

Origin and Range: Curly-leaf pondweed is native to Eurasia. Introduced to the United States some time during the mid 1800s, it has since spread to almost every state in the country. In addition to spread by natural causes and recreational activity, curly leaf pondweed has been planted intentionally for waterfowl and wildlife habitat, and possibly has been spread as a contaminant in water used to transport fish and fish eggs to hatcheries. Curly-leaf was first confirmed in a small pond in southern Maine in 2004 and is currently present in the nearby states of New Hampshire, Massachusetts, Vermont, Connecticut, New York and Rhode Island.

Annual Cycle: Curly-leaf pondweed, an aquatic perennial, is adapted to growing in cool conditions. Plants sprout from rhizomes and turions in the late fall and grow through the winter, reaching maturity relatively early in the season (late spring through early summer). Flowers and turions are produced during the growing season and the plants generally begin breaking up by mid-July. The turions scatter with the plant fragments and drop to the sediments, where they lie dormant until the water begins to cool again in the fall. In addition to propagation by turion and creeping rhizomes, curly-leaf pondweed produces seeds. Little is known, however, regarding the importance of seeds in the spread and propagation of this plant.

Look Alikes: May be confused with clasping-leaf pondweeds, large-leaf pondweed, red pondweed, variable pondweed and white-stem pondweed.

CURLY-LEAF PONDWEED (CLP) – continued

Potamogeton crispus

NOT NATIVE TO MAINE - INVASIVE

LEAF CHARACTERISTICS THAT CLP SHARES WITH SOME NATIVE PONDWEEDS	LEAF CHARACTERISTICS THAT DISTINGUISH CLP FROM OTHER PONDWEEDS
The leaves are alternately arranged.	The leaves are typically finely serrated along the edges. Serrations are tiny but visible.
The leaves are directly attached to the stem (leaves slightly clasping the stem).	The edges of mature leaves may be distinctly ruffled (like a lasagna noodle).
The leaves are strap-shaped and with rounded tips, narrowing toward the base.	The leaves have a unique vein pattern, resembling a narrow, leaded glass window with panes arranged mainly in two columns, enclosed in a frame. (The vein pattern is more visible when illuminated from behind.) See leaf vein pattern illustration on page 39.
The leaves are 4 to 10 cm long, and 5 to 10 mm wide.	
The leaves are somewhat translucent, olive green to reddish brown in color.	

Sunlight strikes a dense patch of curly-leaf pondweed

SUBMERSED PLANTS WITH UNDIVIDED LEAVES

Curly-leaf pondweed

EUROPEAN NAIAD

SPINY NAIAD

Najas minor

NOT NATIVE TO MAINE - INVASIVE

Habitat: European naiad is found in the submersed plant community, growing in ponds, lakes, and slow moving streams in depths up to 5 meters. Preferring sand and gravel, the plants thrive in a wide range of substrates. European naiad is tolerant of turbidity and eutrophic (nutrient rich, productive) conditions.

Description: Unlike most aquatic plants, European naiad is a true annual. Seedlings grow from slender roots, developing stems up to 2.5 meters long that often branch profusely near the top. The leaf arrangement is not strict, and leaves may appear to be opposite, sub-opposite, in whorls or clumps. The leaves are small (rarely more than 3.5 cm long) and very slender (0.3 – 0.5mm wide), strap-shaped, pointed and serrated. Unlike all native naiads whose leaf serrations or spines are virtually invisible to the unaided eye, the leaf serrations of European naiad, though tiny, can usually be observed without magnification. Visible serrations, therefore, provide a key characteristic for identifying this invader. A second characteristic that distinguishes European naiad from two of Maine's three native naiad species—including the most common by far, *Najas flexilis*—is the abruptly protruding (as opposed to gently flaring) blocky or fan-shaped leaf base. The upper margin of the leaf base is finely toothed or fringed in appearance. You may need to carefully pull the leaf away from the stem and use a hand lens to see the base clearly. (Note: The leaf base of a third native species, *Najas gracillima,* is also blocky and toothed, however the occurrence of this species in Maine is rare.) Like all naiads, the flowers are small, inconspicuous, and borne in the leaf axils. The seeds are purplish, 1.5 to 3.0 mm long, spindle shaped and slightly curved, with rectangular indentations arranged in distinct longitudinal rows.

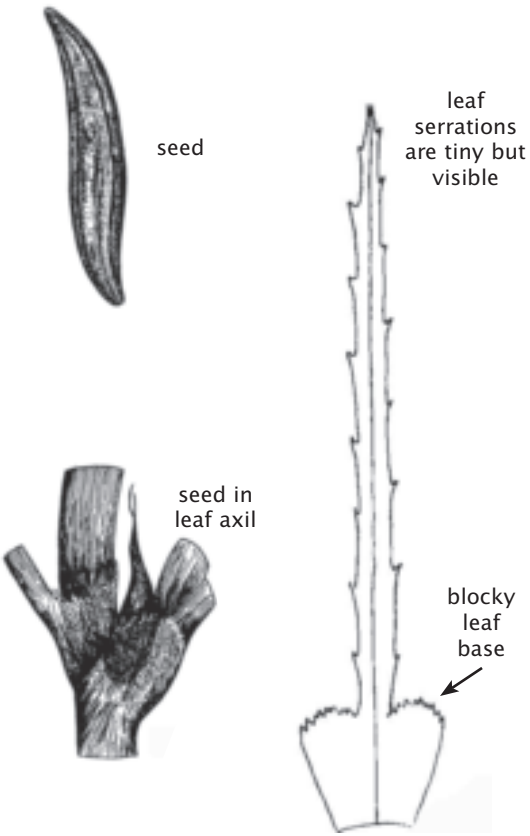
European naiad (*Najas minor*)

Origin and Range: European naiad is native to Europe. It is thought to have been introduced to the US some time in the early 1900s and is now present in much of the Eastern United States including the nearby states of New Hampshire, Massachusetts, Vermont, and New York.

Annual Cycle: A true annual, European naiad grows anew from seeds each spring. Seeds form in the leaf axils from July through September. Although European naiad can reproduce by fragmentation during the growing season, the primary means of reproduction appears to be by seed. It is estimated that a productive, one-acre infestation will produce tens of millions of seeds per season. During the late summer or early fall, the stems of European naiad become brittle, and break up. Seeds remain attached in the leaf axils, and wind and water currents disperse the fragments.

Look Alikes: May be confused with native naiads, some fine-leaved pondweeds, and some stoneworts.

Arching leaves form "tufts" toward the growing tip



HYDRILLA

Hydrilla verticillata

NOT NATIVE TO MAINE - INVASIVE

Habitat: Hydrilla is found in the submersed plant community. The adaptability of this plant to a wide variety of environmental conditions has earned hydrilla its reputation as the perfect weed. Hydrilla can grow in a variety of substrates, in waters still or flowing, low or high in nutrients. Hydrilla may also threaten estuary systems, tolerating salinities up to 10 parts per thousand. Remarkably adapted to low light conditions, hydrilla can photosynthesize earlier and later in the day than most plants, grows well in turbid water and, when the water is clear, to depths exceeding 10 meters. Hydrilla typically occurs in dense, rooted stands, but live fragments may also be found drifting in large mats. Hydrilla is considered one of the most problematic of all aquatic invaders.

Hydrilla (*Hydrilla verticillata*)

Description: Hydrilla is a perennial submersed aquatic plant with long slender, branching stems emerging from horizontal underground rhizomes and above ground stolons. The leaves are strap-like and pointed with claw-like serrations along the outer margins. (The serrations are tiny but generally visible without magnification.) The leaves are typically arranged in whorls of 4 to 8. (Note: the lower leaves may be opposite or in whorls of 3.) Small white flowers rise to the surface on slender stalks from the upper leaf axils. Hydrilla produces two types of over-wintering structures. Spiny green turions (5 to 8 mm long) are produced in the leaf axils. Small, somewhat crescent-shaped tubers (5 to 10 mm long), form along the rhizomes and stolons. The tubers have a scaly appearance under magnification and are pale cream to brownish in color.

Identification of hydrilla is complicated by the fact that there are two distinct forms occurring in the United States. (Please see summary of differences on page 46.)

Origin and Range: Hydrilla is native to Africa, Australia, and parts of Asia. The dioecious form, found primarily in more southern latitudes, was first introduced to the US through the aquarium trade during the mid-1900s. The monoecious form, found primarily in northern latitudes, was introduced some time later and has now been confirmed in several New England states, including Maine, Connecticut, Massachusetts and also New Jersey. See next page for description of the two forms.

Annual Cycle: Hydrilla sprouts from over-wintering rhizomes, tubers and turions in the spring, the leafy stems growing rapidly (about 2 cm per day) toward the surface. Flowers, turions and tubers are produced during the growing season. The turions drop to the sediments when the leafy vegetation begins to break up in the fall. The plants die back completely to the sediments by early winter, a remarkable vanishing act given the amount of biomass involved. The rhizomes, tubers and turions over-winter. The turions will sprout the following spring, but the tubers may remain dormant for several years in the sediments. Research indicates that one tuber can lead to the production of over 5,000 new tubers per square meter. The tubers and turions can withstand ice cover, drying, ingestion by waterfowl, and herbicides. Studies also indicate that the monoecious form (the form found in Maine) puts more of its energy into tuber and turion production than the dioecious form, and may have a greater potential for spread by these means. In addition to reproducing vegetatively by way of tubers and turions, hydrilla propagates readily from stem or root fragment. New plants can sprout from stem fragments containing as few as two nodes or whorls of leaves. The monoecious form can produce viable seeds. Seed production and viability is thought to be low relative to vegetative reproduction.

Dense mat of hydrilla

Look Alikes: May be confused with Brazilian waterweed, native waterweeds, water starworts and mare's tail.

HYDRILLA– continued

Hydrilla verticillata

NOT NATIVE TO MAINE - INVASIVE

Below is a summary of characteristics that help differentiate the two forms of hydrilla that occur in the United States. *(NOTE: Only the monoecious form has been identified in Maine.)*

Monoecious

Range: Generally the form found in waters of the northern United States, including Maine, Connecticut and Massachusetts.

Flowers: Male and female flower parts appear on the same plant. Flowers have three whitish sepals and three translucent petals.

Habit: Plants branch profusely at the sediments, growing rapidly toward the surface (like a shag carpet gone berserk).

Leaves: Delicate, translucent leaves average 4 to 10 mm in length; no pronounced midrib. Leaves generally lacking midrib spines.

Dioecious

Range: Generally the form found in waters of the southern United States, including Florida, Louisiana and Texas.

Flowers: Male and female flower parts appear on separate plants. All populations found in the US are female. (All reproduction of this form in the United States is asexual.)

Habit: Stems grow upward from the sediments, branching profusely at the surface. Plants generally more robust-looking than monoecious form.

Leaves: Robust leaves average 6 to 20 mm in length with pronounced (sometimes reddish) midribs. Sharp spines may be present along the undersides of the midribs.

Leaf serrations on both forms are claw-like

Relative comparison of leaf-size

Dioecious form leaf with barbs along underside of midrib

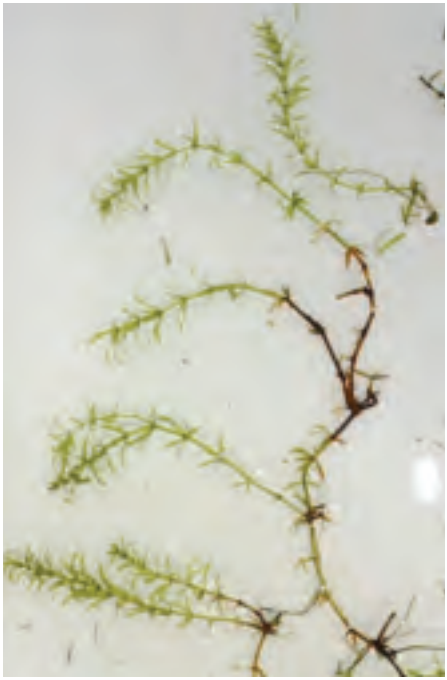
Monoecious form leaf with NO barbs along underside of midrib

Tubers

Turions

Both forms produce tubers and turions

Dioecious form habit



Monoecious form habit

COMMON NATIVE MAINE LOOK ALIKE PLANTS

This section covers some of the more common aquatic plant species, native to Maine, that share a likeness with one or more of the eleven invasive aquatic plants on Maine's list, (usually by sharing one or more common characteristics with the invader). Following the description of each plant is a list of the particular invasive species, that may be confused with the native look alike.

Fragrant waterlily

WATERWEEDS

Elodea canadensis and *Elodea nuttallii*

NATIVE TO MAINE

Habitat: Maine is home to two native waterweed species: common waterweed (***Elodea canadensis***) and slender waterweed (***Elodea nuttallii***). Both are found in the submersed plant community. Preferring fine, nutrient-rich sediment, the plants grow to depths of several meters. (Waterweeds may be found in a wide range of environments, including freshwater ponds, slow moving streams or tidal tributaries.)

Description: Common waterweed and slender waterweed share many common characteristics and it may not always be easy to distinguish between the two. Both have slender stems supporting small, lance-shaped leaves. The stems, anchored to the sediments by shallow roots, grow up to one meter long, often branching profusely and forming dense, tangled stands. The leaves are attached directly to the stem (no petiole) in whorls, with precisely three leaves per whorl. (For both of these species, it would be considered rare to find a whorl of leaves that contained any number other than three.) The leaf edges of both species are finely serrated, visible only with significant magnification. Both species produce small, white flowers with three petals at the tips of long slender stalks and rise to (or above) the water surface at maturity. Female flowers are most often seen; male flowers are rarely produced.

The shape, texture, and proportions of the leaves provide the best means for distinguishing between the two native waterweeds. The relatively firm leaves of common waterweed tend to be shorter, stouter (averaging 2 mm in width), and relatively blunt at the tip. The leaves of slender waterweed are typically longer, more flimsy and slender (averaging 1.3 mm in width), and more sharply pointed at the tip. Also, the leaves of common waterweed tend to get more densely crowded toward the tip then those of slender waterweed. Maine's native waterweeds rarely have more than three leaves per whorl which helps to distinguish them from their invasive look alikes: hydrilla and Brazilian waterweed. Both of these invaders typically have four or more leaves per whorl.

Leaves of common waterweed are generally wider and more blunt at the tip than those of slender waterweed

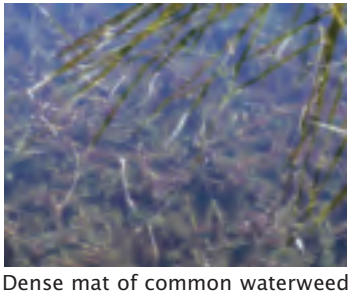
US Range: Both of Maine's native waterweeds are native throughout New England and much of the United States.

Elodea canadensis

Elodea nuttallii

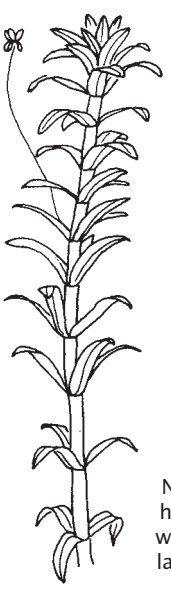
Annual Cycle: Maine's native waterweeds overwinter under the ice as evergreen plants, growing slowly with a reduced rate of photosynthesis. In the spring, faster growth resumes and new shoots appear. Flowering occurs early to midsummer. Reproduction is primarily vegetative through stem fragments. Seeds are rarely produced.

Value to the Aquatic Community: Waterweeds are a source of food and habitat for fish and invertebrates throughout the year. Waterfowl feed upon both the plant and upon the small organisms that inhabit the dense vegetation. Stands of waterweed may become so thick that even fish cannot penetrate the mat.



Dense mat of common waterweed

Look Alikes: May be confused with hydrilla, Brazilian waterweed, and mare's tail.



flower

Native waterweeds have slender stems with whorls of three lance shaped leaves

Herbarium specimen comparison of the two native waterweeds and their two invasive look alikes; hydrilla (left) and Brazilian waterweed (right)

WATER STARWORTS

Callitriche palustris and *Callitriche heterophylla*

NATIVE TO MAINE

Habitat: Maine is home to two water starwort species: common water starwort (***Callitriche palustris***) and large water starwort (***Callitriche heterophylla***). Both are found in the submersed and floating leaf plant communities. Water starworts are generally found in quiet, cool (often spring-fed) waters or along muddy shores, preferring muddy or sandy substrates.

Description: Maine's two water starwort species share many common characteristics. Both water starworts have fine stems that are 10 to 20 cm long. The submersed leaves are opposite, and arranged in pairs or in groups of three. The delicate leaves are simple, entire and variable in appearance. The submersed leaves tend to be pale green and linear. The upper leaves are more rounded (5mm wide) and crowded at the tip, forming a rosette that floats on the surface. The flowers grow in the axils of the leaves and produce very small capsule-like fruits (1 to 1.4 mm).

The fruits provide the best means of distinguishing between the two species. The fruits of common water starwort are 2mm longer than they are wide, winged, with a shallow groove between the wings, and surface pits arranged in vertical rows. The fruits of large water starwort are nearly as wide as they are long (no more than 1 mm longer than wide), sometimes with shallow grooves, but no wings. The surface has pit-like markings, but they are not in rows.

US Range: Both water starworts are native to Maine, New England and much of the United States.

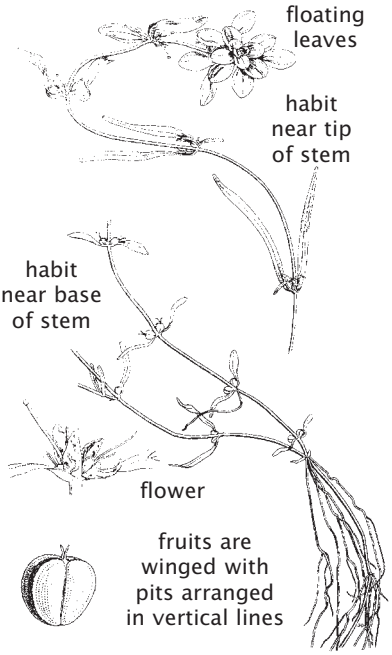
Callitriche palustris

Annual Cycle: Water starworts are annuals that reproduce by seed and stem fragments. Because the plants are adapted to cool water, growth begins early and flowers bloom in early summer. Seeds are mature by mid to late summer.

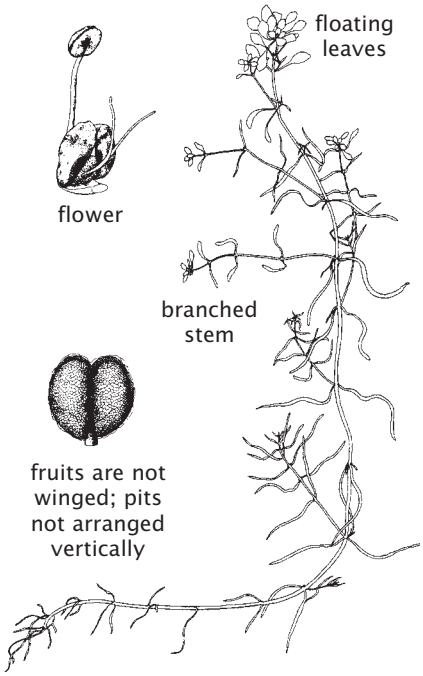
Callitriche heterophylla

Value in the Aquatic Community: The stems and fruits of starworts are grazed by duck and other waterfowl. The branching stems offer shelter and foraging opportunities for fish.

Look Alikes: May be confused with hydrilla, Brazilian elodea, and mare's tail.

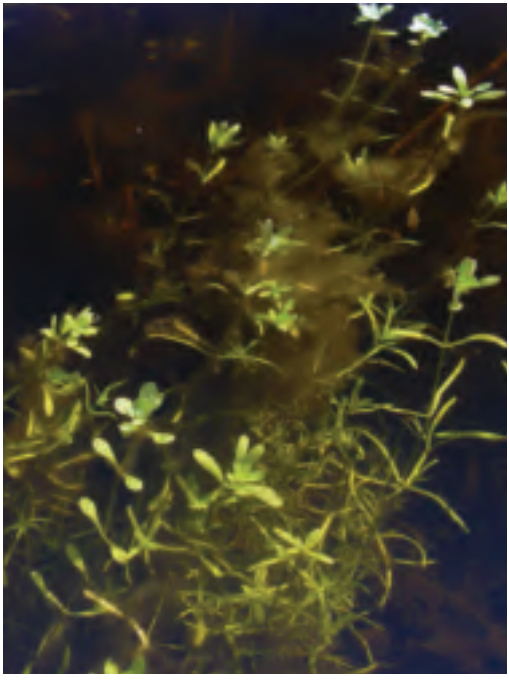


Common water starwort
Callitriche palustris



Large water starwort
Callitriche heterophylla

Common water starwort (top half of photo) and large water starwort (bottom half of photo) growing side by side



Common water starwort

MARE'S TAIL
Hippuris vulgaris

NATIVE TO MAINE

Habitat: Mare's tail grows in the emergent to submersed plant community, generally in muddy substrates, along damp shores and in shallow, quiet waters of ponds and streams. This plant may occur in fresh or brackish water, and prefers non-acidic conditions.

Description: The simple, unbranched stems of mare's tail emerge along stout, spongy, creeping rhizomes. Ribbon-like leaves (length 1 to 10 cm) are entire, and attached at the base with no leaf stem (petiole). The leaves occur in whorls of 6 to 12 leaves, with whorls more closely spaced toward the growing tip. The top part of the stem often emerges from the water. The emergent leaves are linear, with blunt, hard tips. The submersed leaves are generally more elongate, more flaccid and sometimes paler than the emergent leaves. Tiny inconspicuous flowers occur in the axils of the middle and upper leaves.

This is the only aquatic plant native to Maine with blade-shaped leaves occurring in whorls of *more than three leaves.* This feature may cause this plant to be confused with two of the invasive plants on Maine's invasive aquatic plant list: hydrilla and Brazilian waterweed. Unlike both hydrilla (with its finely but conspicuously serrated leaves) and Brazilian elodea (with its minutely serrated leaves), the leaves of mare's tail are strictly entire (smooth edged). Also, both hydrilla and Brazilian elodea branch freely as they grow. Mare's tail may branch at the base where it emerges from the rhizome, but otherwise grows throughout the season on simple, unbranched stems.

The emergent leaves are stiff with blunt tips

US Range: Mare's tail is native to Maine, New England and much of the United States. Mare's tail is considered rare in Maine.

Annual Cycle: Mare's tail is a perennial, with stems emerging anew from stout rhizomes each spring. Flowers occur from June through September, however sexual reproduction (propagation by seed) is considered to be rare. The primary means of reproduction is asexual, through rhizome division and spread.

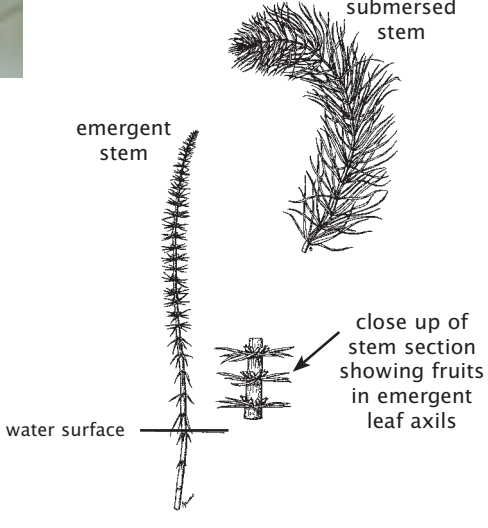
Value to the Aquatic Community: Mare's tail offers habitat and food to various species of fish and invertebrates.

Look Alikes: May be confused with hydrilla, Brazilian waterweed, common waterweed, and slender waterweed. The emergent tips of mare's tail may be confused with the flowering emergent spikes of some water-milfoils.

