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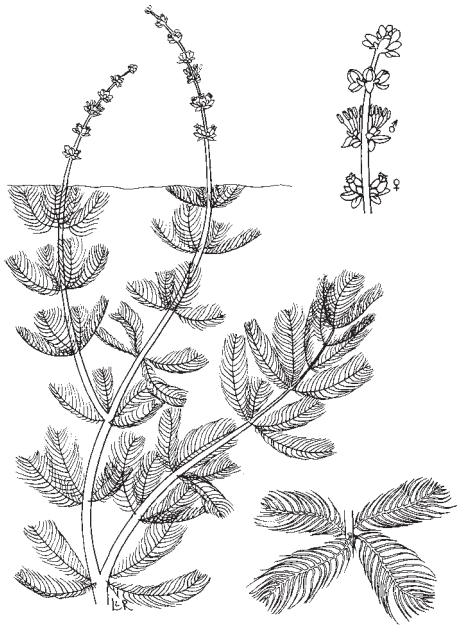


Eurasian watermilfoil

(*Myriophyllum spicatum*)

Identification and management in Idaho

by Timothy S. Prather, Sandra Robins, Sandy Daniel, and Karen Laitala

Origin and Entry

Eurasian watermilfoil is an invasive, submersed aquatic plant that forms very dense mats of vegetation on the water's surface, interfering with water recreation and inhibiting water flow. Eurasian watermilfoil is a native of Europe, Asia, and northern Africa. Reports suggest that it was introduced to the United States in the late 1800s, but it was first documented in the eastern United States in the 1940s. Eurasian watermilfoil is found throughout the United States, from Florida to Quebec in the East and from California to British Columbia in the West.

It spreads rapidly, primarily by fragmentation of plant parts. Plant fragments grow roots, stems, and leaves as they float along in water. Because Eurasian watermilfoil is easily spread by fragments, transport on boats and boating equipment is believed to play an important role in its dispersal and the contamination of new water bodies.

Eurasian watermilfoil can form large, floating mats of vegetation on the surface of lakes, rivers, and other water bodies, preventing light from reaching native aquatic plants and impeding water traffic. The plant thrives in areas that have been subjected to various kinds of natural and manmade disturbance.

Description

Table 1 describes the leaves, stems, and flowers of Eurasian watermilfoil and of other local watermilfoils, both native and introduced. For illustrations of each, see figure 1.

Eurasian watermilfoil, also called spike watermilfoil, is in the watermilfoil family, Haloragaceae. It is a submersed, rooted perennial plant with smooth stems that branch near the water surface. The stems may reach lengths of 10 feet or more, and are usually 1/16- to 3/16-inch thick.

The leaves of Eurasian watermilfoil are finely divided and occur in whorls of four. Each leaf is 0.5 to 2 inches long, with 12 to 21 pairs of fine, thin leaflets. These leaflets give milfoil its distinguishing feathery appearance. The leaves rarely extend above the water surface and collapse around the stem when removed from the water.

Eurasian watermilfoil closely resembles the native northern watermilfoil (*Myriophyllum sibiricum*). One somewhat variable distinguishing characteristic is the number of leaf divisions: northern watermilfoil has fewer leaf divisions (5 to 12) than do the non-native species (12 to 23).

The inflorescence is a terminal spike, 2 to 8 inches long, which is often pink. It is held erect above the water during flowering from June to September, but becomes horizontal as fruits ripen. At the time of flowering, the upper part of

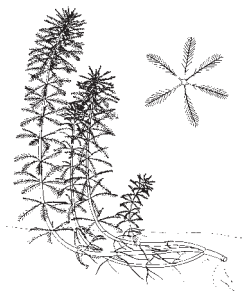
Table 1. A comparison of watermilfoils and similar species.