Two stems showing unbranching habit; lower (submersed) leaves are flaccid; upper (emergent) leaves are stiff

Stem cross-section shows 11 leaves in the whorl

mare's tail habit



Mare's tail (*Hippuris vulgaris*)

CLASPING-LEAF PONDWEEDS

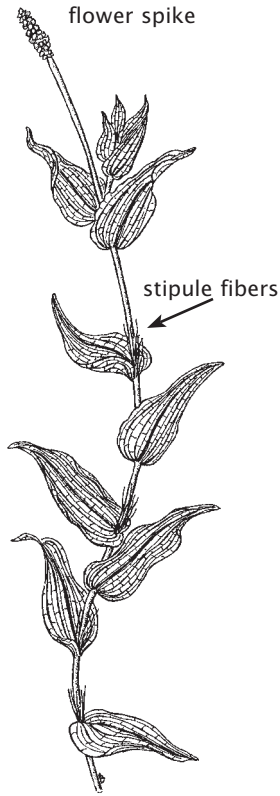
Potamogeton perfoliatus and *Potamogeton richardsonii*

NATIVE TO MAINE

Two Potamogeton species found in Maine share the common name "clasping-leaf pondweed": *Potamogeton perfoliatus* and *Potamogeton richardsonii.* Of the two species, *P. perfoliatus* is more common in Maine. Alternative common names for both species do exist, but are less frequently used. ***P. perfoliatus*** is also called perfoliate pondweed and ***P. richardsonii*** is also called red-head pondweed.

Habitat: Both clasping-leaf pondweeds grow in the submersed plant community. They grow in many types of sediments to depths of up to 4 meters.

Description: Both species have long, branching stems that are rounded in cross-section (1 to 2.5 mm in diameter), emerging from a spreading rhizome. The submerged leaves are alternately arranged, oval to lance-shaped, and clasp the stem with a lobed base. No floating leaves are produced. Fruiting stalks emerge from leaf axils toward the end of the growing season. Clusters of small fruits form in a spike toward the tip. Each fruit is disk-like with an erect beak-like protrusion.



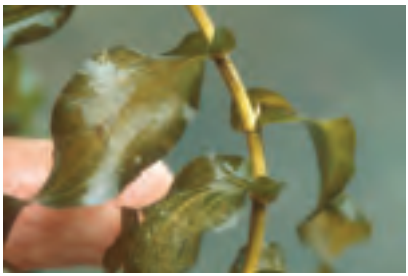
The stipules of *P. richardsonii* disintegrate leaving a tuft of persistent fibers

The leaves help to distinguish the two species. The leaves of ***P. richardsonii*** are 3 to 12 cm long with wavy edges, and 13 to 21 veins (some more prominent than others). The more fibrous portions of the stipules persist in the leaf axils, leaving stiff tufts. The bases of the leaves clasp one-half to three-quarters of the way around the stem. The leaves of ***P. perfoliatus*** are generally smaller (1 to 5 cm long) with 7 to 15 veins. The stipules (which only occur on the upper portion of the stem) disintegrate without a trace fairly early in the growing season. The leaf bases clasp all of the way around the stem.

US Range: Both clasping-leaf pondweeds are native to Maine, New England and other parts of the United States. (*P. perfoliatus* is more common in Maine.) The two species are known to hybridize with each other, and *P. perfoliatus* hybridizes with two other pondweed species as well. All three hybrids occur in Maine.

P. perfoliatus

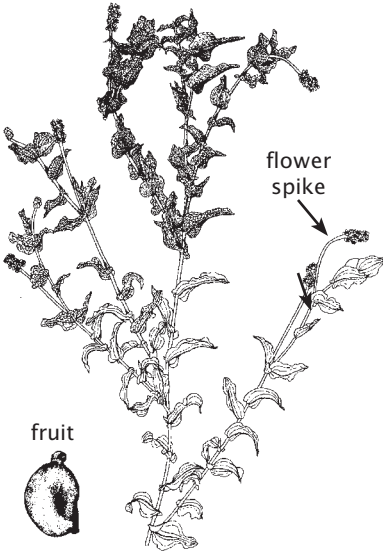
P. richardsonii



The leaves of *P. richardsonii* do not clasp all the way around the stem

Annual cycle: Clasping-leaf pondweeds are perennials that propagate by spreading rhizomes, and, when conditions are favorable, from seed. Flowers, followed by fruits, appear by mid-summer. Plants die back to their rhizomes at the end of the growing season. New growth emerges from rhizomes and seeds when the water begins to warm in the spring.

Value in the Aquatic Community: The fruits of clasping-leaf pondweeds provide food for ducks and geese. The plants are grazed by muskrat, deer, beaver and moose. The leaves and stems are colonized by macroinvertebrates and provide shelter and foraging opportunities for fish.



P. perfoliatus habit

Look Alikes: May be confused with other species of the *Potamogeton* genus, including curly-leaf pondweed.

The leaves of *P. perfoliatus* clasp all the way around the stem; the stipules disintegrate without a trace

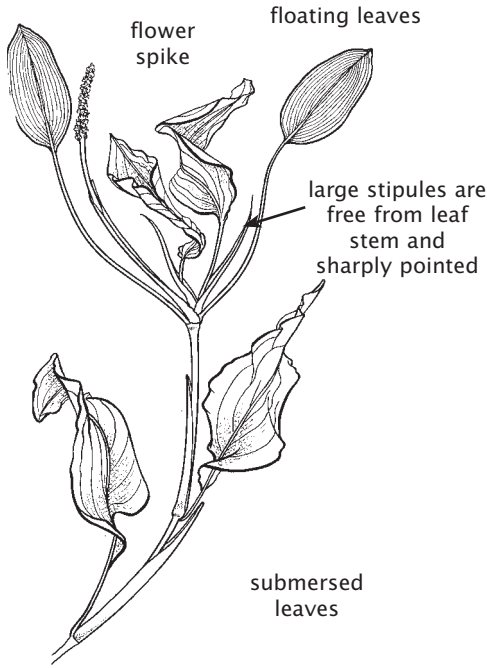
LARGE-LEAF PONDWEED

Potamogeton amplifolius

NATIVE TO MAINE

Habitat: Large-leaf pondweed grows in the submersed plant community. It is found in soft sediments where the water is quiet, in depths up to several meters.

Description: Large-leaf pondweed is a large, stately plant, with two distinct leaf types. The submersed leaves (3 to 7 cm wide) are the broadest of any pondweed in Maine. The many veins of these supple, translucent leaves are easy to see when held to the light. The leaves are often gracefully arched, with the outer margins folding slightly toward one another at the midvein. They are alternately arranged on robust stems, attached by leaf stalks that vary in length from 1 to 6 cm. The floating leaves are slightly smaller (2.5 to 5 cm wide), more oval-shaped, and not translucent. They generally occur in opposite pairs at the top of the plant, also attached to the stem by leaf stalks. The stalks of the floating leaves are generally quite long (up to 30 cm). The stipules of both leaf types are large (3.5 – 12 cm long), largely free from the stem, and tapering to a sharp point. The flowers, followed by fruit, occur among the floating leaves and are densely arranged on an emergent spike. The individual fruits are oval to egg-shaped with a small beak protruding from a point along the outer rim.



Large-leaf pondweed (*P. amplifolius*)

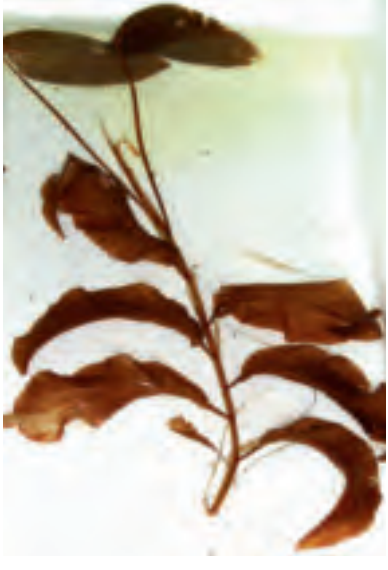
US Range: Large-leaf pondweed is native to Maine, New England and much of the United States.

Annual cycle: Large-leaf pondweed is an aquatic perennial that propagates by seed and spreading rhizome. Plants may overwinter intact, but winter die-back to the rhizome is common. In the spring the rhizomes sprout, flowers appear by midsummer and fruit matures by late summer.

Value in the Aquatic Community: The broad leaves of *P. amplifolius* offer shade, shelter and foraging opportunities for fish. Fruits are produced in abundance and are a valuable food for waterfowl.

Look Alikes: May be confused with other species of the Potamogeton genus, including curly-leaf pondweed.

The leaves of large-leaf pondweed are gracefully arched and translucent



Large-leaf pondweed has folded submersed leaves, flat oval-shaped floating leaves and large pointed stipules

RED PONDWEED
ALPINE PONDWEED
Potamogeton alpinus

NATIVE TO MAINE

Habitat: Red pondweed grows in the submersed plant community. It is found in cold water of lakes and streams.

Description: Red pondweed has two distinct leaf types: submersed leaves and floating leaves. The leaves are oval to oblong, 4 to 25 cm long, tapering to a blunt or slightly acute tip. The leaves are alternately arranged on unbranched stems and attached directly to the stems at the base. Each leaf has 7 to 9 lengthwise veins; the prominent veins generally alternate with faint ones. It is common for the submersed leaves to have a distinctly red tinge, especially when dried. The floating leaves are slightly smaller and delicate, with rounded tips and margins tapering gradually to the petiole. The stems are round in cross-section. The flowers, followed by fruit, occur among the floating leaves and are densely arranged on an emergent spike. The plump fruits have a small stalk protruding from the rim at one end, and a curved beak protruding from the other. The bulging sides are smooth with slight depressions along the middle.

The submersed leaves of *P. alpinus* may be longer with pointed tips (right) or shorter and blunt tips (left)

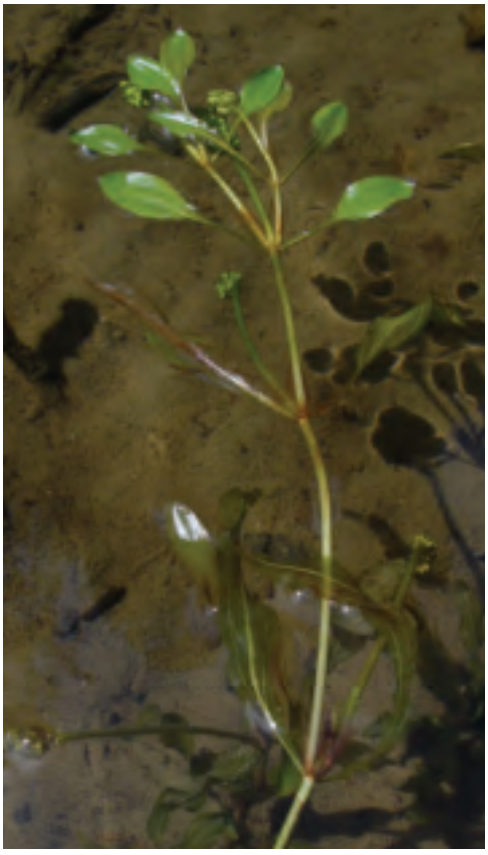
fruit

US Range: Red pondweed is native to Maine, New England and much of the northern and western United States. Two varieties of red pondweed have been documented in the US (var. *tenuifolius* and *subellipticus*), primarily based upon the submersed leaf shape. However, since both leaf types may be observed in the same population, the distinction is rarely recognized.

Annual Cycle: Red pondweed is an aquatic perennial that propagates from seeds and creeping rhizomes. Plants die-back to the rhizome as winter sets in. New growth sprouts from seeds and rhizomes when the water begins to warm in the spring. Flowers appear by mid-summer, and fruit matures by late summer. Hybrids with another native Maine pondweed, *Potamogeton gramineus*, occur in Maine.

Value in the Aquatic Community: The leaves of *P. alpinus* offer shade, shelter and foraging opportunities for fish. Fruits are a valuable food for waterfowl.

Look Alikes: May be confused with other species of the *Potamogeton* genus including curly-leaf pondweed. Red pondweed is most often confused with variable pondweed (*Potamogeton gramineus*), but *P. gramineus* has branching stems and finely serrated margins under magnification.



Two specimens of *P. alpinus* showing the reddish submersed leaves and the greener floating leaves

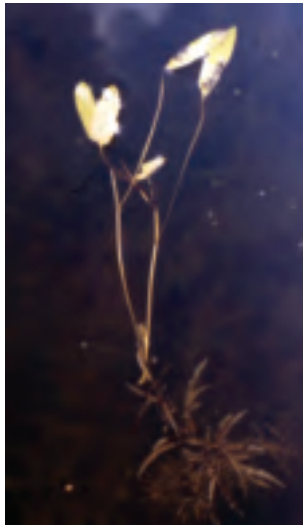
VARIABLE PONDWEED

GRASS-LEAVED PONDWEED

Potamogeton gramineus

NATIVE TO MAINE

Habitat: Variable pondweed grows in the submersed plant community of lakes, ponds and streams. It is generally found in firm sediments at depths of about one meter, but can grow in a range of depths from very shallow to several meters.



Variable pondweed has two distinct leaf types

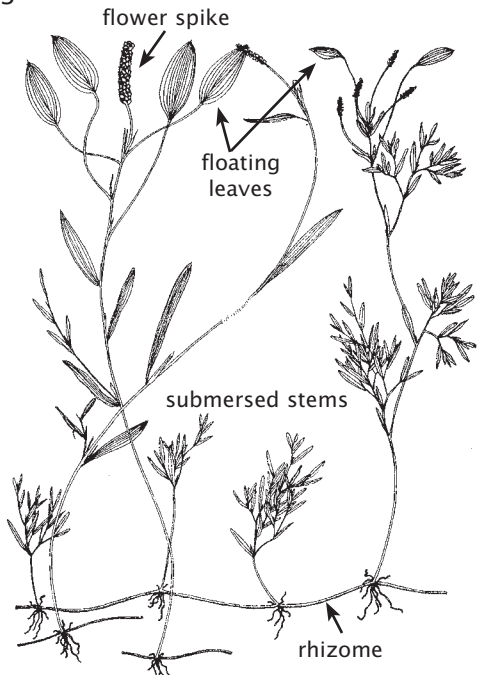
Description: Slender, often profusely branching stems emerge from spreading rhizomes. As the common name implies, the habit and form of individual plants (and plant populations) can be highly variable, depending on growing conditions: some plants are compact, very bushy, with small leaves; others are sprawling, more leggy, with larger leaves. The stems are circular to slightly flattened in cross-section. Variable pondweed has two distinct leaf types. The submersed leaves are alternately arranged, elongate to lance shaped, finely serrate under magnification, 3 to 10 mm wide and 3 to 8 cm long. The leaves lack stems (petioles) but taper slightly at the point where they attach to the stem. Each leaf has 3 to 7 veins running lengthwise. (The submersed leaves are translucent so the best way to view the veins is to hold the leaf up to a light source and observe with a hand lens.) The floating leaves are more elliptical to oval in shape (0.5 to 2.5 cm wide, 2 to 5 cm long), and have slender petioles that are generally longer than the leaf blade. Floating leaves may occur singly, in pairs, or in a whorl. Stipules occur in the axils of both leaf types; they are "free" (not fused to the leaf) with a blunt, slightly hooded tip. The flowers, followed by fruits, occur among the floating leaves and are densely arranged in a cylindrical spike (1.5 to 3 cm long). The individual fruits are oval to egg shaped, with a smooth ridge along a portion of the rim and an erect protrusion called a beak.

Range: Variable pondweed is native to Maine, New England and much of the northern United States. Variable pondweed hybridizes freely with several other pondweed species including *P. perfoliatus*. Four distinct hybrids are known to occur in Maine.

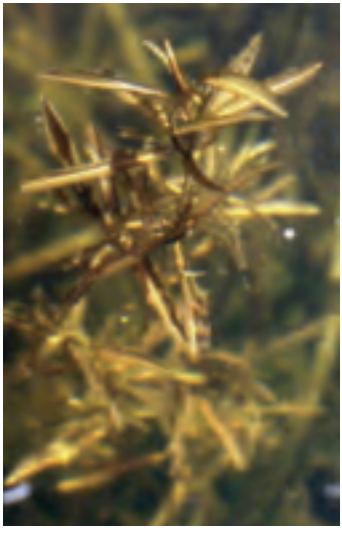
Annual Cycle: Variable pondweed is an aquatic perennial that propagates by spreading rhizome, winter buds (turions), and seeds. Flowering occurs early in the growing season and fruit is produced by mid summer. Turions form toward the end of the growing season in response to the decrease in daylight hours. Plants break up at the end of the season, dying back to their rhizomes. Turions, set adrift in the process of fragmentation, settle to the sediments where they overwinter. New growth sprouts from the rhizomes and winter buds when the water begins to warm in the spring.

Value in the Aquatic Community: The fruits and foliage are grazed by waterfowl, muskrat, beaver, deer and moose. The branching stems provide habitat for invertebrates and shelter and foraging opportunities for fish.

Look Alikes: May be confused with other species of the *Potamogeton* genus including curly-leaf pondweed.



This illustration shows the variability of habit that is typical of variable pondweed



Variable pondweed

The submersed leaves are highly variable in width and length; the leaves lack stems and taper inward at both ends

WHITE-STEM PONDWEED

Potamogeton praelongus

NATIVE TO MAINE

Habitat: White-stem pondweed grows in the submersed plant community of lakes and streams. This species is usually found in the colder, deeper portions of the littoral zone, in moderately fertile substrates.

Description: White-stem pondweed is an aquatic perennial with submersed leaves only. The leaves are large (8 to 30 cm long and 1 to 4 cm wide) and lance to oval shaped. The leaf margins fold toward each other at the tip, resembling the bow of a boat. When pressed to flatten, the tip appears notched. The leaves are alternately arranged, clasping to the stems at the base, with 3 to 5 strong veins and many weaker ones. The stems are pale green to whitish, slightly flattened, with a distinctive zig-zag appearance. Large, persistent, partially-fused stipules occur at the leaf axils. The flowers, followed by fruit, generally occur near the growing tips, and are densely arranged on cylindrical spikes. The small fruits are oval to egg shaped, with a prominent keel along a portion of the outer rim, ending in a blunt protrusion called a beak.

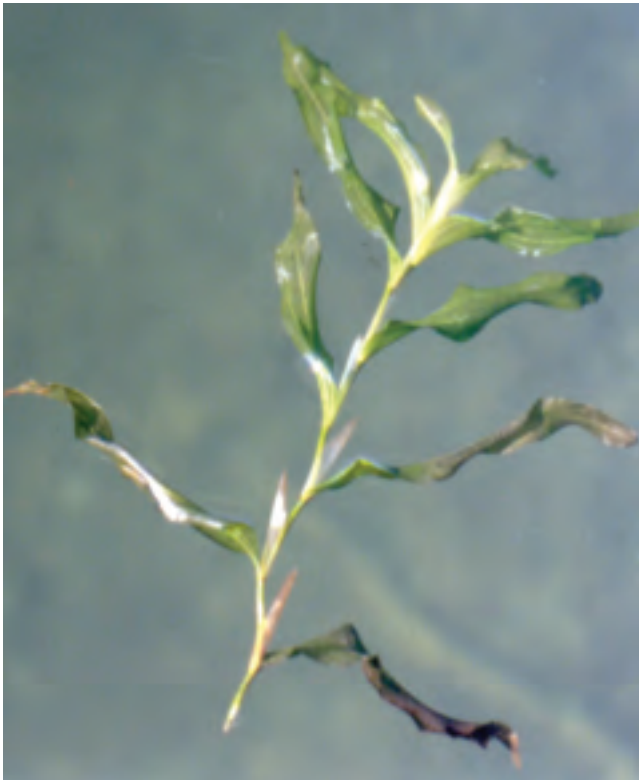
White-stem pondweed
has submersed leaves only

US Range: White-stem pondweed is native to Maine and New England and occurs throughout much of the northern and western United States. White-stem pondweed hybridizes with *P. amplifolius* and *P. perfoliatus*.

Annual Cycle: White-stem pondweed is an aquatic perennial that propagates from seeds and creeping rhizomes. Plants die-back to the rhizomes as winter sets in. New growth sprouts from rhizomes and seeds as the water warms in the spring. Flowers, followed by fruits, occur in mid summer.

Value in the Aquatic Community: The leaves of white-stem pondweed offer shade, shelter and foraging opportunities for fish. Fruits are a valuable food for waterfowl.

Look Alikes: May be confused with other species of the *Potamogeton* genus including curly-leaf pondweed.



White-stem pondweed is easily identified by its large leaves with bow-like tips, large persistent stipules, and zigzag stem

BLADDERWORTS

Utricularia macrorhiza, U. radiata, U. purpurea and *U. intermedia*

NATIVE TO MAINE

Habitat: Nine species of bladderwort are found in Maine. Four of these are possible invasive plant look alikes:

- Common bladderwort ***(Utricularia macrorhiza)***
- Floating bladderwort ***(Utricularia radiata)***
- Large purple bladderwort ***(Utricularia purpurea)***
- Northern bladderwort, or flat-leaf bladderwort **(*Utricularia intermedia*)**

All four species are aquatic and occur in both the floating-leaved and submersed plant communities. They may be found free floating at or below the water surface, or trailing along the bottom of lakes, ponds, slow-moving streams, and wetland pools. Most aquatic bladderworts are adapted to survival on dry land when stranded by low water levels. Unlike rooted aquatic plants, that draw their nutrients primarily from the sediments, bladderworts, lacking roots, draw nutrients directly from the water. Bladderworts are carnivorous, and supplement their nutrient intake by capturing small prey, such as zooplankton or small insects.

Description: Tiny, lopsided sack-like bladders used for capturing invertebrate prey are either attached directly to the leaves or to specialized leafless stems. In addition to this key shared feature, all four bladderworts discussed here have finely-divided, branched, submersed leaves and produce irregular snapdragon-like flowers. Beyond these common characteristics, however, the four look alike bladderwort species are easily distinguishable. The chart on page 68 provides a summary of key distinguishing features.

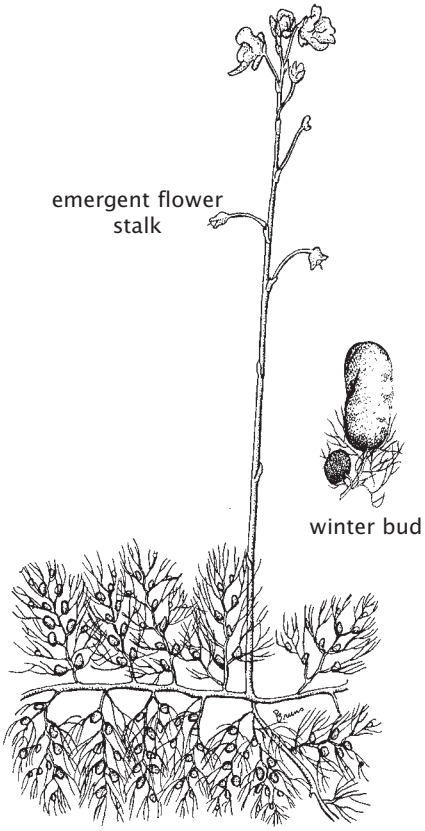
US Range: All four species are native to Maine and found throughout much of New England and other parts of the United States.

Annual Cycle: All four species are aquatic perennials that propagate primarily from stem fragments. Flowers followed by fruits are borne at or above the surface in mid-summer, and winter buds are produced on the submersed stems toward the end of the growing season. At the end of the growing season, plants sink to the sediments and decay. The winter buds and some of the stem fragments overwinter intact. When the water warms in the spring, winter buds inflate with air and float to the surface where new growth begins.

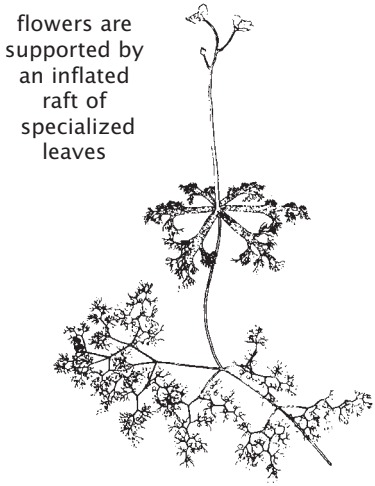
Value in the Aquatic Community: Bladderworts offer shade, invertebrate habitat and foraging opportunities for fish. Common bladderwort and large purple bladderwort often occur in extensive, dense colonies.

Look Alikes: May be confused with other plants with finely divided leaves including fanwort, hornworts, mermaid weed, water crowfoots, water marigold, and leafy water-milfoils.

Common bladderwort with flowers and magnified bladders (insets)



Common bladderwort has coarse, alternately arranged branch-divided leaves

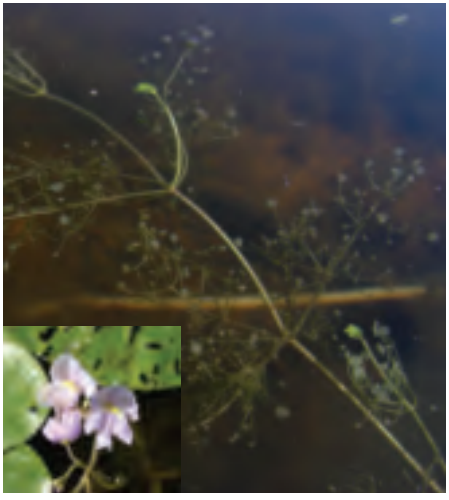


Floating bladderwort has fine, alternately arranged branch-divided leaves

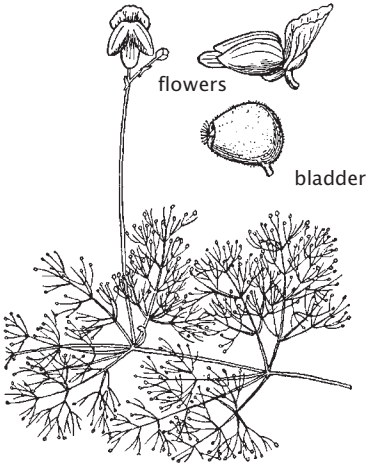
Floating bladderwort in flower

Bladderwort Species Comparison Chart

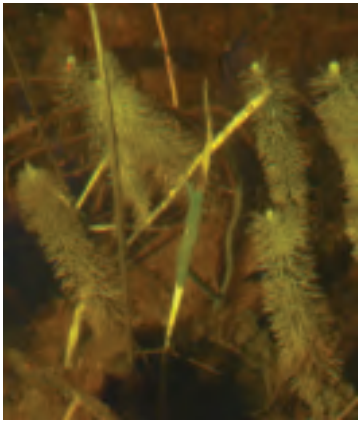
BLADDERWORT SPECIES	RELATIVE STEM LENGTH	LEAF ARRANGEMENT	LEAF DESCRIPTION	FLOWERS	BLADDERS
Common bladderwort (*Utricularia macrorhiza*)	**Long** (up to 3 meters)	The leaf arrangement is **alternate**, but leaves may be divided in such a way that they *appear* to occur in pairs, or lopsided whorls. The leaves are moderately to tightly arranged, giving the plant a **coarse appearance**.	Finely divided leaves are **thread-like** (round in cross-section). Leaves are typically paler and greener toward the growing tip.	**Yellow** snapdragon-like flowers emerge on flower stalks at the surface. There may be 4-20 flowers per stalk.	Bladders are **attached along the edges of the divided leaves**. Young bladders near the growing tip are transparent and tinted pale green. Bladders become darker and less transparent as they age.
Floating bladderwort (*Utricularia radiata*)	**Medium** (up to 1 meter)	The leaf arrangement is **alternate**, but leaves may be divided in such a way that they *appear* to occur in pairs, or lopsided whorls. The leaves are moderately to tightly arranged, but much finer than common bladderwort giving the plant a **delicate appearance**.	Finely divided submersed leaves are **thread-like** (round in cross-section) and **much finer than leaves of common bladderwort**.	**Yellow** snapdragon-like flowers emerge from a slender stalk, **ascending from the center of a whorl of specialized, inflated branches** that act like a float.	Bladders are **attached along the edges of the divided leaves**. Bladders are generally transparent with a pale green tint.
Large purple bladderwort (*Utricularia purpurea*)	**Medium** (up to 1 meter)	The leaves are arranged in strict **whorls**. The whorls are openly spaced along the stem. The whorls at the growing tip curl upward to form a distinctive bird cage-like structure.	Finely divided leaves are **thread-like** (round in cross-section).	**Pale purple** snapdragon-like flowers emerge on slender flower stalks at the surface, often several flowers per stalk.	Tiny transparent bladders are **attached to the tips of the divided leaves**.
Northern bladderwort (*Utricularia intermedia*)	**Short** (less than 0.5 meters)	The leaves are **alternately arranged** in a tight radiating (whorl-like) pattern along the stem.	Finely divided leaves are **flattened and serrated**.	**Yellow** snapdragon-like flowers emerge on flower stalks at the surface.	Bladders **occur on separate, leafless stems**.



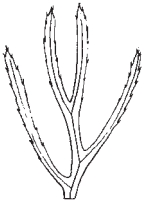
Large purple bladderwort with flowers (inset)



Large purple bladderwort has finely branch-divided leaves arranged in whorls



Northern bladderwort (*U. intermedia*): submersed stems (left)
Leaves and bladders occur on separate stems (right)



divided leaves are flat in cross-section

winter bud

Northern bladderwort leaves are arranged in whorls

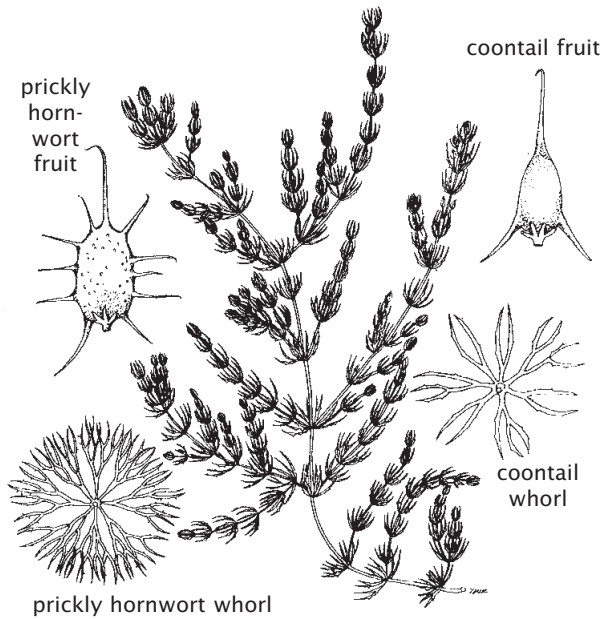
HORNWORTS

Ceratophyllum demersum and *C. echinatum*

NATIVE TO MAINE

Habitat: Maine is home to two hornwort species: coontail ***(Ceratophyllum demersum)*** and prickly hornwort ***(Ceratophyllum echinatum)***, coontail being the more common of the two. Hornworts are found in the submersed plant community from shore to depths of several meters. Lacking roots, the plants may drift at various depths during the growing season, at times becoming loosely anchored in the sediments. Unlike rooted aquatic plants that draw their nutrients primarily from the sediments, hornworts draw nutrients directly from the water. Hornworts are tolerant of cool temperatures and low light conditions.

Description: Both of Maine's hornwort species are submersed aquatic plants with coarse, branching stems and no roots. The leaves of both species are fork-divided and arranged in whorls of 5 to 12 leaves. Whorls of leaves are more closely spaced towards the end of branches giving the plant a raccoon tail appearance. Hornwort leaves are relatively stiff to the touch and typically hold their shape and position when pulled from the water, unlike many other plants with finely divided leaves. A close look at the leaves is needed to distinguish between species. Coontail leaves are generally forked only once or twice, flattened, finely serrated, with tiny teeth often tipped with a sharp spine. The leaves of prickly hornwort are generally forked three or more times, thread-like (round in cross-section) and largely smooth edged (though some small spines may be present). Minute flowers in the leaf axils, followed by spiny fruits, are produced on female plants only. Coontail fruits are smooth and have two spines at the base. The fruits of prickly hornwort have several spines of various lengths around the outer edge and a rough surface.

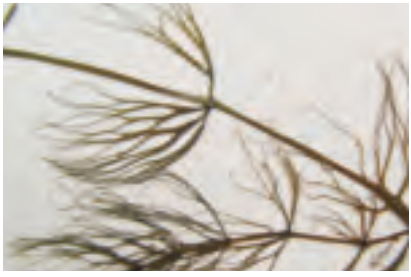


Hornworts have fork-divided leaves arranged in whorls

US Range: Both species are native to Maine, New England and much of North America. Of the two hornwort species found in Maine, coontail *(C. demersum)* is more common.

C. demersum *C. echinatum*

Annual Cycle: Because hornworts are tolerant to low light and cool water, they are able to overwinter under the ice as an evergreen plant. Photosynthesis and growth slow during the winter months and resume with vigor in the spring. Male and female flowers occur on separate plants, making fertilization and seed production unreliable. Reproduction occurs mainly through plant fragmentation.



Prickly hornwort leaves are thread-like, not serrated, and forked three or more times

Value to the Aquatic Community: Because hornworts overwinter as evergreen plants, these species provide important habitat to many invertebrates and fish year-round. Waterfowl feed upon both foliage and fruit.

Look Alikes: May be confused with other plants that have finely divided leaves including fanwort, bladderworts, mermaid weed, water crowfoots, water marigold, and leafy water-milfoils.

Coontail leaves are stiff, flattened and serrated; they generally fork one or two times; note the tiny white flower attached to the stem by a slender stalk

Hornworts have branching stems and no roots

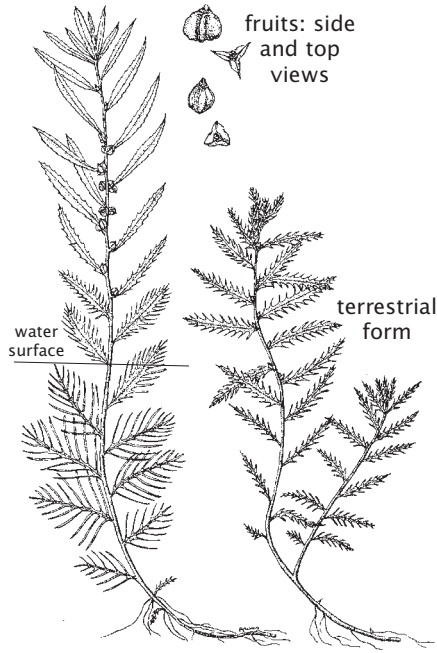
MERMAID WEEDS

Proserpinaca palustris and *P. pectinata*

NATIVE TO MAINE

Habitat: Mermaid weed grows in the submersed and emergent plant communities. It may be found in the shallow waters of bogs, marshes, swamps, and along the muddy shores and banks of ponds and streams. The plants are well adapted to life at the water's edge and may morph to a terrestrial form when water levels drop.

Description: Maine is home to two mermaid weed species: common mermaid weed (***Proserpinaca palustris***) and comb-leaf mermaid weed (***Proserpinaca pectinata***). The green- to reddish-brown stems of both species emerge from long trailing rhizomes. Stems may lie prone along the bottom for some distance, then curve upward toward the water surface. Mermaid weeds have two distinct leaf types: submersed and emergent. The submersed leaves of both species are similar, 5 to 10 cm long, and finely feather-divided. Some of the hair-like leaflets may be forked or appear barbed. The leaves are arranged in a radiating alternate pattern (not whorled). The primary distinction between the two mermaid weed species is found in the emergent leaves (the leaves associated with flowering and fruiting). The emergent leaves of ***P. palustris*** are blade-shaped and conspicuously serrated. The emergent leaves of ***P. pectinata*** are feather-divided to pinnately lobed. Changing water levels may produce alternating sets of the two leaf types. The reddish-purple flowers (2 cm wide) occur in the leaf axils of the emergent leaves, followed by three-sided fruits, or nutlets.



Common mermaid weed
(P. palustris)

US Range: Both mermaid weed species are native to Maine and New England, much of the Eastern United States and the gulf coast states. *P. pectinata* is listed as rare in Maine.

P. palustris

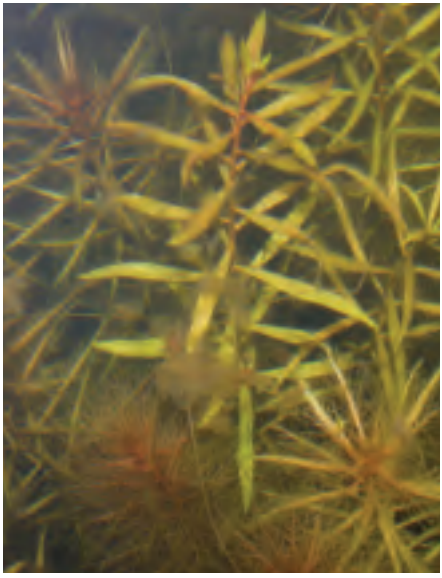
P. pectinata

Annual Cycle: Mermaid weed is an aquatic perennial that propagates from seed, and by spreading roots and rhizomes. Plants die back to the roots and rhizomes as winter sets in. New growth emerges from the seeds and rhizomes in the spring. Flowers occur by mid-summer.

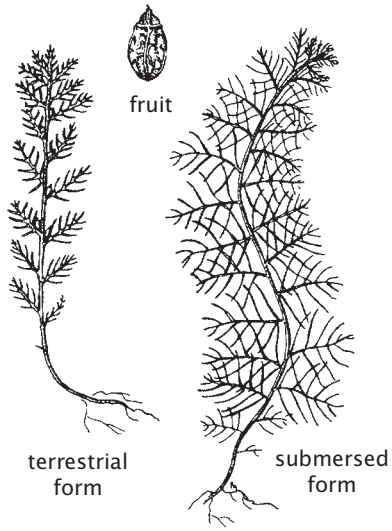
Value in Aquatic Community: Shorebirds and waterfowl feed upon the seeds of mermaid weed, and aquatic invertebrates and fish use the trailing leaves and stems for food and shelter.

Submersed leaves are feather-divided; leaflets may be forked

Look Alikes: The submersed leaves of mermaid weed may be confused with leafy water-milfoils. Mermaid weed's alternate leaf arrangement and forked leaflets help to distinguish it from the milfoils.



Common mermaid weed has feather-divided submersed leaves; emergent leaves are serrated and blade-shaped



The emergent leaves of comb-leaf mermaid weed are finely feather-divided to pinnately lobed (not blade shaped and serrated)

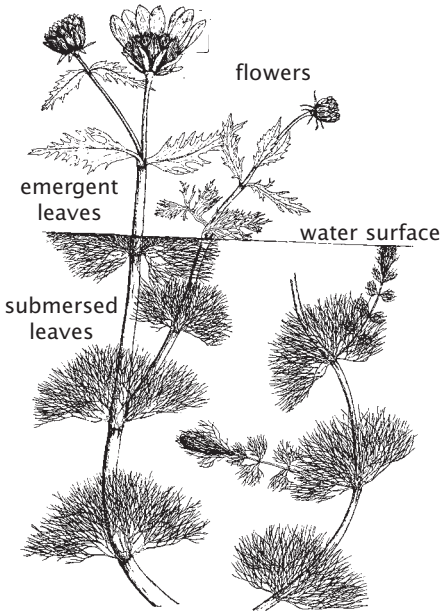
WATER MARIGOLD

Bidens beckii (Megalodonta beckii)

NATIVE TO MAINE

Habitat: Water marigold is found in both the emergent and submersed plant communities. It grows in soft substrates of lakes and streams, from ankle deep water to depths approaching 3 meters.

Description: The stems of water marigold emerge from buried rootstalks and rhizomes. Two distinct leaf types are formed. The submersed leaves are finely divided, and oppositely arranged on the stem. (Note: the opposite leaves, each dividing three times where attached directly to the stem, are widely branched, and not easily distinguished from one another. This creates the appearance of a whorl of six smaller branched leaves on short leaf stems.) When preparing to flower, lance-shaped leaves with serrated margins emerge from the surface of the water on robust stalks. The emergent leaves are also oppositely arranged and attached directly to the stem. Showy, yellow, daisy-like flowers (2 to 2.5 cm wide) are produced among the emergent leaves.



Water marigold has two distinct leaf types

US Range: Water marigold is a native to Maine and New England, and occurs throughout much of the northern United States.

Annual Cycle: Water marigold is an aquatic perennial that propagates during the growing season by stem fragmentation and spreading rhizomes. If conditions are favorable, water marigold will also reproduce from seed. Fruit set is rare in the Northeast. Plants die-back to hardy rootstalks and rhizomes as winter sets in. Some stem fragments also overwinter intact. New growth emerges from stem fragments, seeds and rhizomes as the water warms in the spring. Flowers occur in midsummer, and fruit is produced by late summer.

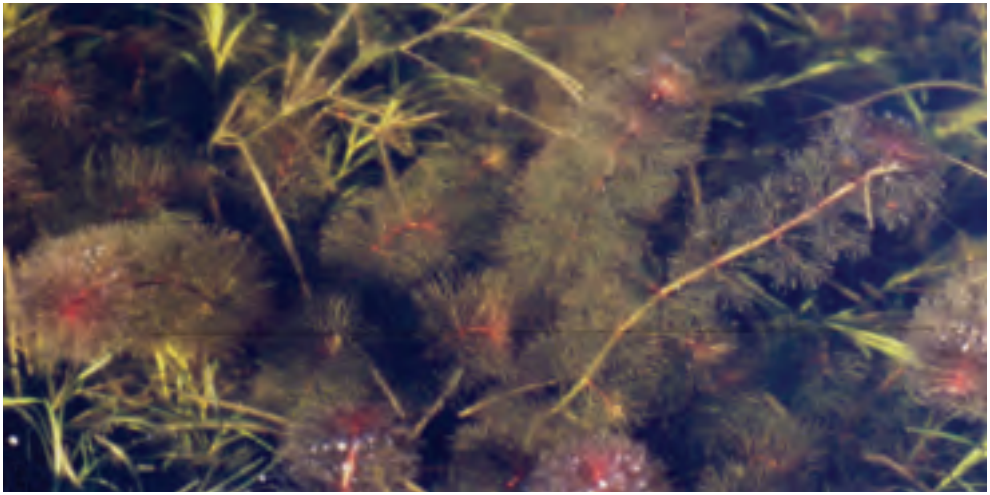
Showy yellow flowers

Value to the Aquatic Community: The submersed foliage of water marigold provides shade, shelter and foraging opportunities for fish. The showy flowers attract insects. Waterfowl and shorebirds may feed upon the fruits.

Look Alikes: May be confused with other plants with finely divided leaves including bladderworts, fanwort, hornworts, mermaid weed, water crowfoots, and leafy water-milfoils.

Stem cross-section showing two oppositely arranged leaves, each dividing three times where attached directly to the stem

Water marigold has finely branch-divided leaves arranged oppositely (but may appear to be in whorls) along slender stems



Water marigold may have bottle brush-like stems and a reddish tinge

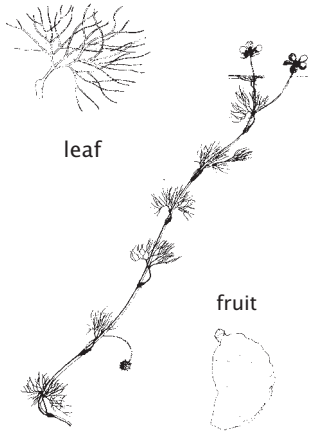
WATER CROWFOOTS

WATER BUTTERCUPS

Ranunculus aquatilis var. *diffusus* and *R. flabellaris*

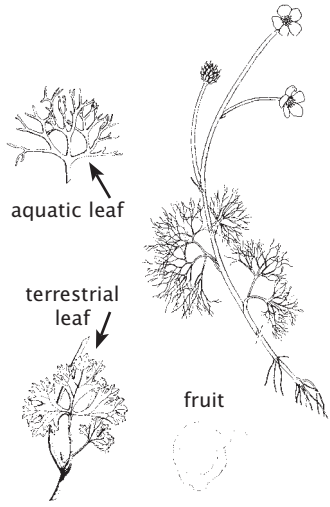
NATIVE TO MAINE

NOTE: Worldwide, most botanists classify the two species described here as being in the genus *Batrachium*. The genus classification of *Ranunculus* for these two species is confined primarily to the United States, and is the exception



White water crowfoot

Habitat: Sixteen different *Ranunculus* species occur in Maine. Several of these are aquatic species, and two: white water crowfoot ***(Ranunculus aquatilis* var. *diffusus)*** and yellow water crowfoot ***(Ranunculus flabellaris)***, are possible invasive aquatic plant look alikes. Both water crowfoot species grow in the submerged plant community, generally in quiet to slow moving water up to two meters in depth. Yellow water crowfoot is well adapted to life at the water's edge and is often found in its terrestrial form, stranded along muddy shores. In Maine, white water crowfoot is more common than yellow water crowfoot.



Yellow water crowfoot

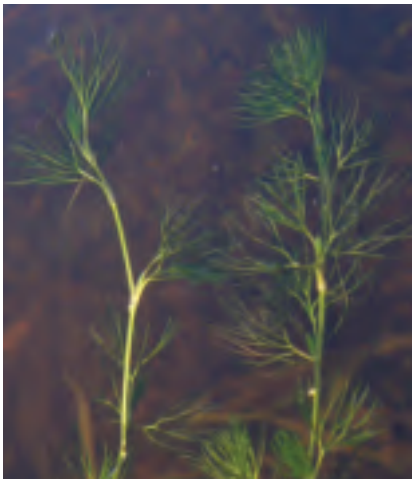
Description: The leaves of both water crowfoot species are borne on long, branching stems emerging from trailing runners or buried rhizomes. Both species have small (1 to 2 cm long) branch-divided leaves, arranged alternately along the stem. The leaves of white water crowfoot are finer, more delicate, and thread-like (round in cross-section). Like the leaves of many aquatic plants, they go limp when removed from the water. The leaves have slender petioles that widen at the stem to form a clasping sheath that wraps all the way around the stem. The leaves of yellow water crowfoot are courser, flattened, and hold their shape when removed from the water. Distinct leaf stems may be absent. Both species produce small buttercup-like flowers, with five petals. The flowers of white water crowfoot are white; the flowers of yellow water crowfoot are yellow. Tiny beaked fruits or nutlets form in clusters on slender stalks.

US Range: Both water crowfoots are native to Maine, New England and much of the United States. In Maine, white water crowfoot is more common than yellow water crowfoot.

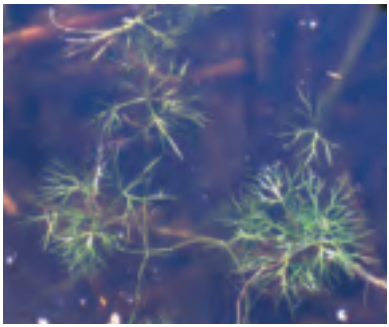
Annual Cycle: Water crowfoots are aquatic perennials, dying back to their rhizomes as winter sets in, and overwintering in the sediments. New growth emerges as the water warms in the spring. Flowers are produced in the early summer, followed by fruits in mid-summer. Plants propagate from seed, and also reproduce vegetatively from stem fragments, rhizomes and runners.

Value in the Aquatic Community: The fruit and foliage of water crowfoot is a source of food for some waterfowl; the plants also offer food and shelter for fish.

Look Alikes: May be confused with other plants with finely divided leaves including bladderworts, fanwort, hornwort species, mermaid weeds, water marigold, and leafy water-milfoils.