Species	Leaves	Stems	Flowers
Eurasian watermilfoil (*Myriophyllum spicatum*) Introduced	Arranged in **whorls of 4, rarely 5**, around the stem at nodes **Generally has 12 or more pairs of leaf divisions** **No emergent leaves** 0.5-2 inches long **Collapse around the stem when out of water** No turions produced (winter buds)	**Smooth stems branch abundantly near the water surface** in water 3-9 feet deep Usually 5 feet long but may reach lengths of 10 feet or more Flower stem width almost doubles below the inflorescence and curves to lie parallel to the water surface Shoot tip tassel-like	Emergent flower stalks **spike-like**, 2-8 inches long Small **pinkish flowers** are in the axils of upper bract-like leaves **Floral bracts as long as fruits or longer** Upper bracts subtending flowers entire and ovate Lower bracts subtending flowers often pectinate (like teeth of a comb) Flower stems have 2 or 3 distinct black scales at the nodes between the flowers
Northern watermilfoil (*Myriophyllum sibiricum*) Native	Arranged in whorls of 4 or 5 around the stem at the nodes **Generally has 12 or fewer pairs of leaf divisions** ⅝-1 3⁄16 inch long **Leaves sturdy and maintain their spread-leaf shape when out of water** **No emergent leaves** **Turions present in fall** (winter buds)	**Stems rarely branch near the water surface** in water more than 3 feet deep No change in stem width below the inflorescence; flower stems remain slender and erect near the water surface Often whitish Shoot tip knob-like	Emergent flower stalks **spike-like**, 1.5-4 inches long Small **pinkish flowers** are in the axils of upper bract-like leaves **Floral bracts shorter than fruits or, rarely, equaling them in length** Upper bracts subtending flowers entire and ovate-oblong Lower bracts subtending flowers mostly serrate 0 to 2 indistinct, brown or black scales at the nodes between the flowers
Whorl-leaf watermilfoil (*Myriophyllum verticillatum*) Native	Arranged in whorls of 4 or 5 around the stem at the nodes ¾-1 ¾ inches long **Emergent leaves** **Generally has 9-17 pairs of leaf divisions** Turions (winter buds) yellow-green	**Stems rarely branch near the water surface** in water more than 3 feet deep 1-3 feet long No change in stem width below the inflorescence	Emergent flower stalks **spike-like** Upper **flowers** with **yellow-green** petals **Floral bracts very variable,** from one to 10 times length of the fruits **Bracts** subtending flowers pectinate or pinnate, **never entire**
Andean watermilfoil (*Myriophyllum quitense*) Native	Arranged in whorls of 4 or 5 around the stem at the nodes ⅜-1 inch long Pectinately divided into 13-21 thread-like segments Bracts ovate to oblong, ⅜-⅜ inch long, and pectinate (comb-like) to lightly toothed Emergent leaves less than ¾ inch long	Simple or branched 1-3 feet long	**Inflorescence commonly forked** and submersed to emergent Subtended by small, whitish, pectinate (comb-like) bracts less than ⅛ inch long

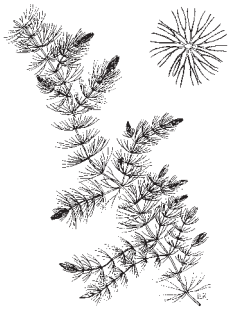
Figure 1. Comparison of watermilfoils and similar species.

Eurasian watermilfoil (*Myriophyllum spicatum*) | Northern watermilfoil (*Myriophyllum sibiricum*) | Whorl-leaf watermilfoil (*Myriophyllum verticillatum*) | Andean watermilfoil (*Myriophyllum quitense*) | Western watermilfoil (*Myriophyllum hippuroides*)

Species	Leaves	Stems	Flowers
Western watermilfoil (*Myriophyllum hippuroides*) Native	Arranged in whorls of 4 or 5 around the stem at the nodes **Submersed leaves pinnately dissected** into 13-23 thread-like segments Bract leaves linear to oblong, with serrate bracts	Freely branched 4 inches to 2 feet long	Emergent flower stalks **spike-like** Yellowish-white or cream-colored flowers Subtended by a bract-like scale
Parrotfeather (*Myriophyllum aquaticum*) Introduced	Arranged in whorls of 4-6 around the stem at the nodes **Has both emergent and submersed leaves** **Emergent leaves** 1-1 ⅜ inch long, with 9-18 linear segments on each side of the leaf **Submerged leaves** are more feather-like, 1-2 inches long, with 25-37 thread-like divisions	**Stems stout,** 1/16 –3/16 inch thick Submersed until time of flowering 6 inches to 3 feet long	Emergent flower stalks **spike-like** White flowers Subtended by a bract-like scale
Coontail (*Ceratophyllum demersum*) Native **Note:** one of the few genera of vascular plants that do not have roots	Dense bulky whorls around the stems **Usually 5-12 leaves per whorl** **Each leaf forks into thread-like segments with fine teeth along one side of each segment**	Long, stiff, brittle, with many branches	Submersed, located in the leaf axils Inconspicuous
White water-buttercup **Whitewater crowfoot** (*Ranunculus aquatilis*) Native	Alternate **Of two types:** **Submerged leaves** finely divided **Floating leaves** broad, flat, 3-5, palmately lobed	Submerged, sparingly branched Greater than 1/16 inch thick 3 feet long	**Solitary and terminal on long stalks** **White**, ⅜-⅝ inch wide Five sepals and petals
Fanwort (*Cabomba caroliniana*) Native	**Of two types:** **Submerged leaves fan-shaped**, ⅜-2 inches wide, arranged in pairs on the stem; **leaves opposite** with palmately finely dissected linear segments **Floating leaves** small, **linear to oval, alternate**, with the stem attached at the center of the leaf	Branched 6.5 feet long Submerged stems have a tubular appearance	**Mostly in the axils of floating leaves** Small, white flowers with a yellow base float on the water surface
Common bladderwort (*Utricularia macrorhiza*) Native	Finely divided into segments **Paired, bladder-like cavities** attached at leaf axils along stems	Branched, up to 6 feet long Free floating or sometimes attached to substrate	**Occur on upright stalks above water** Yellow, 2-lipped, with a 1-inch-wide spur



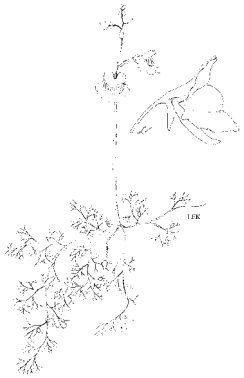
Parrotfeather
(*Myriophyllum aquaticum*)



Coontail
(*Ceratophyllum demersum*)

White water-buttercup
(*Ranunculus aquatilis*)

Fanwort
(*Cabomba caroliniana*)



Common bladderwort
(*Utricularia macrorhiza*)

the stem, below the inflorescence, is double the width of the lower stem.