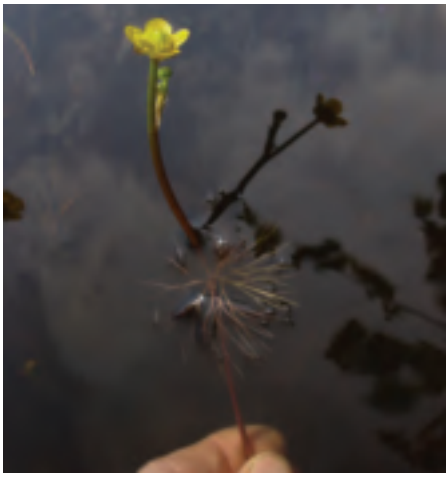


White water crowfoot has finely branch-divided, thread-like leaves



Yellow water crowfoot has branch divided leaves, flattened in cross-section

White water crowfoot in flower



Yellow water crowfoot in flower

WATER-MILFOILS
Myriophyllum species

NATIVE TO MAINE

Maine is home to six native water-milfoil species. Five of these are leafy milfoils, bearing some resemblance to one or more of the invasive milfoils.The sixth native species, dwarf water-milfoil (*Myriophyllum tenellum*), is a diminutive bottom dweller. Lacking true leaves, and not bearing any resemblance to the invasive milfoils, *M. tenellum* is not featured in this field guide. Specific information for each of the other five native milfoils is presented on the following pages:

- Alternate-flowered water-milfoil ***(Myriophyllum alterniflorum)***
- Farwell's water-milfoil ***(Myriophyllum farwellii)***
- Low water-milfoil ***(Myriophyllum humile)***
- Northern water-milfoil ***(Myriophyllum sibiricum)***
- Whorled water-milfoil ***(Myriophyllum verticillatum)***

In addition to the species-specific information for each of the five native species, please see the chart comparing key diagnostic features of the five natives and the three invasive water-milfoils on pages 86 and 87.

NOTE: *All leafy milfoils display a wide range of vegetative variability. Any milfoil found in Maine waters should be considered suspicious until a positive identification has been confirmed by someone with the appropriate expertise.*

Habitat: All of Maine's native water-milfoils are found in the submersed and emergent plant communities. They are best adapted to the quiet waters of lakes and streams.

Northern water-milfoil (*Myriophyllum sibiricum*) has emergent flowers and is a Group 1 milfoil

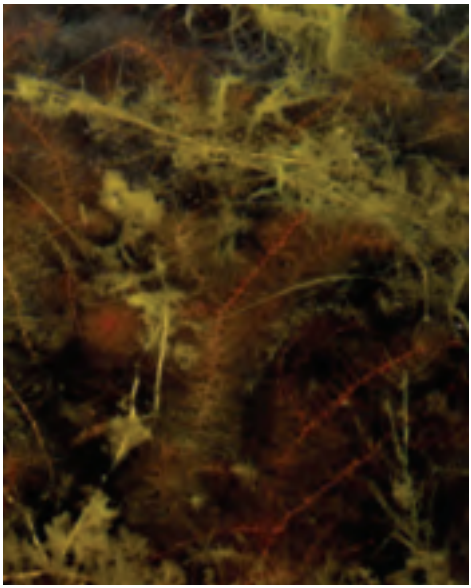
Description: All five leafy native milfoils have long branching stems emerging from sprawling roots. All have finely-divided leaves arranged in a radiating pattern around the stem. The submersed leaves of all five species are feather-divided. Beyond these common features, Maine's native milfoils could be sorted into two distinct groups:

Group 1 ~ Milfoils with Two Distinct Leaf Types and Emergent Flowers; Submersed Leaves are Consistently Whorled.

In the first group are the milfoils that have two distinct leaf types: submersed leaves, and emergent leaves. The emergent leaves, called bracts, are directly associated with the flowers. These milfoils produce flowers and fruits above or at the water's surface on emergent spikes, and the submersed leaves are consistently arranged in whorls. There are three native milfoils in this group: alternate-flowered water-milfoil (***M. alterniflorum***), northern water-milfoil (***M. sibericum***), and whorled water-milfoil (***M. verticillatum***). NOTE: All three invasive milfoils prohibited in Maine also fit into this general category.

Group 2 ~ Milfoils with One Leaf Type Only and Submersed Flowers; Submersed Leaves Not Consistently Whorled.

The second group consists of the milfoils that have one leaf type only (submersed leaves). The plants in this group produce flowers and fruits below the surface of the water in the axils of the submersed leaves. The leaf arrangement of the milfoils in this group is less uniform, sometimes whorled, sometimes not; overall more of a scattered radiating pattern. There are two milfoils in this group: Farwell's water-milfoil (***M. farwellii***), and low water milfoil (***M. humile***) NOTE: None of the three invasive milfoils prohibited in Maine fits into this category. If you find a milfoil with several clearly identifiable flowers or fruits located in the leaf axils of the submersed leaves, all three invasive milfoils may be ruled out.



Low water-milfoil (*Myriophyllum humile*) has submersed flowers and is a Group 2 milfoil (*M. humile* is the more reddish plant of the two species seen growing here; the other is large purple bladderwort)

US Range: All five milfoils are native to Maine, New England and to other parts of the United States.

Alternate-flowered water-milfoil
(M. alterniflorum)

Northern water-milfoil
(M. sibiricum)

Whorled water-milfoil
(M. verticillatum)

Farwell's water-milfoil
(*M. farwellii*)

Low water-milfoil
(*M. humile*)

Annual Cycle: All native milfoil species are perennials that propagate from stem fragments, spreading roots and (to a lesser degree) seeds. Flowers, followed by fruits, develop by mid-summer. Three species flower above the water surface on emergent spikes, and two species produce flowers below the water surface in the leaf axils of the submersed stems (see Group descriptions on page 79). With the exception of low water-milfoil, all may produce winter buds toward the end of the growing season. The buds drop to the sediments as the plants decay. In certain conditions, some species may overwinter intact, but die-back to the rootstalks is common. New shoots emerge in the spring from overwintering rootstalks and winter buds. Certain milfoil species are able to hybridize with other, closely related milfoil species.

Value in the Aquatic Community: The fine leaves and bushy form of water-milfoils provide good cover and trap detritus and other food particles, providing favorable habitat for invertebrates and fish. Both foliage and fruits may be grazed by waterfowl.

Look Alikes: All five native milfoils may be confused with other plants that have finely divided leaves including bladderworts, fanwort, hornwort species, mermaid weed, water crowfoot species, water marigold, and other members of the water-milfoil genus.

Information specific to the five individual species follows.

GROUP 1

ALTERNATE-FLOWERED WATER-MILFOIL
LITTLE WATER-MILFOIL, SLENDER MILFOIL
Myriophyllum alterniflorum

Description: Alternate-flowered water-milfoil has two distinct leaf types: submersed leaves and emergent leaves (called bracts). Alternate-flowered milfoil is the smallest of the water-milfoils, having submersed leaves typically less than 1 cm long. The leaves are finely feather-divided (3 to 7 thread-like leaflet pairs per leaf), cupped slightly upward, and arranged in strict whorls (3 to 5 leaves per whorl) that are noticeably spaced along a slender stem. Both leaves and stems may be reddish. The tiny flowers occur in the axils of the bracts, in a generally alternate arrangement, on an emergent spike that projects less than 5 cm above the water. (The arrangement of flowers and bracts may be opposite near the bottom of the spike.) The bracts are entire or slightly serrated, and are the same length or slightly longer than the flowers and fruits. Toward the end of the growing season, winter buds (or turions) comprised of small stiff leaves are formed along the submersed stems.

Look Alikes: The combination of miniature form, strictly whorled submersed leaves spaced along slender stems, and flowers alternately arranged on the flower spike generally help to distinguish this species from other water-milfoils.

Alternate-flowered milfoil seen growing here with a native pondweed

Fruits occur on emergent spikes in axils of alternately arranged bracts

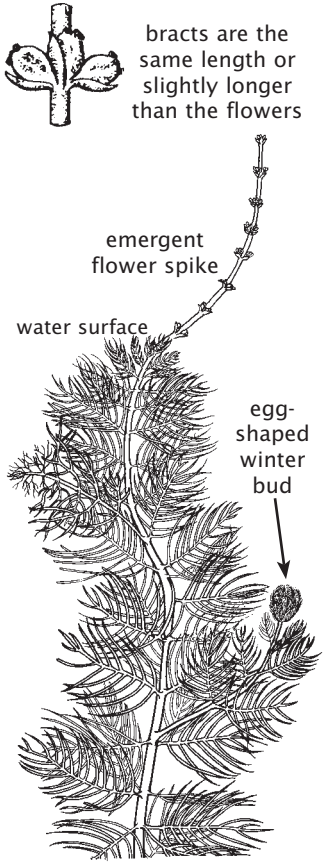
NORTHERN WATER-MILFOIL

Myriophyllum sibiricum

Flowers and bracts arranged in whorls on emergent spike

Description: Northern water-milfoil has two distinct leaf types: submersed leaves and emergent leaves associated with the flowers (called bracts). The submersed leaves are finely feather-divided (1 to 5 cm long), with 5 to 14 pairs of leaflet pairs per leaf. Whorls of 4 or 5 leaves are spaced (up to 1 cm apart) along the stem. Northern milfoil produces flowers and fruits above or at the water's surface on erect (4 to 15 cm) spikes. The bracts have entire or slightly serrated margins. Even when fully developed, the flowers are very small. The bracts are the same length or slightly longer than the flowers and fruits. (A hand lens is helpful for studying the flowers and bracts.) Toward the end of the growing season, egg-shaped winter buds (or turions) comprised of small stiff leaves are formed along the submersed stems.

Look Alikes: The native milfoil that northern water-milfoil most closely resembles is whorled water-milfoil. Northern milfoil may also be confused with two of the invasive milfoils: variable water-milfoil and Eurasian water-milfoil. Northern water-milfoil is the closest native look alike to Eurasian water-milfoil and has been known to hybridize with this invader.



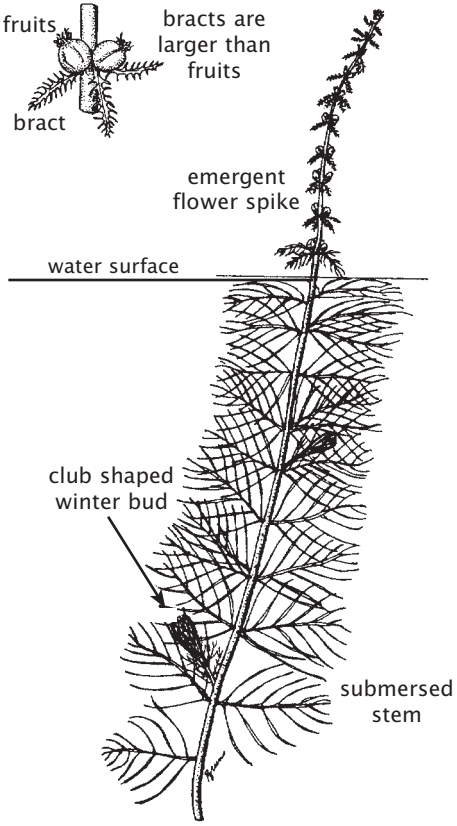
Northern water-milfoil

WHORLED WATER-MILFOIL

COMB WATER-MILFOIL

Myriophyllum verticillatum

Description: Whorled water-milfoil has two distinct leaf types: submersed leaves and emergent leaves (called bracts). The submersed leaves are finely feather-divided, with 5 to 14 thread-like leaflet pairs per leaf. Whorls of 4 or 5 leaves are spaced (up to 1 cm apart) along the stem. Whorled milfoil produces flowers and fruits above or at the water's surface on erect (4 to 15 cm) spikes. The bracts occurring on the emergent spike are pinnately lobed (like a double-sided comb). Even when fully developed, the flowers are very small. (A hand lens may be needed to study this feature.) The bracts are typically two or more times longer than the flowers and fruits. Toward the end of the growing season, elongated club-shaped winter buds (or turions), comprised of small stiff leaves, are formed along the submersed stems.



Whorled water-milfoil in flower

Look Alikes: The native milfoil that whorled water-milfoil most closely resembles is northern water-milfoil. Whorled milfoil may also be confused with two of the invasive milfoils: variable water-milfoil and Eurasian water-milfoil. Whorled water-milfoil is the closest native look alike to variable water-milfoil.

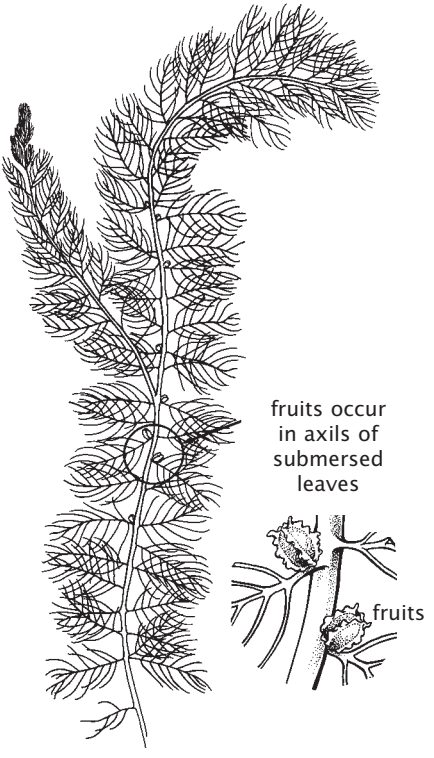
Club-shaped winter buds

GROUP 2

FARWELL'S WATER-MILFOIL

Myriophyllum farwellii

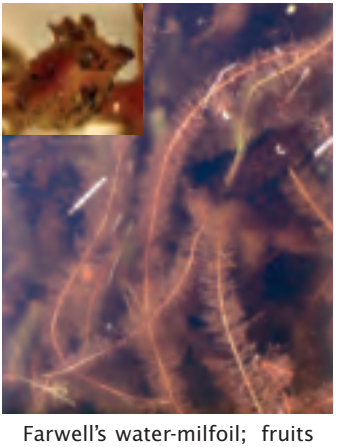
Description: Farwell's water-milfoil has submersed leaves only. The leaves are typically 1 to 3 cm long and finely feather-divided, with 5 to 12 thread-like leaflet pairs per leaf. The leaves are closely spaced, radiating from the stem, and arranged both in whorls (3 to 5 leaves per whorl) and also in a more scattered radiating pattern. Stems are generally slender; both stems and leaves may be reddish. Unlike all of the invasive milfoils prohibited in Maine, and most of the other Maine native milfoils, Farwell's does not produce flowers on an emergent stalk. Farwell's water-milfoil and its close native look alike, low water-milfoil, both produce flowers, followed by small fruits, along the submersed stems in the leaf axils. The tiny fruits of Farwell's have bumpy ridges (as opposed to the smooth fruits of low water-milfoil). Toward the end of the growing season, winter buds (or turions) comprised of small stiff leaves are formed along the submersed stems.



Farwell's water milfoil has submersed leaves only

Look Alikes: The milfoil that Farwell's most closely resembles is low water-milfoil. This species may also resemble immature variable water-milfoil.

Leaves may be arranged in whorls or a scattered radiating pattern

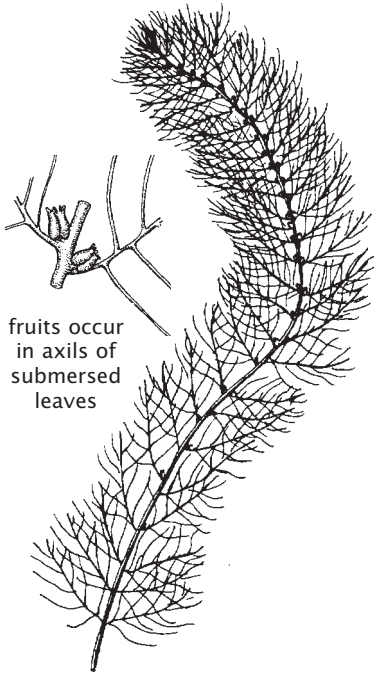


Farwell's water-milfoil; fruits have bumpy ridges (inset)

LOW WATER-MILFOIL

Myriophyllum humile

Description: Low water-milfoil has submersed leaves only. The leaves are finely feather-divided, with 5 to 12 thread-like leaflet pairs per leaf. They are typically closely spaced along the stem in a scattered radiating arrangement (as opposed to strict whorls). Both stems and leaves may be brownish red in color. Unlike all of the invasive milfoils prohibited in Maine and most of the other Maine native milfoils, low water-milfoil does not produce flowers on an emergent stalk. Low water-milfoil and its close native look alike, Farwell's water-milfoil, both produce flowers, followed by small fruits, along the submersed stems in the leaf axils. The tiny fruits of low water-milfoil are comprised of four smooth-sided sections (as opposed to the bumpy ridged fruits of Farwell's water-milfoil). Low water-milfoil does not form winter buds.



Low water milfoil has submersed leaves only

Look Alikes: The milfoil that low water-milfoil most closely resembles is Farwell's water-milfoil.

Leaves are arranged in a scattered radiating pattern

Low water-milfoil; fruits have mostly smooth ridges (inset)

LEAFY MILFOIL FEATURE COMPARISON CHART

Note: All leafy milfoil species display a wide range of vegetative variability. The characteristics described in this chart should be viewed as typical, not definitive. Occasional exceptions are to be expected.

MILFOIL SPECIES	INVASIVE OR NATIVE	LEAF ARRANGEMENT	AVG # LEAVES PER WHORL	AVG # LEAFLET PAIRS PER LEAF	AVG DISTANCE BETWEEN WHORLS (Internodal spacing)	WINTER BUDS	REPRODUCTIVE STRUCTURES AND OTHER DISTINGUISHING FEATURES
Eurasian water-milfoil *Myriophyllum spicatum*	INV	whorled	3 to 6	12 to 24	1 cm or more	n	Flowers and bracts are arranged in whorls on emergent spikes; bracts are blade-shaped and entire; flowers are larger than bracts
Parrot feather *Myriophyllum aquaticum*	INV	whorled	4 to 6	10 to 18	1 cm or more	n	Flowers occur in the axils of the emergent leaves; emergent stems may grow to a height of 30 cm above the surface; tiny flowers are white and inconspicuous
Variable leaf water-milfoil *Myriophyllum heterophyllum*	INV	whorled	4 to 6	5 to 14	less than 5 mm	y	Flowers and bracts are arranged in whorls on emergent spikes; bracts are blade-shaped, serrated and larger than the flowers; red stems are common
Hybrid water-milfoil *M. heterophyllum X M. laxum*	INV	whorled	4 to 6	5 to 14	less than 5 mm	n	Flowers and bracts are variously arranged on emergent spikes; bracts are variously shaped and larger than the flowers; red stems and leaves are common

MILFOIL SPECIES	INVASIVE OR NATIVE	LEAF ARRANGEMENT	AVG # LEAVES PER WHORL	AVG # LEAFLET PAIRS PER LEAF	AVG SPACING BETWEEN WHORLS / LEAVES	WINTER BUDS	REPRODUCTIVE STRUCTURES AND OTHER DISTINGUISHING FEATURES
Alternate leaf water-milfoil *Myriophyllum alterniflorum*	**NAT**	whorled	3 to 5	3 to 7	up to 1 cm	y	Flowers and bracts are arranged alternately on emergent spikes; bracts are blade-shaped, entire or serrated, and larger than the flowers; typically the smallest leafy milfoil
Farwell's water-milfoil *Myriophyllum farwelli*	**NAT**	radially scattered & whorled	3 to 5	5 to 12	less than 5 mm	y	Flowers occur in submersed leaf axils; tiny sectioned fruits have bumpy ridges; reddish leaves and stems are common
Low water-milfoil *Myriophyllum humile*	**NAT**	radially scattered	na	5 to 12	less than 5 mm	n	Flowers occur in submersed leaf axils; tiny sectioned fruits are smooth; reddish leaves and stems are common
Northern water-milfoil *Myriophyllum sibiricum*	**NAT**	whorled	4 to 5	5 to 14	up to 1 cm	y	Flowers and bracts are arranged in whorls on emergent spikes; bracts are entire or finely-serrated, and the same length or slightly longer than the flowers
Whorled water-milfoil *Myriophyllum verticillatum*	**NAT**	whorled	4 to 5	5 to 14	up to 1 cm	y	Flowers and bracts are arranged in whorls on emergent spikes; bracts are pinnately lobed, and 2 (or more) times longer than the flowers

WATER-MILFOIL SPECIES COMPARISON CHART

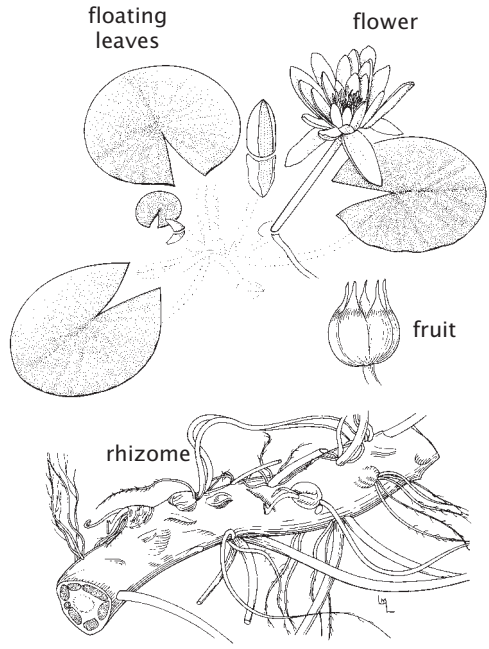
FRAGRANT WATER LILY

WHITE WATER LILY

Nymphaea odorata

NATIVE TO MAINE

Habitat: Fragrant water lily is found in the floating-leaved plant community. It thrives in quiet water of lakes, ponds and slow moving streams, growing well in a variety of sediment types, to depths up to two meters.



Fragrant water lily *(Nymphea odorata)*

Description: Fragrant water lily is a floating-leaved plant with lobed leaves and spectacular white flowers. Long, elastic stems rise toward the water surface from fleshy rhizomes buried in the sediments. Stems may be faintly striped, and are round in cross-section, containing a bundle of four large air passages. The leaves are fairly round in shape (10 to 30 cm in diameter) with a narrow pie-shaped notch (or sinus) dissecting the circle between two (often overlapping) lobes. The notch between the lobes extends to the stem on the underside of the leaf. The lobes are bluntly to sharply pointed, with the tips gently flaring outward (like a cat's ear). The tops of the leaves are leathery and green; the undersides are reddish purple. The strongly-fragrant flowers are large (7 to 20 cm in diameter), with numerous white petals arranged in a circular cluster around a delicate spray of yellow stamens. The flowers are produced on separate flower stalks arising directly from the rhizome. Native water lilies with pale pink flowers occur in Maine. The dark pink forms, however, are thought to be hybrids with the horticultural *Nymphaea alba*. Though not native to Maine, the dark pink form is not generally considered invasive.

Fragrant white flower

Though not native to Maine, this dark pink form is not generally considered invasive

Note: A subspecies, *Nymphea odorata* subspecies *tuberosa*, has recently been recognized in Maine. As a result, *Nymphea odorata* may now be referred to as *Nymphea odorata* ssp. *odorata*. Whether *N. o. tuberosa* is native or was introduced remains uncertain. The two subspecies do interbreed, and differences in some populations may not be distinct. To differentiate between the two subspecies, closely observe the following four characteristics:

Petioles (leaf stems) are more distinctly marked with brownish-purple stripes on *N. o. tuberosa*;

Seeds of *N. o, tuberosa* are larger (2.8 to 4.5 mm long as opposed to 1.5 to 2.5 mm long for *N. o. odorata*);

Small tubers along the main rhizome of *N. o. tuberosa* have narrow constrictions at their base. This allows them to break off the parent plant very easily. The narrow constriction is lacking on *N. o. odorata*.

Leaves of pure N. o. tuberosa, are green, but the leaves of *N. o. odorata* can be any color. Intermediates between the two often have light reddish tinge to the underside of the leaf.

US Range: Fragrant water lily is native to Maine and New England. Its range includes most of the United States.

Annual Cycle: Fragrant water lily is an aquatic perennial that propagates by creeping rhizomes and seeds. Flowering occurs throughout the summer. Flowers open in the morning and close by mid-afternoon. After pollination, flowers submerse and seeds mature inside a fleshy fruit. Rhizomes and seeds sprout new growth as the water begins to warm in the spring.

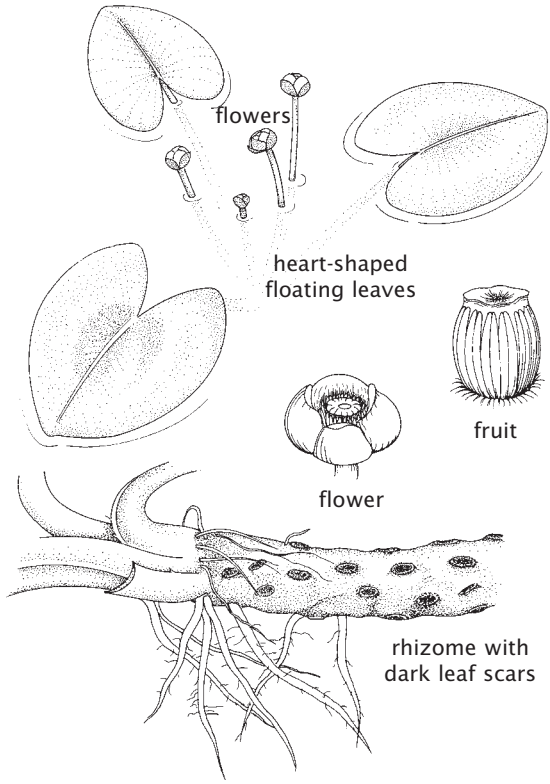
Value to the Aquatic Community: The leaves of fragrant water lily produce shade for aquatic invertebrates and fish. Waterfowl feed upon the seeds. Rhizomes are eaten by deer, muskrat, beaver, moose and porcupine.

Look Alikes: May be confused with European frogbit, yellow floating heart, little floating heart, spatterdock and watershield.

Fragrant water lily *(Nymphea odorata)*

SPATTERDOCK
COW LILY
Nuphar variegata

NATIVE TO MAINE



Spatterdock *(Nuphar variegata)*

Habitat: Spatterdock is part of the floating-leaved plant community, growing in depths up to 2 meters. It is especially abundant in still or slow moving waters with soft sediments. Spatterdock can grow in sun or shade, but flowers more readily in good light.

Description: Spatterdock is a floating-leaved perennial. The leaves are elongate and heart-shaped, 7 to 40 cm long, with rounded lobes. The lobes are parallel or overlapping and the leaf notch is usually less than half the length of the midrib. The leaf and flower stalks emerge from a thick spongy rhizome marked with a spiraling pattern of leaf scars. The leaf stalks are thick and elastic. One side of the stalk is rounded, flaring out at the edges to create wing-like structures that run the length of the stalk. The other side is more flattened. The stalks are unbranching; each stalk supports one leaf. The flowers of spatterdock are yellow and ball-shaped with 5 or 6 petals around a yellowish-green stigmatic disk. The disk eventually develops into a large seedpod that is shaped like a barrel or vase.

US Range: Spatterdock is one of the most common aquatic plants in New England and is widely distributed in Maine. Its range includes much of the northern United States.

Annual Cycle: Spatterdock over-winters as rhizomes and seeds. New leaves begin to emerge from the rhizomes early in the summer. Later, flowers are borne above the floating leaves, often blooming all summer long.

Value to the Aquatic Community: Spatterdock is an important food source for a wide variety of wildlife including, waterfowl, deer, muskrat, beaver, and porcupine. The leaves offer shade and habitat for fish and invertebrates.

Look Alikes: May be confused with European frogbit, yellow floating heart, small and large yellow pond lilies (both species uncommon in Maine and not included in this guide), little floating heart, watershield, and fragrant water lily.

Spatterdock leaves may grow up to 40 cm long

The flowers are yellow and ball-shaped; the stigmatic disk develops into a vase-shaped seedpod (inset)

The leaf stalks are thick and elastic
Stem cross-section (inset) resembles a smile

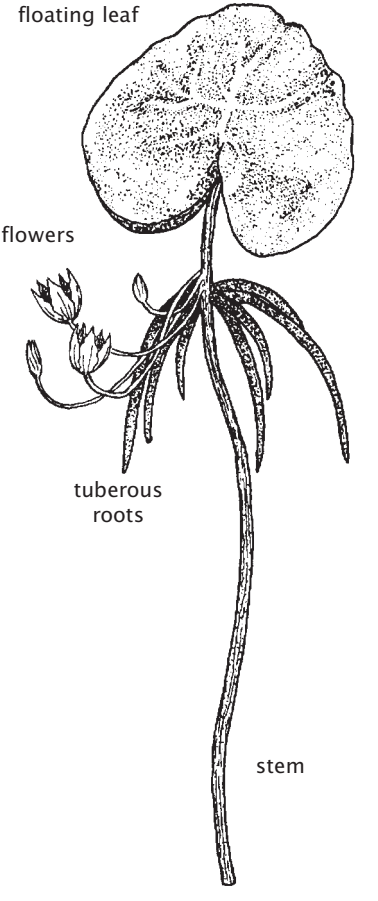
LITTLE FLOATING HEART
SMALLER FLOATING HEART
Nymphoides cordata

NATIVE TO MAINE

Habitat: Little floating heart is found in the floating leaved plant community. It grows in quiet waters of lakes and streams.

Description: Small (1.5 to 5 cm wide), heart-shaped leaves with entire (or slightly scalloped) margins emerge from rhizomes on long slender stems. Each stem produces a single leaf only. The delicate white flowers (about 1 cm in diameter) have five petals, and emerge from the submersed stem to the water's surface on slender stalks. Clumps of elongate tuberous roots resembling tiny bunches of bananas are also borne along the stem, generally near the surface.

US Range: Little floating heart is native to Maine and New England, and occurs in most states along the eastern seaboard and gulf coast.

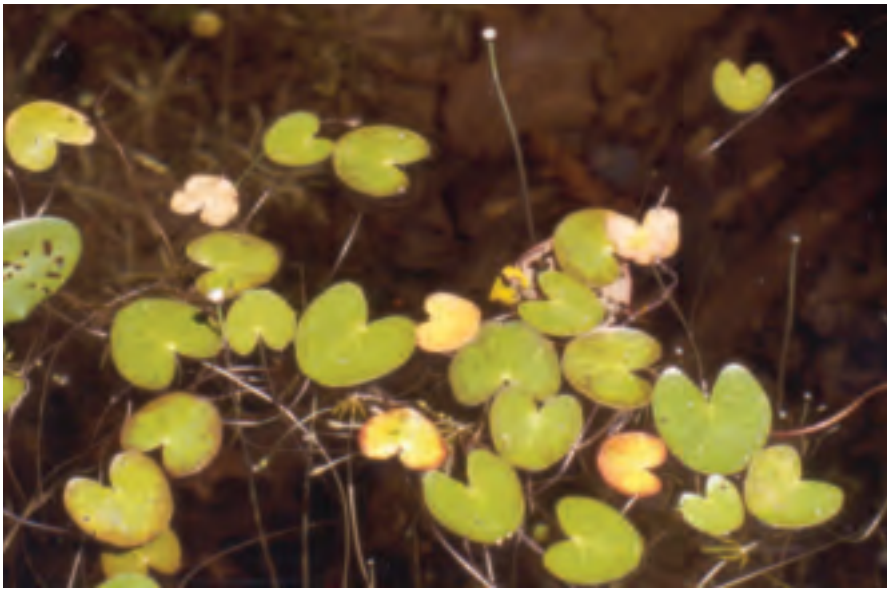


Little floating heart (*Nymphoides cordata*)

Annual Cycle: Little floating heart is an aquatic perennial that propagates by rhizomes, tubers and seeds. Flowers are produced from June to September. Plants die back to their rhizomes with the onset of winter. Rhizomes, tubers and seeds sprout new growth as the water begins to warm in the spring.

Value in the Aquatic Community: Little floating heart provides food and shelter for wildlife, including fish.

Look Alikes: Maybe confused with European frogbit, yellow floating heart, watershield, spatterdock, and fragrant water lily.



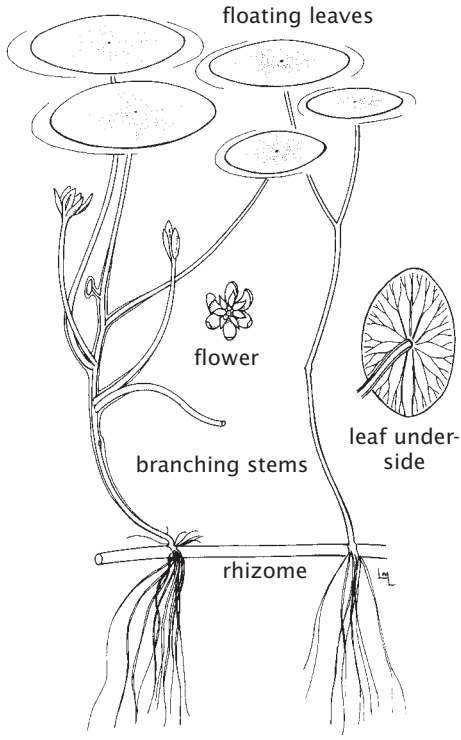
The slender stems of little floating heart often get twisted and tangled but a careful look will reveal that the stems are unbranching, with one leaf per rooted stem; tiny white flowers occur at the water's surface (top of photo)

The leaf margins are entire or slightly scalloped; clumps of elongated tuberous roots resembling tiny bunches of bananas are borne along the stem, generally near the surface

WATERSHIELD
WATER TARGET
Brasenia schreberi

NATIVE TO MAINE

Habitat: Watershield is found in the floating-leaved plant community. It thrives in soft- water lakes, ponds and slow moving streams, especially those with sediments that are rich in organic matter.



Watershield (*Brasenia schreberi*)

Description: Watershield is a floating-leaved plant with moderately-sized, (4 to 12 cm long, 2 to 6 cm wide), oval to football-shaped leaves. Long, elastic stems (round in cross-section) rise toward the water's surface from buried rhizomes. Stems are often loosely branching, with a single leaf attached (from the middle of its underside) to the end of each branch. The tops of the leaves are leathery and green during the growing season, grading to brilliant yellows, oranges and reds in the fall. The undersides of the leaves are reddish-purple. All submersed portions of the plant, including the undersides of the leaves, are coated with a clear mucilaginous jelly. The flowers are maroon to purple, less than 3 cm wide, and produced on stalks that emerge just above the water surface.

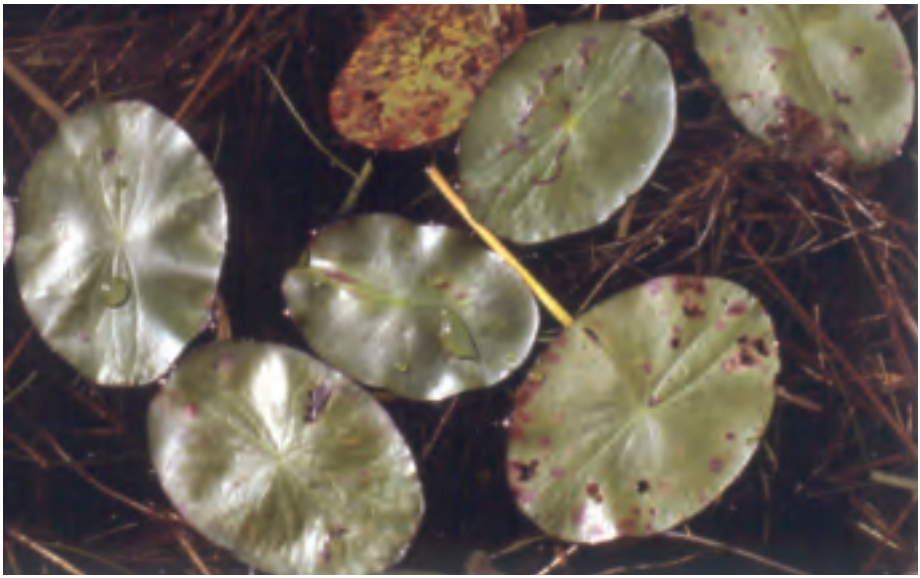
Range: Watershield is native to Maine and New England, and occurs throughout much of the eastern United States and some western states.

Annual Cycle: Watershield is an aquatic perennial that propagates by creeping rhizomes, seeds, and winter buds (or turions). Flowers are produced in early to mid-summer. Seeds and winter buds are produced in the late summer, and settle to the bottom as the plants decay. Rhizomes, seeds and winter buds sprout new growth as the water begins to warm in the spring.

Value to the Aquatic Community: The leaves of watershield produce shade for aquatic invertebrates and fish. Waterfowl feed upon the leaves, stems, seeds and buds.

Look Alikes: May be confused with European frogbit, yellow floating heart, fragrant water lily, little floating heart, and spatterdock. The unnotched, oval leaves with stems attached dead center help to distinguish watershield from all of these look alikes.

The flowers are maroon to purple and emerge above the water's surface



Watershield's unnotched oval-shaped floating leaves, with stems attached dead center to the underside, help to distinguish this native aquatic plant

NORTHERN SNAIL-SEED PONDWEED

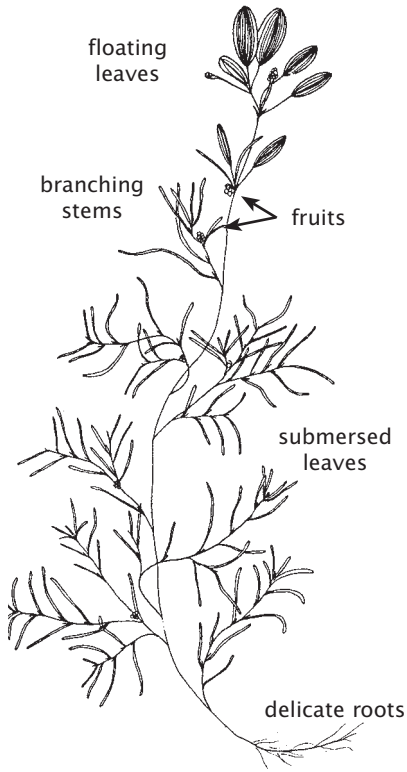
SPIRAL-FRUITED PONDWEED

Potamogeton spirillus

NATIVE TO MAINE

Habitat: Northern snail-seed pondweed grows in the submersed plant community. It is found in relatively shallow, quiet portions of lakes, ponds and slow moving streams, and prefers neutral to acidic water.

Description: Northern snail-seed pondweed produces two distinct leaf types: submersed leaves and floating leaves. Both leaf types are entire. Compact clumps of slender, often profusely branching stems emerge from delicate roots and rhizomes. Stems are slightly compressed in cross-section. Submersed leaves are narrow and strap-shaped (1 to 8 cm long, and 0.5 to 2 mm wide), rounded at the tip, and often slightly curled. They are attached directly to the stems (no petioles) and are alternately arranged in spirals along the stem. Light-colored, translucent bands of air-filled cells (called lacunae) occur along both sides of the midvein. Stipules are fused to submersed leaves for more than half of their length (often only the tips of the stipules are free). Floating leaves, when present, occur at the water's surface on slender petioles (0.5 to 2.5 cm long). The leaves are small (0.7 to 3.5 cm long) and oval. Flowers are minute and inconspicuous. Tiny fruits are generally produced in clusters, and occur either in the leaf axils or dangling loosely on the ends of thread-like stalks. Fruits look like flattened, faintly-spiraled disks. A series of blunt points may occur along a portion of the disk edge. (A hand lens is helpful when observing lacunae, stipules and fruits.) Northern snail-seed pondweed is often light green to golden in color.



Northern snail-seed pondweed (*Potamogeton spirillus*)

Range: Northern snail-seed pondweed is native to Maine and New England, occurring throughout much of the northeast and north central United States.

Annual Cycle: Northern snail-seed pondweed is an aquatic perennial that propagates by creeping rhizomes and seeds. Flowers occur in the spring and fruits mature by mid-summer. Plants die back to their rhizomes as winter sets in, depositing seeds on the sediments. New growth sprouts from the rhizomes and seeds as the water begins to warm in the spring.

Value in the Aquatic Community: Northern snail-seed pondweed is grazed upon by fish, waterfowl and invertebrates. The compact, bushy plants provide shelter for fish fry.

Look Alikes: Submersed leaves of northern snail-seed pondweed may be confused with some other narrow-leaved species of the *Potamogeton* genus, European naiad, slender naiad, thread-like naiad, and some stoneworts.

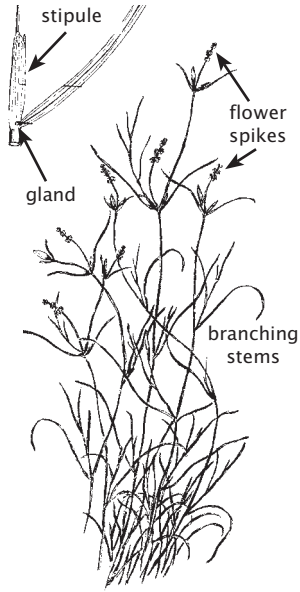
Disk-like fruits

Northern snail-seed pondweed; the plant on the right has submersed leaves only; the plant on the left has submersed and floating leaves

SLENDER PONDWEEDS

Potamogeton pusillus, P. berchtoldii, and *P. gemmiparus*

NATIVE TO MAINE



Slender pondweed

Recent DNA evidence has identified three distinct species of slender pondweed occurring in Maine: ***P. gemmiparus*** (previously *P. pusillus* var. *gemmiparus*), ***P. pusillus*** (previously *P. pusillus* var. *pusillus*), and ***P. berchtoldii*** (previously *P. pusillus* var. *tenuissimus*). The description that follows has been generalized to pertain to all three species.

Habitat: Slender pondweeds grow in the submersed plant community. They are found in soft sediments in quiet water of lakes, ponds and slow-moving streams, in depth up to three meters. These pondweeds thrive in deeper, darker water and will tolerate turbid and brackish conditions.

Description: Slender pondweeds have submersed leaves only. Sinuous stems (up to 1.5 meters long) emerge from delicate roots. Stems may be round to slightly compressed in cross section, and often branch repeatedly near the growing tips. Narrow leaves (1 to 7 cm long and 0.2 to 2.5 mm wide) are entire, alternately arranged in a spiral, and attach directly to the stems at their base (no petioles). A pair of tiny bumps (actually glands) occur at the nodes, one on each side of the base of the leaf. (Not every node has well-developed glands, so you may need to check several.) The leaves have one to three veins, and the mid-vein may be bordered by one or more light-colored, translucent bands of air-filled cells called lacunae. Leaves taper slightly toward the base; the tips of the leaves are varied depending on sub-species, and may be blunt or sharply pointed. Flimsy, tube-like stipules may occur around the stems, but they are fairly inconspicuous, and are not always persistent. Flowers, followed by tiny fruits, occur in whorls on slender spikes (0.5 to 6 cm long). The spikes grow from stem and leaf axils and may be submersed or emergent. The plump fruits are asymmetrical but somewhat rounded to oval in shape, with a short protrusion (called a beak) at one end. Numerous winter buds (or turions) are produced in the leaf axils toward the end of the growing season. The buds are elongated (1 to 3 cm long), generally dark in color, resembling tiny, partially-unhusked corn cobs. (A hand lens is helpful when observing lacunae, leaf glands, stipules, fruits, and winter buds.) Slender pondweeds are generally light green to olive green (occasionally reddish) in color.

Slender Pondweed Species Comparison Chart

	P. pusillus	*P. berchtoldii*	*P. gemmiparus*
LEAVES	O.2 to 2.5 mm wide; 0 to 2 lacunae bands on each side of midvein; sharply pointed at the tip	O.2 to 2.5 mm wide 1 to 5 lacunae bands on each side of midvein; bluntly to sharply pointed at the tip	O.2 to 0.7 mm wide; one vein; 1 lacunae band on each side of midvein; sharply pointed at the tip
STIPULES	wrapping around the stem and fused at the margins, forming a tube surrounding the stem	wrapping around the stem, but not fused at the margins	wrapping around the stem, but not fused at the margins
FLOWERS	flower spikes mostly at the growing tip; 1 to 3 per plant; flowers arranged on spike in distinct, interrupted whorls	flowers spikes at the growing tip or along the stem; generally more than 3 per plant; flowers arranged on spike in crowded whorls	flowers uncommon
WINTER BUDS	elongate winter buds	elongate winter buds	very slender elongate winter buds

Range: Slender pondweeds are native to Maine and New England. The range of *P. gemmiparus* is limited to New England. The other two sub-species occur throughout most of the United States. *P. pusillus* and *P. berchtoldii* are both known to hybridize with another native pondweed species. Populations of these hybrid pondweeds occur in Maine.

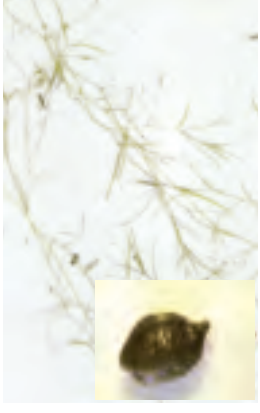
Winter bud (turion)

Annual Cycle: Slender pondweed is an aquatic perennial that propagates by spreading roots, winter buds and, to a more limited degree, seeds. Flowers occur in the spring. Fruits and winter buds mature by early to mid-summer. Plants often die-back to their roots before the end of the growing season, depositing winter buds and seeds on the sediments. New growth sprouts from the roots, buds and seeds as the water begins to warm in the spring.

Value in the Aquatic Community: Slender pondweed is an important food source for a variety of waterfowl. The fine-leaved plants often form extensive beds, providing food and cover for fish and their fry. Muskrat, deer, beaver and moose are all known to feed upon this plant.

Look Alikes: Submersed leaves of slender pondweed may be confused with other narrow-leaved species of the *Potamogeton* genus, European naiad, slender naiad, thread-like naiad, and some stoneworts.

Slender pondweed has submersed leaves only



The slender flower spikes grow from stem and leaf axils; the fruits are rounded to oval with a short beak (inset)

NAIADS

WATER NYMPHS

Najas flexilis and *N. gracillima*

NATIVE TO MAINE

Maine is home to three native naiad species. One species, slender naiad (***N. flexilis***), also called northern water-nymph, is common in Maine. The others: southern naiad (***N. guadalupensis***) and thread-like naiad (***N. gracillima***) are quite rare. Though a rare species, thread-like naiad has been included in this guide because it has more features in common with the invader European naiad than the more common, slender naiad.

Habitat: Both native species discussed below are found in the submersed plant community, often growing in the sandy or gravel substrates of lakes, ponds and slow moving streams. Thread-like naiad is particularly sensitive to pollution, and has disappeared in some parts of its natural range.

Description: The branching stems of both native naiads are slender and flexible (up to 1 meter long, but often much shorter), growing from slight roots. Thread-like naiad is a very delicate plant with wispy stems branching lightly near the tips. The habit of slender naiad is more variable: some plants are tall and sparse; others short and bushy. The leaf arrangement of both species is mixed. Leaves may occur in opposite pairs and/or whorls along the stem, and be clumped into delicate sprays at the stem tips. The leaves are slender (1 to 4 cm long), linear, serrated (actually spined) along their margins, and sharply pointed at the tip. The tiny, inconspicuous flowers, followed by slender fruits, develop in the leaf axils. The fruits are about 3mm long, cylindrical, and pointed at both ends. The surface may appear to be smooth but magnification reveals many tiny, shallow indentations, or pits, arranged in longitudinal rows. The fruits turn brown as they mature.

The table on page 102 compares four key features that help to distinguish the two native naiads from each other and from their invasive look alike, European naiad, *Najas minor*: (Magnification is generally needed to observe these features. To observe leaf bases, gently pull the leaf away from the stem.)

Slender naiad leaves at the stem tip

Origin and Range: Both species are native to Maine and New England. Slender naiad's range includes much of the northern and western United States. The range of thread-like naiad includes most of the eastern and central-eastern United States and California. In Maine, the distribution of slender naiad is fairly widespread. The other two native species, including thread-like naiad, are rare.

N. flexilis

N. gracillima

Annual Cycle: Unlike most aquatic plants, naiads are true annuals, dying back completely in the fall and relying upon seeds to regenerate the following season. Seeds germinate in the spring and plants are generally visible by early summer. Vegetative reproduction may occur during the growing season. Tiny flowers, followed by seeds, are produced in the leaf axils. (Male and female flowers occur separately on the same plant.) Plants become brittle and begin to break down at the end of the growing season, fragmenting, drifting and eventually depositing their seeds on the sediments.

Value to the Aquatic Community: Naiads are an important food source for a wide variety of waterfowl and marsh birds. Muskrats also feed upon the stems and leaves. The slender branches provide food and shelter for fish and invertebrates.

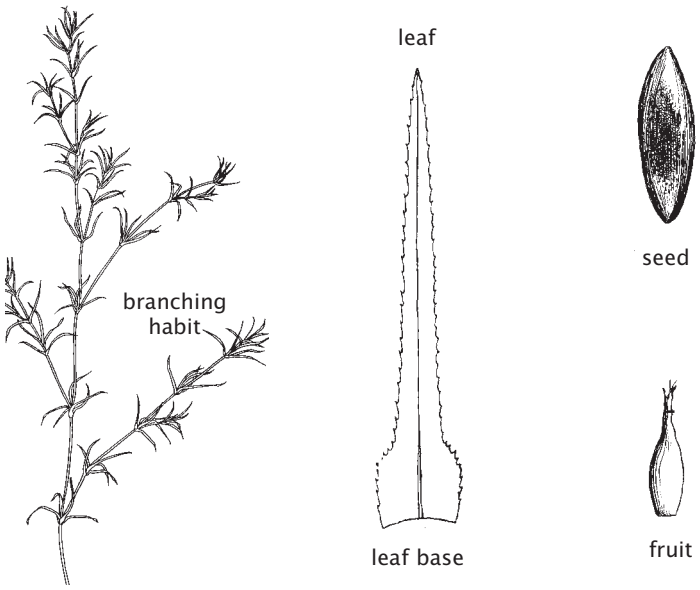
Look Alikes: Maine's native naiads may be confused with European naiad, some fine-leaved pondweeds, and some stoneworts.

Thread-like naiad leaves at stem tip; note the visible serrations

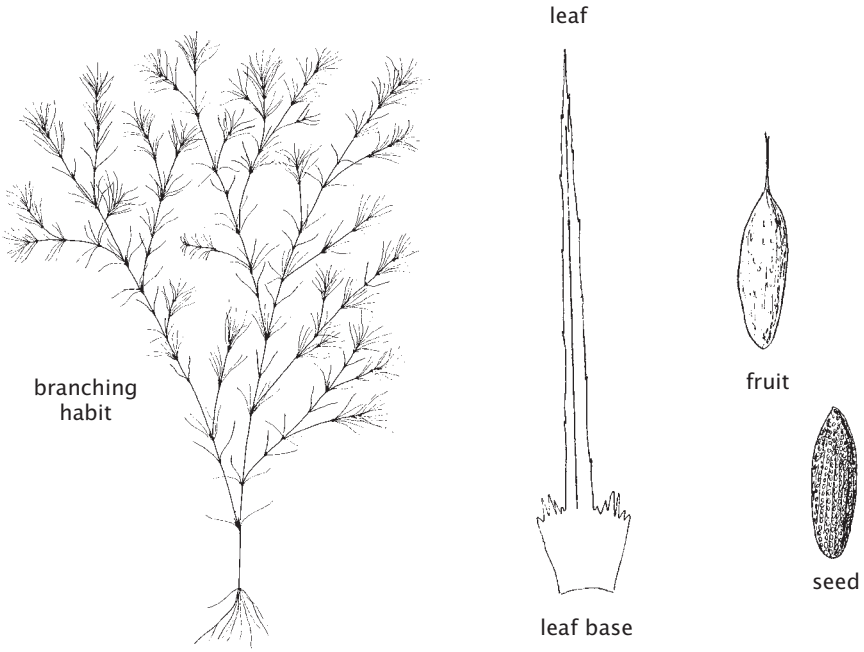
Thread-like naiad leaf base

Naiad Species Comparisons Chart

NAIAD SPECIES	LEAF SERRATIONS	LEAF BASES	LEAF FORM	SEEDS
slender naiad *Najas flexilis* (common native)	Very fine serrations (actually spines) are often hard to see, even with a good hand lens. Each side of the leaf has 20 to 100 minute spines.	Leaves broaden gently where they meet the stem (like sloped shoulders).	Slender leaves (0.2 to 1 mm wide) are somewhat stiff, and tend to arch backward as they mature.	Seeds straight lengthwise.Faint pits on seeds are longer than they are wide (elongate along the length of the seed).
thread-like naiad *Najas gracillima* (rare native)	Fine serrations (actually spines) are generally visible with a good hand lens. Each side of the leaf has 13 to 17 minute spines.	Leaf bases blocky, bulging out abruptly, with a fringed or jagged margin along the upper side.	*Very* slender thread-like leaves (generally less than 0.2 mm wide)are flimsy, and do not arch backward.	Seeds straight lengthwise. Pits on seeds are longer than they are wide (elongate along the length of the seed).
European naiad *Najas minor* (invasive)	Small serrations are generally visible without magnification. Each side of the leaf has 7 to 15 small spines.	Leaf bases blocky, bulging out abruptly, with a fringed or jagged margin along the upper side.	Slender leaves (0.3 to 0.5 mm wide) are somewhat stiff, and tend to arch backward as they mature.	Seeds slightly curved lengthwise. The pits on the seeds of are wider than they are long (elongate around the girth of the seed).



Slender naiad (*Najas flexilis*)



Thread-like naiad (*Najas gracillima*)

STONEWORTS
Chara and *Nitella*

NATIVE TO MAINE

Habitat: Stoneworts are found in the submerged plant community. They grow on soft sediments in depths up to 10 meters.

Description: Stoneworts are macro algae that resemble higher plants. The stems are comprised of chains of single tube shaped cells; no connective tissue is present. Instead of true roots, there is a simple rhizoid structure. Both have slender "branches" of cells arranged in whorls along the main stem. The stems may grow to a height of 0.5 meter.

The following characteristics help to distinguish the two genera:

Chara (Muskgrass): When fresh from the water, *chara* has a distinctively skunky odor. The stems, usually dark green in color, are ridged and often encrusted with calcium carbonate, feeling rough and crusty to the touch.

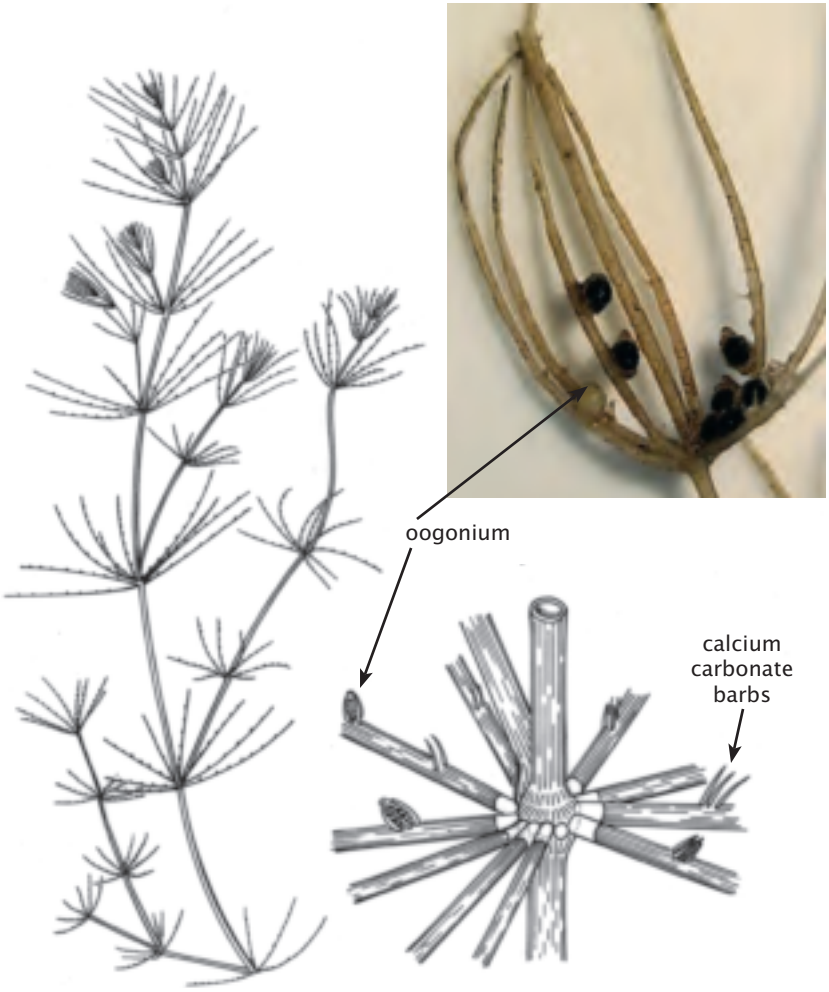
Nitella: No skunky odor. The stems and branches of nitella are generally bright green, translucent and smooth to the touch.

Range: Stoneworts are native to Maine and New England. They occur throughout most of the United States.

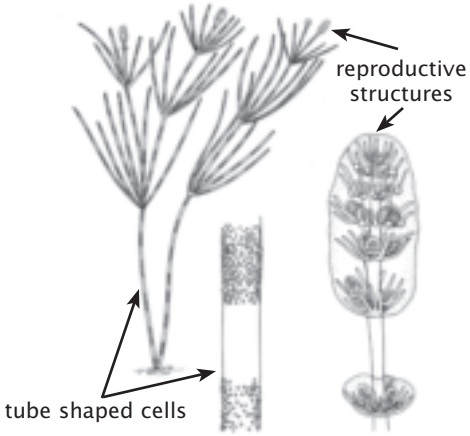
Annual Cycle: Stoneworts reproduce vegetatively through rhizoids and fragments, and sexually with male reproductive structures (antheridium) and female structures (oogonium). Rhizoids and stem fragments overwinter in and on the sediment. Growth begins when the water warms in the spring and continues through late fall.

Value to the Aquatic Community: Stoneworts provide cover and food opportunities to fish and invertebrates. Muskgrass is a favorite food of many waterfowl species. Algae and invertebrates that collect on the thickly growing tangles of stonewort stems are also attractive to waterfowl.

Look Alikes: Stoneworts may be confused with European naiad, Maine's native naiads, and some fine-leaved pondweeds.



Muskgrass (*Chara)* has a skunky smell and feels rough



Nitella has no odor and feels smooth

CONDUCTING AN INVASIVE AQUATIC PLANT SCREENING SURVEY

Overview

The primary purpose of the invasive aquatic plant screening survey is to: 1) visually scan as much of the aquatic plant habitat as possible, looking for target invasive plants; and 2) record the location of any suspicious plant (or plant patches) in a way that will ensure timely and effective follow up action. (Survey training, technical support, and data forms are available through the Maine Center for Invasive Aquatic Plants.)

Invasive aquatic plant surveys may be conducted at various levels of detail, depending on the amount of time and effort surveyors are able to spend on the project.

Level 1: Survey points of public access and other areas of concentrated boat traffic, e.g., marinas and narrow navigation channels. Boat launch survey areas should extend horizontally along the shoreline at least 100 meters (~300 feet) on either side of the boat launch area, and outward along the entire length to the depth at which the bottom is no longer seen. If the access area is in a distinct cove, it is recommended that the survey include the entire littoral zone of the cove, even if the shoreline distance from the launch area to the mouth of the cove is greater than 100 meters.

Level 2: Survey all Level 1 areas, plus all areas of the shoreline that are likely to provide suitable habitat for aquatic plants, such as shallow, sheltered coves. Floating leaved plants are often a good indicator of a rich plant community below the surface. In addition to supporting native plants, these areas may provide suitable habitat for an invader to take hold and (at least initially) hide.

Level 3: Survey the entire shoreline area and littoral zone. (The littoral zone includes all areas in the waterbody where sunlight reaches the bottom and rooted aquatic plants may grow.) In the case of the confirmed presence of an invasive aquatic plant in a waterbody, it is recommended that a Level 3 survey be conducted in order to determine the full extent of the infestation.

Level 4: Conduct a Level 3 Survey and also collect additional information about natural and altered conditions along the shoreline. This higher-level survey is intended to help surveyors (and agencies

such as the Maine DEP) assess the effects of human activities on shoreline areas. In some cases, the findings from a Level 4 survey may be significant to the issue of aquatic plants because of the potential for habitat alteration associated with development. Conducting a survey of the natural and human-altered features of the shoreline may provide some insight into the distribution of aquatic plants in a lake or pond. A description of the Level 4 survey process is available as a separate document from the Maine Center for Invasive Aquatic Plants.

Effective screening surveys can be carried out by any interested individual or group with a minimum of training, provided basic procedures are followed carefully, and suspicious plants are sent to professionals for identification. It is highly recommended that all those participating directly in the survey attend an Invasive Plant Patrol training workshop, offered free of charge to volunteers though the Maine Center for Invasive Aquatic Plants. (Please see title page for contact information.)

Survey and Mapping Equipment

With the exception of the boat (or boats), the equipment needed to conduct an invasive aquatic plant survey and mapping project is fairly simple, inexpensive, and easy to come by and/or fabricate.

Here is what you will need:

Small shallow-draft boat, canoe or kayak - Large boats and motors are not recommended as they actually make the process more difficult, and can destroy sensitive aquatic vegetation. Surveys are accomplished most easily, and are safer, with at least two persons in the boat: one to paddle and/or steer; one to watch for obstacles, observe plants and record findings.

Personal flotation device - Always practice safe boating during surveys.

Documentation forms - (available on line at www.mciap.org under "publications and resources"), **pencil and clipboard**

Map of the survey area - can be copied or traced from lake depth map available from VLMP, or PEARL website (www.pearl.maine.edu)

Pocket knife or snips - for obtaining specimens

Small leaf rake - for grabbing specimens and retrieving fragments

Wide angle viewing scope - available commercially, or constructed from 5 gallon plastic bucket and Plexiglas. (Construction plans are available on line at www.mciap.org under *publications and resources*.)

Weighted measuring tape, **Secchi disk, or marked anchor line** to determine plant observation depths

Ziploc bags (various sizes) and cooler - for storing plant specimens. Bags should contain enough water to float the specimens.

Anchor

Plant identification guides and keys - available through MCIAP

Buoys to mark the location of suspicious plants; commercially available or fabricated from empty plastic jugs, pieces of floating noodles, tied to bags of stones, cored bricks, etc.

Permanent marker pens - to mark specimen containers.

Magnifying glass or hand lens - for examining plant specimen structure. 5X to 10X pocket magnifiers are recommended.

Small white tray or shallow plastic container (such as margarine tub) - for floating and observing specimens in the field

Polarized sun glasses - greatly improve visibility under most conditions.

The following items are not essential, but may be very helpful under certain circumstances:

Colored pencils or highlighter pens - useful for tracking the progress of the survey on the map.

Long-handled net - for catching stray fragments. In most cases the leaf rake can perform this task sufficiently.

Long-handled cultivator - useful for collecting specimens from the bottom in shallow areas.

Weed weasel - a tined tool on a rope, used in deeper water for obtaining samples of plants that are not visible from the boat. (Construction plans are available from MCIAP (Please see title page for contact information)

Hand-held depth finder - a flashlight-like device that provides a

quick, efficient way to determine water depth; especially useful when spiking out (heading out perpendicular to shore) to check for the outside edge of the littoral zone.

GPS (geographic positioning system) receiver - a useful tool for mapping the general locations of individual invasive plants or small patches, and showing the general extent of larger infested areas. Keep in mind that unless you have access to one of the higher-end GPS units, the accuracy of your marked waypoints may be off by 15 feet or more. All GPS waypoints marking individual plants or small patches should correspond to actual marks (buoys) deployed next to the plants in the waterbody.

SCUBA divers - can be helpful members of the survey team, especially in areas where the water is deeper and the visibility from the surface is low. (In shallower depths, SCUBA divers may stir up bottom sediments, reducing visibility.)

Underwater video camera - used in deeper water to see plants that are not visible from the boat. (Available from fishing supply dealers.)

Small gas powered or electric motor - facilitates travel to survey locations and through plant-free sections of the littoral zone. Motors should not be used in areas where there is significant plant growth.

Getting Ready

1. It is always best to start with a reality check. What resources are available for this project? Resources include human, expertise, financial, survey equipment, etc. Given your resources, who will be responsible for conducting the survey project? Options include: professionals, student researchers, trained volunteers, or a combination of these.

2. Determine the scope of your project. What level of survey will you and/or your survey team be conducting? Will you be screening the survey area for one, several or all of the eleven of the invasive aquatic plants on Maine's invasive aquatic plant list? You may choose to use this opportunity as a chance to inventory the dominant native plant species growing in the waterbody. (A common native plant inventory sheet has been included on the back side of the IAP Screening Survey Documentation Form for this purpose. Survey documentation forms are available on line at www.mciap.org under publications and resources.) Will surveyors also be asked to be on the lookout for other invaders on Maine's radar such as purple loosestrife and Chinese mystery snail?

3. Learning the structural characteristics of the target invaders and their common native look alike plants before beginning the survey, will save time and energy, and greatly increase the effectiveness of the survey. It is highly recommended that all those participating directly in the survey attend an Invasive Plant Patrol training workshop, offered free of charge to volunteers though the Maine Center for Invasive Aquatic Plants.

4. Obtain a depth map for your waterbody. Depth maps are available from the Volunteer Lake Monitoring Program and the PEARL website at (www.pearl.maine.edu). Study the map. Determine and mark, using highlighters, colored pencils, marking pens, etc., the approximate extent of the littoral zone (in general, areas with depths equal to or less than 15 feet). It is also useful to mark the location of all shallow, protected areas that are likely to provide good plant habitat, inlets, outlets, and high-use areas, such as public and private boat launches, marinas, etc. Make field copies of the map for all survey teams.

5. Surveys should be conducted when there is adequate light, and when conditions are relatively calm. Early morning conditions are often ideal because the water is calm and reflection on the water surface is minimal. It will be difficult to conduct an effective survey during windy conditions. Weekends may be problematic because of heavy powerboat activity on some lakes and ponds.

6. The survey may be conducted over a period of time. Level 3 surveys on large lakes may require several days, or longer, to complete.

7. Mid-July through September is generally the best time of year to conduct IAP screening surveys. Prior to July, many aquatic plants are not fully developed. Emergent flowering structures are sometimes needed for plant identification and for many species, variable milfoil for example, flowers do not typically start to develop until July. One of the plants on Maine's invasive aquatic plant list, curly leaf pondweed (*Potamogeton crispus*) is an exception to this rule, usually reaching maturity by late spring to early summer.

Conducting the Survey

1. Fill out Section I of IAP Screening Survey Documentation Form and begin the survey.

2. The survey area extends from the shoreline to the depth at which it is no longer possible to see the lake bottom with a viewing scope. The depth of the littoral zone will vary, depending on the clarity of

the water. Very clear lakes may support rooted plants at depths of 15 to 20 feet. Shallow ponds may support rooted plants from shore to shore. The course your boat will travel will vary in accordance with the natural variability of the littoral zone and, to a lesser extent, to occasional human placed obstacles. (If you are using SCUBA divers, an underwater video camera, or a weed weasel your survey area may extend slightly beyond the visible zone.)

3. In areas where the lake bottom drops relatively steeply from the shore, plotting a straight course roughly parallel to the shore generally allows adequate screening of the area from both sides of the boat. Working in teams of two, one surveyor scans the area from the boat toward the shore, the other from the boat toward the outward extent of the littoral zone. "Scanning" will involve looking through the glass-like surface of the water, when weather and light conditions are optimum; or through the view scope, when they are not.

4. The distance from the shore the boat travels will be determined by the width of the littoral zone and various conditions including: water clarity, wind and wave activity, cloud cover, the angle of the sun, plant density, etc. The straight line of travel along the shore may wiggle and contort from time to time to conform to, and accommodate, shoreline features, docks, moored boats, floats, etc. The assumed width of the littoral zone should be verified from time to time by spiking out (heading out perpendicular to shore) and visually checking the depth.

5. Remember, the surveyor in the bow must also watch for hazards and the surveyor in the stern must steer the boat! Watch out for submersed mooring pulley lines!

6. In areas where the littoral zone is wider, in shallow coves inlets and outlets, and where the plant community is dense and complex, other course patterns including point-to-point transects should be employed (figure 1, next page). The configuration and spacing of the patterns and transects will vary in accordance with the observation conditions, density of the plant communities, etc. The overall goal in selecting a proper course pattern is to optimize direct observation of the littoral zone.

7. Use a highlighter pen or colored pencils to track the progress of your survey on your field map.

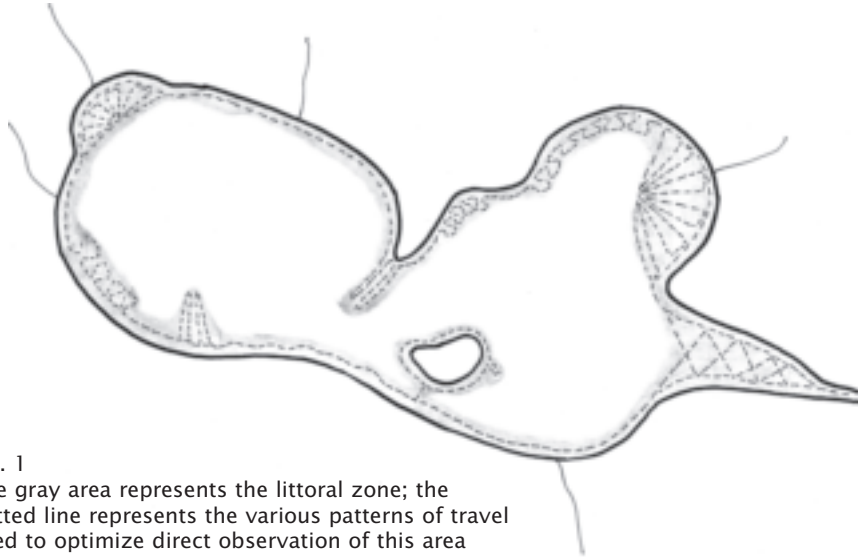


Fig. 1
The gray area represents the littoral zone; the dotted line represents the various patterns of travel used to optimize direct observation of this area

8. Obtain specimens when a closer look is needed to distinguish native from invasive. Snip a small section of the plant in question and float it in clean water in a white tray or container. Use a hand lens to view minute features. Consult your plant identification guides and keys.

9. If you suspect you may have found an invasive plant (or patch of invasive plants), record your finding in "section 2" of the survey documentation form, mark the location using a weighted buoy and plot it on the field map. Indicate local landmarks (shoreline cottages, unusual rocks or trees, etc) to help others re-locate the site. Use a consistent marking code on the survey form, the plant specimen bag, the map, and the marking buoy. If you are using a GPS receiver, mark a waypoint or record longitude/latitude coordinates. (But remember, unless you have a very high-end GPS unit, the accuracy may be off by 15 feet or more, so a physical marker is still needed.)

10. Once you have marked and recorded the location, you will need to collect a sample of the suspicious plant for the purpose of confirming the species identification. It is very important to follow the proper protocol, discussed in the next section: If You Find a Suspicious Plant.

11. Remember that many aquatic plants (native and invasive) can spread through fragmentation. Avoid disturbing plants unless a specimen is required. Specimens should be obtained by a clean cut, if possible. Scoop up all fragments with the leaf rake or a net.

12. If you are noting dominant native plants observed in your survey (this is optional), be sure to record these as you go, using the checklist on the back of the survey documentation form.

13. When the survey is complete, finish filling out the survey documentation form(s) and organize your findings. Consider how you are going to use the data. Data may be organized simply by copying and collating the documentation forms and field maps. However, to share your findings with the public, you will want to present the information in more user-friendly formats. Options include a narrative report, a poster sized map showing the area or areas surveyed, a PowerPoint presentation, etc. Be sure to submit copies of all survey data to MCIAP to ensure that this important information will be included in the statewide database.

If You Find a Suspicious Plant

1. Mark the location of the suspicious plant or patch of plants as described in item 9 of the above section.

2. Obtain a specimen. Great care must be taken when collecting a plant specimen, as the creation of fragments could result in an invasive plant spreading to other areas of the waterbody.

3. If possible, collect several (3-5) healthy stems of the plant in question. The flower, fruits and winter buds of many aquatic plants are helpful in the identification process. If these structures are present, be sure to include them in your sample. Gently snip or break off stem section about 12 to 15 cm long, from the top portion of the plant. For rooted floating leaved plants, be sure to include as much of the stem as possible.

4. DO NOT ATTEMPT TO PULL THE PLANT OUT BY ITS ROOTS. (This is very important!)

5. If the plant is covered with algae or tangled in debris, remove as much of the unwanted material as possible, without damaging the specimens.

6. Try to send plants as soon as possible (see # 8). If necessary, specimens may be kept alive in a container full of water in the refrigerator until you are ready to mail them to MCIAP for species confirmation. When you are ready to ship, place wet specimens in a Ziploc bag. If the plant is delicate or flimsy, add enough water to the bag to cushion the plant and keep it wet. If the plant is relatively sturdy, remove all the air from the bag and seal. DO NOT wrap the plant in a wet paper towel or other absorbent material. Make sure the bag is

sealed tight and place it in a small box with enough packing material to prevent movement. Cardboard mailing envelopes are fine for sturdy specimens that are not packed in water. Padded envelopes do not work well for plant specimens.

7. Include a Suspicious Plant Form in the box with the specimen(s). The form can be obtained from MCIAP or downloaded online at www.mciap.org/SuspiciousPlantForm.pdf This information is critical to tracking plants sent in for identification, and ensuring a timely response.

Flimsy plant sample packed in enough clear water to keep hydrated, and to cushion

Sturdy plant sample packed wet, but without additional water; remove air from the bag before sealing

8. Mail the specimen on a Monday or Tuesday, to minimize the possibility of weekend delays. Please contact MCIAP at (207) 783-7733 or mciap@mainevlmp.org to report that a specimen is on its way.

9. Send packaged specimens to:
Maine Center for Invasive Aquatic Plants
24 Maple Hill Road
Auburn, Maine 04210

10. You will be contacted by MCIAP with information pertaining to the identification of your specimen(s) within 72 hours of receipt.

OTHER INVADERS ON MAINE'S RADAR SCREEN

While the focus of this field guide has been on learning how to recognize Maine's "eleven most unwanted" invasive aquatic plants, and to distinguish them from their native Maine look alikes, it is important not to lose sight of the bigger picture. Maine's lakes, ponds, streams and wetlands are threatened by a wide array of non-native invaders, some plant, some animal. Some have been here in Maine for decades; others are relatively new to our region, and are only now beginning to appear on Maine's radar screen. Here is an introduction to some of the other invaders to be aware of as you are out and about on your favorite lake, pond, or stream. Prevention, early detection and rapid response are key to protecting Maine waters from the spread of these invaders. Please see *An Ounce of Prevention* on page 129.

Invasive Fauna

Asian Clam *(Corbicula fluminea)*

The Asian (or Asiatic) clam is a freshwater bivalve mollusk native to southern and eastern Asia and Africa. The source of introduction to the United States is unknown, but it is suspected that this species was brought from China by immigrants as a food source and subsequently released. The popularity of these small clams as aquarium specimens and as bait may have further exacerbated their spread. The Asian clam is now found in fresh waters throughout much of the United States including New England. (As of 2007, Asian clam populations have been discovered in Massachusetts and Connecticut.)

The clams thrive in sandy lake bottoms where they form dense communities; the population in a single waterbody may easily reach into the billions. The sexes are normally distinct; however, hermaphrodites exist that are capable of self fertilization. When the second stage larvae, called veligers, reach approximately 1mm in size they are discharged from the gills of the parent to begin life as juveniles on the bottom sediments. (Under ideal conditions a single clam can release hundreds or even thousands of baby clams a day, up to 70,000 a year!) Asian clams reach maturity at about 6 to 10 mm. Adults may reach up to 4 cm in length during their lifespan of one to four years. The shell of the Asian clam is ovate, and normally yellow-green to brown in color with thick concentric rings. The inside of the shell is layered with polished, light purple material called nacre. Other shell colors (called morphs) do occur. Like other bivalves Asian clams are filter feeders; and collectively they eat plankton in vast quantities.

Asian clam infestations may clog power plant and industrial water systems, cause problems in irrigation canals and pipes, and foul boating equipment. Ecologically, this species can alter benthic substrates and compete with native zooplankton, mussel and fish species for food and/or space. Asian clams appear to be capable of tolerating polluted environments better than many native bivalves. In cases where Asian clam infestations have been intentionally controlled by a cold weather draw-down the clams have produced ammonia in high enough quantities to be lethal to other fish and wildlife.

Chinese Mitten Crab
(*Eriocheir sinensis*)

Chinese mitten crabs are native to parts of China and Korea (where they are considered a culinary delicacy). The first record of this species in the United States was in 1965 in the Great Lakes region; the likely vector was the ballast tanks of commercial vessels. Mitten crabs have since been sighted in regions of the US as far a field as the Mississippi River delta and San Francisco Bay. In 2005, mitten crabs were caught in crab pots in Chesapeake Bay. This was the first reported sighting of this invasive crab in the eastern United States. In May of 2007, the crabs were found in Delaware Bay.

Chinese mitten crabs occur in both fresh and salt water. At the age of two to five years old the crabs leave their burrows along the riverbanks of freshwater rivers and tributaries to mate and spawn in saltwater estuaries, migrating overland when necessary. Once the crabs have mated, the males are believed to die, leaving the females to brood the eggs. In the spring the eggs hatch into larvae and after about six to seven weeks these metamorphose into juvenile crabs, which then migrate back up the river into freshwater to complete the life cycle. These migrations can be extensive: in China mitten crabs have been found 1500 km inland. The Chinese mitten crab is easily identified. It is the only crab known to occur in fresh waters of North America. Its claws are equal in size and covered with fur-like setae (soft bristles), or mittens, and eight sharp-tipped walking legs (no swimming legs). The adult carapace (body shell) is 8 - 10 cm wide, and light brown to olive green in color.

The mitten crab is an omnivorous predator that will devour just about anything it can catch and swallow, including native freshwater crayfish. Mitten crabs also burrow, and in large numbers can cause substantial damage to unprotected riverbanks.

Chinese Mystery Snail
(Cipangopaludina chinesis malleatus)

Chinese mystery snails, native to parts of Southeast Asia, were brought to this country as a food source for Asian markets. It is believed that imported snails were intentionally released in some areas to create a locally-harvestable supply. Since their introduction, Chinese mystery snails have spread to many parts of the United States, and can now be found in a number of Maine lakes and ponds.

Chinese mystery snails are distinctively large; at the size of a walnut or golf ball, they are half-again as large as Maine's largest native freshwater snail. Though they spend a good portion of their lives under the water surface, half buried in the bottom sediments, Chinese mystery snails may also be encountered with their trap doors sealed up tight, floating along at the water's surface. When these large snails die, they often wash up on shore, where their dark, olive-colored shells can be easily seen and (unpleasantly) smelled. Chinese mystery snails prefer the quiet waters of lakes, ponds, roadside ditches and slower portions of streams.

Once in a body of water, the Chinese mystery snail may be transported, as adults or tiny juveniles, via bait buckets and water holding areas on boats. Like other snail species, this species may serve as a vector for various parasites and diseases. Chinese mystery snails occur in a number of Maine waterbodies, but the full distribution of this snail in Maine is unknown. MCIAP currently manages a statewide database on reported sightings of *C. chinesis malleatus*. You can assist the effort to get a better handle on this invasive organism by reporting any sightings to MCIAP at 207-783-7733 or mciap@mainevlmp.org.

Northern Pike *(Esox lucius)*

Northern pike is native to parts of Eurasia and North America, but is not native to Maine. This popular "sport fish" was illegally introduced into the Belgrade Chain of Lakes in the 1970's, is now present in at least sixteen lakes in the Kennebec, Androscoggin, and coastal river drainages, and is suspected to occur in several additional waters.

Esox lucius can inhabit almost every type of freshwater, from cold deep lakes, to warm shallow ponds, to sluggish streams. Having a broad range of tolerances for various water conditions such as temperature, clarity and dissolved oxygen, *E. lucius* is considered to be one of the most adaptable freshwater species.

Northern pike are voracious predators and spend much of their time stealthfully hunting in quiet weed beds. Pike ambush their prey by holding perfectly still for long periods, then striking with remarkable acceleration and precision. The fish has a distinctive habit of catching its prey sideways in the mouth, killing or immobilizing it with needle-like teeth, and then turning the prey lengthwise to swallow it. An average pike consumes three to four times its weight during the course of a year. Besides fish, its diet includes frogs, crayfish, small mammals, and birds — just about anything it can sink its teeth into. Pike will attack any fish in the vicinity, even other pike. Young pike have been found dead from choking on a pike of a similar size.

Pike move into the shallows, marshes and small streams to spawn after the spring ice melts, (in late March to early May). Females deposit up to 100,000 eggs at random. The adhesive eggs stick to flooded vegetation for about two weeks before hatching. During the summer the fish retreat to deep, cool waters. Sexual maturity is generally reached between three to five years of age. Pike grow to a relatively large size; average lengths of 46 to 51 cm are common, and lengths of 150 cm (59 inches) and weights of 25 kg (55 pounds) are not unheard of. Pike exceeding 30 pounds have been caught in Maine.

A northern pike may be confused with its close relative, the chain pickerel (*Esox niger*), a fish that is native to Maine. The two species are distinguished from one another by looking at the gills, cheeks (located just forward of the gill plate) and sensory pores along the lower jaw. On the pike, scales are present on the upper half of the gill cover, but are absent on the lower half. The cheek area is fully scaled. In comparison, the cheeks and gill covers of chain pickerel are all fully scaled. Pike usually have five pairs of sensory pores along the underside of the lower jaw where pickerel generally have only four. The upper sides of the adult northern pike vary from shades of dark green to olive green to brown, with 7 to 9 horizontally arranged rows of yellowish, bean-shaped spots. (The pattern of markings on the juvenile pike are different; juveniles have wavy, white to yellow vertical bars.) The underside of the fish is white to cream-colored. Pike can hybridize with chain pickerel, and the resulting hybrid may possess markings common to either or both species.

Unauthorized introductions of invasive, exotic fish species are particularly destructive to Maine's native brook trout populations, but they may also cause irreversible changes to entire aquatic ecosystems by restructuring plankton and forage fish communities that have evolved since the last glacial retreat. Pike are particularly voracious fish eaters, and their presence in one Maine lake is suspected of destroying one of the state's premier landlocked salmon populations. Strategies to eliminate or control invasive fish are difficult to design and implement, costly, and almost entirely ineffective. The illegal introduction of any fish into any Maine water is a Class E crime, punishable by fines up to $10,000. The Maine Department of Inland Fisheries and Wildlife offers a minimum reward of $2,000 for information leading to the apprehension of persons responsible for the illegal introduction of fish. Call Operation Game Thief at 1-800-253-7887. If you suspect that you have seen or caught a northern pike, please report your findings to the Maine Department of Inland Fisheries at 207-287-8000.

Quagga Mussels
(Dreissena bugensis)

Quagga mussels are native to the Caspian Sea, and like zebra mussels, are thought to have come to this country in the ballast water of ocean going ships. Quagga mussels were first discovered in the Great Lakes region in 1989, but were not identified as a distinct species until 1991.

These invaders prefer silty or sandy lake bottoms, but may be found in waters ranging from warm and shallow to deep and cold. Like zebra mussels, the shell is distinctly striped in dark and light bands. Adult quagga mussels are generally larger than zebras, 20 mm long (roughly the size of your thumbnail) and their shells are broader and more fan-shaped. The ventral (or hinged) side of the shell is convex, preventing the quagga mussel from being balanced, on this side, on a flat surface. (The zebra mussel will remain upright when placed on its ventral side.) Quagga mussel feed year round, even in winter when zebra mussels are dormant.

Quagga mussel infestations may clog power plant and industrial water systems, cause problems in irrigation canals and pipes, and foul boating equipment. Ecologically, they can alter benthic substrates and compete with native zooplankton, mussel and fish species for food and/or space. Quagga mussels have not yet been detected in Maine.

Rusty Crayfish
(Orconectes rusticus)

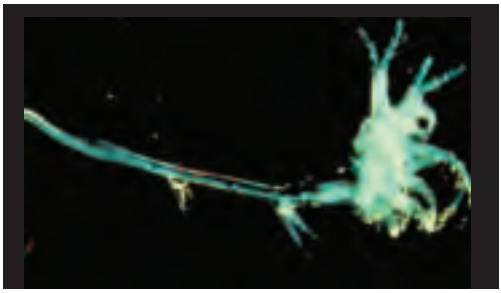
Maine is now home to several non-native crayfish species. Of those species known to be from "away," two are considered by state experts to pose the greatest threat to native ecosystems: rusty crayfish *(Orconectes rusticus)* and red swamp crayfish *(Procambarus clarkii)*. Though some non-native crayfish populations are now well known, the statewide distribution of these species is not fully known. Rusty crayfish are believed to be native to the Ohio River Basin and the states of Ohio, Tennessee, Indiana and Illinois. This mid-western crayfish species has now spread to other regions in the United States from New Mexico to Maine. Rusty crayfish have been in Maine for several decades, and were probably first introduced by non-resident anglers who brought them here to use as fishing bait. Once invasive crayfish populations were well established, the sale of trapped crayfish by bait dealers may have increased the rate of spread within the state.

Rusty crayfish inhabit lakes, ponds and streams. They generally dig small pockets under rocks and other debris, though under some circumstances they may dig more substantial burrows. Unlike some other crayfish species that may inhabit seasonal waterbodies, *O. rusticus* needs permanent (year-round) water. Rusty crayfish have robust claws with black bands at the tips and an oval gap when closed. They also have dark, rusty spots on each side of their carapace as though you picked up the crayfish with rust-colored paint on your forefinger and thumb. (The spots may not always be present or well developed.) Like all crayfish, *O. rusticus* is an opportunistic omnivore. Rusty crayfish feed on a variety of aquatic plants, benthic invertebrates (like aquatic worms, snails, leeches, clams, aquatic insects and crustaceans), detritus (decaying plants and animals and the associated bacteria and fungi), fish eggs, and small fish.

Introductions of both *O. rusticus* and *P. clarkii* have caused serious damage to aquatic ecosystems outside of Maine; the latter being a notorious invasive globally. *O. rusticus* is an aggressive species, and is known to displace native crayfish in two ways: though crayfish-to-crayfish competition and by causing increased fish predation on native species. (Rusty crayfish, for example, force native species from the best daytime hiding places.) Rusty crayfish also are known to reduce plant and invertebrate diversity and abundance in the

aquatic ecosystem. This may in turn negatively impact native fish and waterfowl populations. Many of these impacts only occur after crayfish populations have reached high nibble-your-toes densities. Impacts of these crayfish on Maine ecosystems have not been studied. Environmentally sound ways of controlling introduced populations have not yet been developed. The best way to prevent potential ecological damage is to prevent or slow the spread of these species into new waters. Maine Department of Inland Fisheries and Wildlife and other Maine researchers have begun collecting crayfish distribution data. Distribution data for *all* crayfish species found in Maine is valuable to researchers. Please report any crayfish sightings to: MCIAP at 207-783-7733 or mciap@mainevlmp.org.

Spiny Water Flea
(Bythotrephes cederstroemi)



Spiny water flea is native to Great Britain and parts of northern Europe. This tiny crustacean was first found in Lake Huron in 1984, likely the result of another ballast water introduction. Populations can now be found throughout the Great Lakes and numerous other inland lakes in the northern Midwest region.

Spiny water fleas are more common in deep, cool lakes. However, they also inhabit warmer lakes where surface water temperatures exceed 25˚ C. The creature is small (1 to 1.5 cm long) with transparent exoskeleton, a large black eye spot on both sides of the head, and four pairs of legs. Most distinctive is the crustacean's long, barbed tail spine. Spiny water fleas are often first noticed by anglers, when they become entangled in fishing lines. When the line is pulled from the water, something resembling tiny straight pins waving about perpendicular to the line may be noticed. These are the miniscule creatures, raising and lowering their tails as they cling to the line. Impacts to aquatic ecosystems caused by the spiny water flea are not fully understood. What is known is that spiny water fleas reproduce rapidly, (both sexually and asexually) producing numerous offspring during the growing season, and "resting eggs" that overwinter in the sediments.

Once well established in the waterbody, spiny water fleas compete directly with other zooplankton feeders in the ecosystem (eating up to three times as much food as similar species). Their sharp spine prevents fish of a certain size class from eating them. It is believed that both of these impacts have the potential to trigger disturbances throughout the aquatic food web.

Zebra Mussels *(Dreissena polymorpha)*

Zebra mussels are thought to have been introduced to this country as accidental stowaways attached to hulls, or in the ballast water of ships entering the Great Lakes from Europe. Since they were first discovered in this country in 1988, these tiny, freshwater bivalves, have become a major aquatic pest throughout much of the Midwest. Spreading to New England, primarily by way of boating activity, they have now impacted waters in Vermont and are known to be on the move elsewhere in New England. (Indeed, in 2006 a Courtesy Boat Inspector on Lake Winnipesawkee in New Hampshire detected-and successfully averted-some zebra mussels that were hitching a ride on a boat from New York.)

Zebra mussels begin life as tiny free-swimming larvae, called veligers. It is during this stage that they are most readily transported from one waterbody to another (attached to boating gear, in bilgewater, bait buckets, etc.) and also most difficult to detect. After two or three weeks, the veligers "settle out" in the waterbody, attaching by way of strong, threadlike filaments to just about any hard surface they encounter. Rocks, sediment, wood, intake pipes, moorings, boat hulls, native mussel beds, are all at risk of colonization. Zebra mussels are small (adults are about 15 mm long) but they are voracious filter feeders, straining out major portions of the phytoplankton population and effectively starving out many native zooplankton species. The gap created in the food web may cascade through the entire ecosystem.

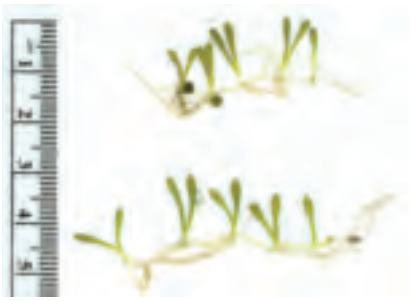
Zebra mussel infestations may clog power plant and industrial water systems, cause problems in irrigation canals and pipes, and foul boating equipment. Ecologically, they can alter benthic substrates and compete with native zooplankton, mussel and fish species for food and/or space. Zebra mussels have not yet been detected in Maine.

Invasive Aquatic Plants

Glossostigma
(Glossostigma cleistanthum)

This low-growing, mat-forming invasive aquatic plant is a relative newcomer to North America. *Glossostigma* was first identified in the United States in 1992, in a single location in southern Connecticut. It has since (as of 2005) spread to nineteen known locations in Connecticut, New Jersey, Rhode Island, and Pennsylvania. It is believed that *Glossostigma* may even be more widely occurring,

but its diminutive size and peoples' lack of familiarity with the plant have allowed it to remain largely under the radar. Pairs of leaves, resembling tiny green rabbit ears, occur along dense networks of slender rhizomes. Leaf size varies depending upon growing conditions; most are 1 to 4 cm long. *Glossostigma*, once established, can form a dense monoculture (averaging 10,000 to 25,000 plants per square meter) on the lake floor, carpeting the bottom from the shoreline to depths greater than two meters. Where exposed at the waters edge, *Glossostigma* behaves as an annual--flowering, fruiting, and then dying back each winter. Submersed, it is a hardy perennial, remaining green and growing year round.



Because of its short stature, this invader is not considered to pose much of a threat to recreational activity (boating, swimming, etc.). However, the ability of the plant to form dense, monotypic mats makes it an ecological threat to native plant and animal communities. *Glossostigma* has not yet been detected in Maine. If you suspect that you have found this plant, please notify MCIAP or Maine DEP immediately.

Invasive Wetland Plants

(European) Common Reed
(Phragmites australis)

The current distribution of common reed includes Europe, Asia, America, and Australia. The origin of the plant is unclear. Though *Phragmites* rhizomes have been found in North American peat cores dated 3,000 years old, the plant was not common in New England marshes at that time. The recent explosion of this plant in New England in the last 100 years, however, has led researchers to take a closer look at the origin of this now-aggressive species. Recent genetic evidence has confirmed that a more aggressive genotype from Europe was introduced some time in the late 1800's along the Atlantic

coast, where problems associated with the non-indigenous genotype are currently most severe.

The European form of common reed is very aggressive, robust, densely growing wetland grass species that thrives in freshwater and brackish tidal wetlands. The hollow woody stems of this plant can grow up to five meters in height. Flowers develop by mid-summer and are arranged in tawny spikes among tufts of silky, hair-like fibers. Pollen is carried from plant to plant by the wind, and seed set is highly variable. The large purple flower heads turn gray and fluffy in late summer as they go to seed, and remain on the plant throughout the winter. Seeds germinate on exposed moist soils in the spring. Vegetative spread by below-ground rhizomes can result in dense stands.

When *Phragmities* invades a wetland, it alters the structure and function of the ecosystem by changing nutrient cycles and hydrological regimes. Dense *Phragmities* stands decrease native biodiversity and quality of wetland habitat for migrating wading birds and waterfowl. Rare and threatened bird species are particularly vulnerable to exclusion. Research to find appropriate biological controls for this species is underway, but incomplete at this time.

Purple Loosestrife *(Lythrum salicaria)*

Purple loosestrife is native to Europe and Asia, and was introduced into North America about 200 years ago. This plant now occurs in wetlands across the United States; with some of the largest infestations occurring in the northeast states, including Maine. Purple loose-strife is a wetland perennial that prefers open sunny areas and wet soils.

Plants may be found in wet meadows, floodplains, disturbed areas such as roadside ditches, along stream banks and around the edges of ponds, lakes and marshes. When mature (at three to five years) a single plant may be over three meters tall and produce as many as fifty stems. Leaves are blade-shaped, entire and oppositely arranged on the stems. The stems are usually square in cross-section, but may be five or six-sided. Leaves and stems may be (but are not always) covered with soft hairs. Plants form dense, woody rootballs (up to 50 cm in diameter) with a strong taproot. Purple loosestrife blooms during the summer. Its reddish-purple flowers, each with five to seven petals, are closely arranged on tall flower spikes. A mature

plant may produce up to 2.5 million seeds per year. Seeds, which remain viable in the ground for at least five years, are as small as a grain of sand and are easily carried by wind, water, and passing animals, and may go undetected on muddy boots.

When purple loosestrife moves into wetlands, it displaces native plants such as cattails, sedges, bulrush and ferns. Wetlands infested with purple loosestrife have decreased native biodiversity and quality of wetland habitat for migrating wading birds and waterfowl. Rare and threatened bird species are particularly vulnerable to exclusion.

As with virtually all invasive species, control is problematic. Young purple loosestrife plants may be removed by hand or with a garden fork. It is very important that the entire plant and root system is removed, as roots broken off in the ground during the process of removal will likely sprout new plants. Removing larger plants by hand is more difficult, and may need to be repeated several times each year until the desired control is achieved. Ideally plants are removed before they flower (to prevent the possibility of seed release). In cases where flowers are present, the flowers should be carefully bagged, removed and properly disposed of prior to removing the rest of the plant. Simply removing flower spikes early in their development (by cutting or mowing) will help to reduce seed spread. However, as the plants themselves will easily regenerate, this is at best a temporary and limited means of control.

Biological control is widely recommended as a cost-effective, long term means of controlling purple loosestrife. The goal with biological control is to reduce, not eliminate, this wetland invader. Several species of insects have been approved by the United States Department of Agriculture for biological control of purple loosestrife. The Maine Department of Transportation and The Maine Department of Agriculture have recently launched an experimental program in which *Galerucella* beetles are being introduced into several severely infested areas.

Contrary to popular belief (that claims some ornamental cultivars of this plant are sterile), all purple loosestrife cultivars have been shown to be fertile, and capable of serving as pollen or seed sources for invasive loosestrife populations. Gardeners are advised to seek native-friendly alternatives. For more information contact MCIAP.

Flowering Rush *(Butomus umbellatus)*

Flowering rush is native to Eurasia. Populations in the United States have now been recorded in numerous Midwestern states and parts of New England, including Maine. Flowering rush was first observed

in North America in1897 in LaPrairie, Quebec. The first collection in New England was in Vermont in 1929. By the 1950s the plant was well established along the St. Lawrence River.

This hardy aquatic perennial will grow in the shallow waters of ponds, lakes and streams in water several meters deep. Its flowering stem, when present, may rise up to 1 meter above the water surface. It may also occur in forested floodplains. This species is intolerant of salt or brackish waters. The leaves are 0.6 to 0.9 meters long, fleshy, triangular in cross-section and twisted at the ends, and can be erect or floating on the surface. The plants flower from summer to fall depending upon conditions, and some populations rarely flower. The small three-petal flowers are white to deep pink to purplish brown in color, and occur on long slender stalks, arranged in an umbel-like spray of up to 30 flowers. The inflorescence is said to resemble an inverted umbrella frame.

Flowering rush can displace native riparian vegetation, decrease biodiversity, alter ecosystem function and change hydrologic regimes.

Invasive Algae

Didymo
(Didymosphenia geminata)

Didymo, widely referred to as "rock snot," has historically been found in the cool, oligotrophic waters of the far northern regions of Europe and North America. Since the mid-1980s, it has begun to take on the characteristics of an invasive species in its original range, and has also been expanding its range to warmer, more nutrient rich waters. The mechanism by which this organism has become more invasive is not well understood, but some researchers believe that climate change may be playing a significant role. In the past several years, didymo has expanded its range in the Western United States and has infested rivers and streams in several southeastern states, including Virginia, West Virginia, Tennessee and North Carolina. In 2007, didymo was found in the northern reaches of the Connecticut River in Vermont, marking the first official report of *Didymosphenia geminata* in the Northeastern United States. Blooms have since been detected in New York and New Hampshire. To date there have been no sightings in Maine.

Didymo is a freshwater diatom that produces stalks on which it attaches itself to rocks and vegetation. This species generally lives in clear, cool streams and rivers, especially those with moderate, year-round flows and good light. (Rarely, it may occur along the rocky shores of lakes and ponds.) It may exist for a time as small (relatively benign) bubbly colonies on submerged rocks, boulders and gravel, and then suddenly "bloom" into a thick yellowy-brown layer, capable of covering large areas. Didymo mats are distinctive from other algal species that attach to rocks in that they are not green and not slimy. They feel more like wet cotton or thick wet felt. In a more advanced stage, didymo forms long streaming filamentous carpets, each streamer up to several centimeters long. The streamers eventually turn white at their ends and fragments (resembling clumps of tissue paper) break away and float downstream.

Prolonged severe blooms can negatively impact the habitat for beneficial macroinvertebrates (such as stoneflies, mayflies and caddisflies). These stream dwelling invertebrates are a critical food source for brook trout, river dwelling birds and other native species, so an infestation will negatively affect these natives as well. In advanced stages, a didymo bloom may restrict water flows, deplete dissolved oxygen levels (a result of the decomposition of the algal mats) and smother native mussel beds. Intense blooms make angling difficult and less appealing.

There are currently no known methods for controlling or eradicating didymo once it infests a water body. Preventing its spread is seen as the best (and currently only) defense against the harmful affects of this species. Anglers, kayakers and canoeists, boaters and jet skiers can all unknowingly spread didymo. The microscopic (and virtually invisible) algal cells cling to fishing gear, waders, boots and boats, and remain viable for several weeks under even slightly moist conditions. Decontamination requires soaking clothing and equipment in hot water containing a liberal amount of detergent. Thoroughly drying clothing and equipment for a minimum of 48 hours can also be effective, but only if completely dry conditions are maintained.

Starry Stonewort
(Nitellopsis obtusa)

Starry stonewort is a green macroalga (a complex, multicellular algae that resembles a higher plant). Native to Eurasia, and believed to have been introduced to this continent through ballast water contamination, starry stonewort was first recorded in North America in 1978, growing in the St. Lawrence River. It has since spread to many sites along the St. Lawrence, and to portions of the Great Lakes region, (especially around Lake Ontario, parts of Michigan and New York). Though not yet known to be present in New England, Maine's proximity to infestations in the St. Lawrence River valley warrant putting this invader on our radar screen.

Like Maine's native stoneworts, *Nitella* and *Chara*, starry stonewort forms dense colonies of upright, plant-like stems sprouting whorls of slender, tentacle-like branches. Distinctive, are the tiny, cream-colored, star-shaped reproductive structures called "bulbils" that occur at the base of branch clusters. Even before they are evident to the naked eye, the bulbils can be detected by feel, by gently squeezing the stems at the whorls. The tiny bulbils are distinctly "firm" relative to the soft gelatinous feel of the rest of the algae. If you suspect that you have found this invader, please notify MCIAP or Maine DEP immediately.

If you are interested in obtaining a more comprehensive listing of aquatic invaders on Maine's radar screen, please see the "advisory list" published in Maine's Action Plan for Managing Invasive Aquatic Species, available on line at:

www.maine.gov/dep/blwq/topic/invasives/invplan.htm.

An Ounce of Prevention . . .

Presently, the best defense against aquatic invaders is to prevent their transfer to new waterbodies. Some invasive aquatic organisms may be virtually invisible. Depending on the species, hitchikers can find their way into bilge water, bait buckets and livewells and adhere to boats, trailers, motors, paddles, hipwaders and fishing tackle. Some species can survive for several days, even weeks, out of water. Below is a list of actions you can take to help reduce the spread of invasive aquatic species in Maine.

Before leaving the waterbody:

- **Inspect** your boat, trailer, boating equipment, fishing tackle, nets, etc. and remove any visible plants or animals. Properly dispose of any material that is found (away from the water, preferably in a waste receptacle).
- **Drain** water from the motor, live well, bilge and transom wells on dry land.
- **Empty** your bait bucket on land. Never release live bait into a waterbody, or release animals from one waterbody into another.

After leaving the waterbody:

- **Wash** your boat and equipment with hot water (> 40˚ C) and soap; or
- **Spray** your boat and equipment with high pressure water (250 psi); or
- **Wipe** your boat and equipment down with a 2% solution of bleach; or a 5% solution of dishwashing liquid. (Bleach solution must be *fresh* to be effective)
- **Dry** your boat and equipment for at least 48 hours before transporting to another waterbody. (The drying time will be longer if the weather is not perfectly dry.)

If you collect an animal that you suspect to be an invasive species:

- **Do not throw it back alive.**
- **Note the precise location** and date where the animal was found.
- **Take a close-up photo** of the specimen if possible.
- **Freeze** the specimen and keep it on ice (or preserve in rubbing alcohol).
- **Contact** MCIAP at 207-783-7733 or mciap@mainevlmp.org for further instruction.

If you find a suspicious plant; follow instructions on page 113

FIELD GUIDE SOURCES

The primary sources referenced for the plant identification pages of the Maine Field Guide to Invasive Aquatic Plants are listed below:

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Below is a list of the primary sources referenced for the Other Invaders on Maine's Radar:

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1. Common Reed; Blossey, Schwarzlander, Hafliger, Casagrande and Tewksbury; Invasive Plants of the Eastern U.S. website; www.invasive.org
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Northern Pike (*Esox lucius*)
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The images in this publication were used courtesy of the following sources:

Cover: Lake Umbagog [Mark Hunt]

ii: Loon [illustration by Joan Irish, courtesy of Kezar Lake Watershed Association]

Page 1: Man in canoe [MCIAP]

Pages 4&5: Plant communities' illustration [Shiela Murray]

Page 6: Water marigold (B. beckii) in hand [Sandra Smith]

Page 7: Leaf arrangement: alternate [UFL], opposite [UFL] and whorled [UFL]; Leaf margins: entire [UFL], toothed or serrated [UFL], pinnately lobed [UFL], finely divided [UFL]; Leaf shapes: triangular [UFL], heart [NYSM], strap or elongate [UFL], oval [UFL], ellipti cal [MCIAP], lance or blade [UFL]

Page 8: Flower parts: side view [UFL], top down view [UFL]; Variable leaf milfoil *(M. hetero phyllum)* flowers & bracts [UFL], flower spike [UFL]; Eurasian milfoil *(M. spicatum)* flowers & bracts [UFL], flower spike [UFL]

Page 9: Stem and leaf structures [], blade & sheath [UFL]; stipule [C&H]; stolon [UFL], tubers [UFL], rhizome [UFL], corm [UFL]; tuber [UFL]

Page 10: Leaf patterns: fork-divided [UFL], branch-divided [UFL], feather-divided [UFL]; Variable leaf milfoil *(M. heterophyllum)* cross section [UFL]; Mermaid weed *(Proserpinaca)* submerged leaves [UFL], emergent leaves [UFL]

Page 11: Side view: bladderwort *(Utricularia)* [UFL]; Cross section: coontail *(Ceratophyllum)* [UFL]; Side view: fanwort *(Cabomba)* [UFL]; Cross section: Eurasian milfoil *(M. spicatum)* [UFL]

Page 12: Yellow waterlily *(N. microphylla)* illustration [NYSM]; Elodea *(Elodea)* illustration [UFL]; Clasping-leaf pondweed *(P. richardsonii)* illustration [WLP]; Common mermaid weed *(P. palustris)* illustration [C&H]

Page 13: Yellow waterlily *(N. microphylla)* illustration [NYSM]; Roberta Hill with lily pads [MCIAP]

Page 14: Elodea *(Elodea)* illustration [UFL]; Slender naiad (N. flexilis) illustration [WLP]

Page 15: Clasping-leaf pondweed *(P. richardsonii)* illustration [WLP]; Advanced Plant Identification Workshop [MCIAP]

Page 16: Common mermaidweed *(P. palustris)* illustration [C&H]

Page 17: Invasive Plant Patrol on-lake training [Christine Guerette]

Page 19: Variable water-milfoil *(M. heterophyllum)* [Dennis Roberge]

Page 20: European Frog-bit *(H. morus-ranae)*: U.S. range map [USDA], in situ [Mark Malchoff, Lake Champlain Sea Grant Project]

Page 21: European Frog-bit *(H. morus-ranae)*: illustration [UFL], in hand [Mark Malchoff, Lake Champlain Sea Grant Project], flower [Robin Scribalio, Perdue University], specimen [UFL]

Page 22: Water chestnut *(T. natans)* specimen [MCIAP]

Page 23: Water chestnut *(T. natans)*: illustration [UFL], flower [Robert Johnson], nut [MCIAP], U.S. range map [USDA]

Page 24: Yellow floating heart *(N. peltata)* U.S. range map [USDA]

Page 25: Yellow floating heart *(N. peltata)*: floating leaves [MCIAP], illustration [UFL], flower [Les Merhoff], in situ [C. Barre Hellquist]

Page 26: Fanwort *(C. caroliniana)*: with flower [Vic Ramey, UFL], in hand [Amy Murray, UFL]

Page 27: Fanwort *(C. caroliniana)*: U.S. range map [USDA], illustration [UFL], live stem [MCIAP]

Page 28: Eurasian watermilfoil *(M. spicatum)*: stem [MCIAP], whorl [MCIAP]

Page 29: Eurasian water-milfoil *(M. spicatum)*: U.S. range map [USDA], illustration [UFL], in situ [Don Cameron, MNAP], flower [Don Cameron, MNAP]

Page 30: Variable-leaf watermilfoil *(M. heterophyllum)*: terrestrial morph [Dan Buckley], whorl illustration [UFL], illustration [UFL]

Page 31: Variable-leaf watermilfoil *(M. heterophyllum)*: U.S. range map [USDA], in situ [MCIAP], emergent stem [Gerry Nelson], flowers (inset) [MCIAP]

Page 33: Variable-leaf watermilfoil hybrid *(M. heterophyllum x M. laxum)*: live stems [MCIAP], flower [Michael Moody]

Page 34: Parrot feather *(M. aquaticum)* illustration [UFL]

Page 35: Parrot feather *(M. aquaticum)*: U.S. range map [USDA], flowers [Kerry Dressler, UFL], with dog [Vic Ramey, UFL], stem tips [Vic Ramey, UFL]

Page 36: Brazilian waterweed *(Egeria densa)*: illustration [UFL], in hand [Amy Murray, UFL]

Page 37: Brazilian waterweed *(Egeria densa)*: U.S. range map [USDA], in situ [Amy Murray, UFL]

Page 38: Curly-leaf pondweed *(P. crispus)*: fruit [FMC], specimen [MCIAP], leaf [UFL], turion [MCIAP]

Page 39: Curly-leaf pondweed *(P. crispus)*: illustration [UFL], leaf illustration [UFL], in hand [Vic Ramey, UFL], U.S. range map [USDA]

Page 40: Curly-leaf pondweed *(P. crispus)* [Ann Bove, VTDEC]

Page 41: Curly-leaf pondweed *(P. crispus)* specimen [Dennis Roberge]

Page 42: European naiad *(N. minor*) illustration [FMC]

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Page 47: Hydrilla *(H. verticillata)*: leaf illustration [MCIAP], dioecious habit [UFL], monoecious habit [MCIAP], tubers [MCIAP], turions [W.T. Haller, UFL]

Page 49: White water lily *(N. odorata)* flower [Don Cameron, MNAP]

Page 50: Common waterweed *(E. canadensis)* in hand [Don Cameron, MNAP]

Page 51: Common waterweed *(E. canadensis)* U.S. range map [USDA], dense mat [Don Cameron, MNAP]; Slender waterweed *(E. nutellii)* U.S. range map [USDA]; Elodea species: illustration [UFL]; comparison chart: hydrilla *(H. verticillata)* [Don Cameron, MNAP], slender waterweed *(E. nutallii)* [Don Cameron, MNAP], common waterweed *(E. canadensis)* [Don Cameron, MNAP], Brazilian waterweed *(E. densa)* [Don Cameron, MNAP]

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Page 54: Mare's tail *(H. vulgaris)*: emergent stalks [Don Cameron, MNAP], U.S. range map [USDA]

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Page 60: Red pondweed *(P. alpinus)*: illustrations [C&H2], U.S. range map [USDA]

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Page 62: Variable pondweed *(P. gramineus)*: in situ [Don Cameron, MNAP], U.S. range map [USDA]

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Page 70: Hornwort species *(Ceratophyllum)* illustration [www.eFloras.org]

Page 71: Coontail (C. demersum): U.S. range map [USDA]; specimen [MCIAP]; submersed stem with flower [Dennis Roberge]; Prickly hornwort (C. echinatum): U.S. range map [USDA]; specimen [Don Cameron, MNAP

Page 72: Common mermaid weed *(P. palustris)* illustration [C&H]

Page 73: Common mermaid weed *(P. palustris)*: U.S. range map [USDA], habit [Don Cameron, MNAP]; Comb-leaf mermaid weed *(P. pectinata)*: U.S. range map [USDA], illustration [C&H]; Mermaid weed species *(Proserpinaca)* submersed leaf [MCIAP]

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Key to Source Acronyms

AWPSUS-D: Godfrey, Robert K. and Jean W. Wooten. 1979, 1981. Aquatic and Wetland Plants of Southeastern United States: Dicotyledons. The University of Georgia Press, Athens, Georgia

AWPSUS-M: Godfrey, Robert K. and Jean W. Wooten. 1979, 1981. Aquatic and Wetland Plants of Southeastern United States: Monocotyledons. The University of Georgia Press, Athens, Georgia

CBVRM: Conseil de bassin versant de la rivière Matapédia (Matapedia River Watershed Council, Quebec)

C&H: Crow, G.E. and C.B. Hellquist. 1982, 1983. Aquatic vascular plants of New England. New Hampshire Agricultural Experiment Station Bulletins 520, 524. Durham, New Hampshire

C&H2: Crow, G.E. and C.B. Hellquist. 2000. Aquatic and wetland plants of northeastern North America. Volumes 1 and 2. The University of Wisconsin Press, Madison, Wisconsin

FMC: Mason, Herbert L. 1957. A Flora of the Marshes of California. University of California Press, California

MCIAP: Maine Center for Invasive Aquatic Plants, Auburn, Maine.

MNAP: Maine Natural Areas Program, Maine Department of Conservation

NOAA: National Oceanic and Atmospheric Administration

NYSM: New York State Museum, Albany, New York, 12230

UFL: University of Florida Center for Aquatic and Invasive Plants, Gainesville, Florida

UMF: University of Maine at Farmington

USDA: U.S. Department of Agriculture (USDA), NRCS. 2007. The PLANTS Database (http://plants.usda.gov, 25 June 2007). National Plant Data Center, Baton Rouge, LA 70874-4490 USA

USGS: United States Geological Survey

WIDNR: Wisconsin Department of Natural Resources, University of Wisconsin, Madison, WI

WLP: Wisconsin Lakes Partnership, University of Wisconsin - Cooperative Extension and the Wisconsin Department of Natural Resources, Stevens Point Wisconsin. Through the Looking Glass: A Field Guide to Aquatic Plants. DNR Publication #FH-207-97.

VTDEC: Vermont Department of Conservation

Other Useful Resources:

Aquatic Plant Information System Compact Disc. Department of the Army. Engineer Research and Development Center, Corps of Engineers. Waterways Experimental Station. CEERD-EE-A. 3909 Halls Ferry Road, Vicksburg, MI 38180-6199

Maine Center for Invasive Aquatic Plant Virtual Herbarium website: www.mciap.org/herbarium

Northeast Aquatic Nuisance Species Panel website.

Links to Identification Resources for Non-Native Species: www.northeastans.org/idresources.htm

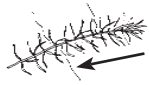
Links to Resources for Geographic Information about Non-Native Species: www.northeastans.org/georesources.htm

Prescott, G.W. 1980. How to Know the Aquatic Plants. Second edition. WCB McGraw-Hill. Boston MA. 158 pages.

University of Florida Center for Aquatic and Invasive Plants website: http://plants.ifas.ufl.edu/

University of Wisconsin Herbarium website: www.botany.wisc.edu/wisflora/

GLOSSARY



Adventious roots – Slender hair-like roots that emerge along the growing stem or stem fragment

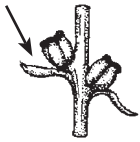
Alternate – Leaves spaced singly along a stem, one at each node

Axil – The angle created between two structures on a plant, such as the notch formed between the base of a leaf and the stem

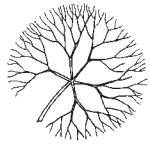
Bathymetry – The three dimensional relief of the waterbody floor.

Beak – A beak-like protrusion, generally used to describe the shape of a seed

Blade – The expanded portion of a leaf, in contrast to the leaf stalk



Bracts – Small specialized leaves that are directly associated with a flower or fruit



Branch-divided – A divided leaf pattern in which the leaflets branch from the leaf stem many times like the branches of a tree

Clone – A form of asexual reproduction such as budding, fragmentation, and tubers that produces a genetically identical plant

Dioecious – Having male and female reproductive structures on separate plants

Divided (Finely-divided) – Used to describe a compound leaf that is divided into distinct parts called leaflets; a leaf may be divided in a various ways, for example, it may be fork-divided, branch-divided, or feather-divided

Double node – Two nodes occurring together; in some species a point from which new branches or flower stalks emerge

Emergent – Plants have leaves that extend above the water surface, usually found in shallow water

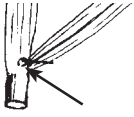
Feather-divided – A compound leaf with slender pairs of leaflets arranged in two opposite (or roughly opposite) rows along a common midrib; a pinnate leaf with thread-like leaflets

Floating-leaf – Describes plants that produce leaves that typically float on the surface

Fork-divided – Leaf or leaflet that divides by forking one or more times (generally less than three)

Fruit – The seed bearing portion of a plant

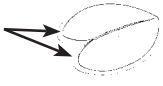
Gland – A protrusion or depression on a structure that produces a sticky or greasy substance



Lacuna (plural: Lacunae) – A space or gap located within tissues

Littoral Zone – The near shore shallow water zone of a lake, where light reaches the bottom and aquatic plants grow

Lobe / Lobed – A projecting portion of a leaf, too large to be called a tooth; lobed describes a leaf with lobes



Margin – The edge of a leaf

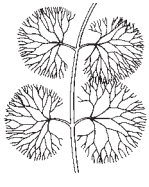
Mid-rib (Mid-vein) – The central vein of a leaf that runs from the tip to the base of the leaf

Monoecious – Having male and female reproductive structures on the same plant

Node – The point on a stem from which a leaf or branch grows

Nut (Nutlet) – Dry fruit having a hard shell which usually contains only one seed; nutlets are very small nuts

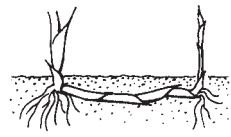
Opposite – Two leaves emerging from one node directly across from one another; leaves occurring in pairs

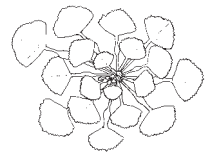


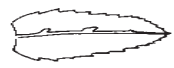
Petiole – A leaf stalk 

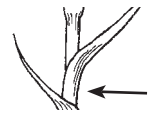
Pinnate – A compound leaf with pairs of leaflets arranged in two opposite rows along a common midrib 

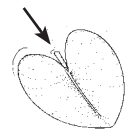
Pinnately lobed – A compound leaf with pairs of leaflets arranged in two opposite (or roughly opposite) rows along a common midrib; the leaflets are generally flattened in cross section (with the same general pattern as a feather-divided leaf, but with wider leaflets)

Rhizome – A creeping underground stem 

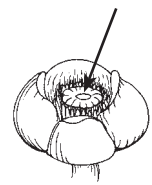
Rosette – Leaves arranged in a radiating pattern at the base or top of the plant, as in basal rosette (at the base of the plant) or floating rosette (at the top) 

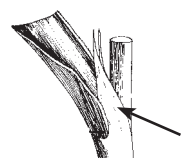
Serrate/Serrated – A sharply toothed leaf margin; serrations are conspicuous on some species; on other species they are visible only with magnification 

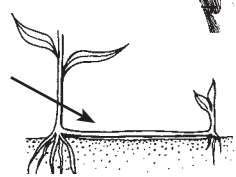
Sheath – A portion of the leaf that wraps around the stem of the plant 

Sinus – An indented area between two lobes 

Spike – A flower or fruit bearing stalk 

Stigma / Stigmatic – The pollen receiving, seed producing portion of the flower; stigmatic refers to stigma 

Stipule – A bit of tissue associated with the base of a leaf; may be stiff or supple, fused to the leaf, partially fused, or free; important feature for identifying pondweeds 

Stolon – A stem that creeps along the surface of the sediment or ground 

Sub-opposite – Leaves almost opposite each other on the stem, but not precisely opposite

Sub-species – Similar to variety; sub-species is not a traditional biological category and is generally applied if there is uncertainty if a given organism is a different species or is a variety

Submersed – Describes plants that have most of their leaves growing underwater. Submersed plants may also produce floating leaves or emergent flowering stalks

Tuber – A bulb-like structure produced along the rhizomes. Tubers provide food storage and facilitate asexual reproduction

Turion – A compacted vegetative bud produced along the stem that can overwinter and form a new plant. Also known as winter buds

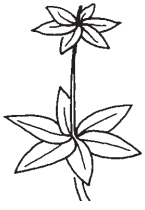
Variety – In botany, variety indicates a variant of the species that differs in one or more characteristics from the main species, but is still included in the species, and can easily cross with the main species

Veliger – The free swimming, planktonic larva of certain aquatic molluscs such as zebra mussels

Winter bud – See turion

Wing/Wings – Refers to a ridge-like protrusion

Whorl / Whorled – An arrangement of three or more leaves, flowers or bracts radiating from a common node, spread at intervals along the stem



COMMON NAME INDEX

SCIENTIFIC NAME INDEX

Measurement Conversion

1 centimeter = 0.39 inches

2.5 centimeters = 1 inch

25.4 millimeters = 1 inch

30.5 centimeters = 1 foot

1 meter = 3.28 feet

0.914 meters = 1 yard