The flowers are grouped in whorls of four. The lower whorls are female flowers and the upper male. The lower flowers are surrounded by floral bracts that are often longer than the flowers and have pectinate (comb-like, fringed) margins. Higher on the spike the bracts become shorter than the flowers, broader than long, and have entire margins.

The fruit is a hard, segmented capsule containing four seeds.

Biology

Eurasian watermilfoil is found in lakes, ponds, rivers, irrigation canals, and other waterways in waters up to about 19 feet deep, depending on light penetration. Eurasian watermilfoil plants branch prolifically at the water surface, forming an interlaced canopy. Turbid water limits Eurasian watermilfoil to shallow rooting depths, whereas in clear waters it grows at greater depths. Although most frequently found in quiet bodies of water, it has also shown an ability to grow in rapidly flowing water. Eurasian watermilfoil occurs mainly in nutrient-rich lakes and waterways.

Eurasian watermilfoil may reproduce from seed, but the most efficient method of reproduction and spread is by fragmentation of plant parts. Plant parts break off and float to new locations, or plant tips are abscised, float for a period of time, and then settle to the bottom. The abscised tips develop roots that anchor the plant to the soil and, under favorable conditions, create new colonies.

During the fall, plants die back to the root crowns. In warmer climates where the water surface does not freeze, relatively little dieback occurs and watermilfoil frequently overwinters in an evergreen form. The root crowns begin growth in the spring when temperatures increase. Growing stem tips are tassel-like and often red early in the growing season.

Eurasian watermilfoil can develop into semi-aquatic plants. The leaves of the semi-aquatic phase are smaller, stiffer, and have fewer divisions.

Flowering may occur from June to September. After flowering, spikes lie parallel to the water surface as fruits mature. The fruits float for a while, to allow for some dispersal in moving water. Seeds exhibit prolonged dormancy, and seedlings are rare.

Detection

The process for detection of Eurasian watermilfoil should begin with a risk assessment. A risk assessment will determine if a survey is necessary and can help determine when and where to survey to maximize detection. Risk assessment and survey methods are described in the next two sections.

Risk Assessment

Use table 2 to assess the risk of infestation to water resources in your area. If a water body is high risk in the proximity category and high risk in one or more other categories you should consider conducting a survey.

Survey Methods

Once a risk assessment has been conducted and a water body is considered at risk, use the following procedure to detect Eurasian watermilfoil. First, survey all access points from the shore, including public boat ramps and both public and private boat docks. Second, conduct a survey along the shoreline downwind of the prevailing winds. To collect vegetation that appears suspicious, tie a rope to a garden rake, throw it into the water, and pull the rake to shore. Wear polarized sunglasses to improve visibility into the water when a glare is present.

After the shoreline survey, conduct a survey from a boat sometime during the months of July, August, and September. Choose a cloudless day with no wind. Use the garden rake to obtain samples of vegetation that could be Eurasian watermilfoil.

Another method for detecting Eurasian watermilfoil is to build a 4- to 6-inch-diameter tube fitted with glass on one end. Place the tube partially into the water (glass side down) and look down

Conducting a survey for Eurasian watermilfoil

Timing

- July through September.

Priorities

- Public and private access points.
- Windward side of lake or pond where depth is less than 30 feet and the surface is not shaded.

Methods

- Shoreline survey using a garden rake tied to a rope to collect plant samples.
- Boat survey on a calm, cloudless day using a garden rake tied to a rope to collect plant samples.
- Diver survey.

Table 2. Risk assessment of water bodies susceptible to invasion.

Category	Description	Risk
Proximity	Lake or pond connected to a currently infested water body	High
	Lake or pond within 1 day travel distance of currently infested water body	High
	Lake or pond within weekend travel distance of a currently infested water body	Moderate
	Lake or pond more than weekend travel distance of a currently infested water body	Low
Access	Lake or pond with public access boating ramp	Moderate
	Lake or pond without public access boating ramp	Low
Water body characteristics	Significant depth at shoreline less than 30 feet	High
	Lake or pond less than 30 feet deep	High
	Lake or pond more than 30 feet deep	Low
	Muck, clay, or silt bottom	High
	Sand or gravel bottom	Low
	Water level fluctuation more than 30 feet	Low
	Water level fluctuation more than 10 feet but less than 30 feet	Moderate
	Water level fluctuation less than 10 feet	High
	Lake or pond shaded	Low
Aquatic vegetation	Native milfoil present	Moderate
	Richardson pondweed, potamogeton, fern leaf pondweed well established	Low

into the water from the opposite end.

If you find Eurasian watermilfoil using these procedures, the infestation likely is at least 3 to 4 acres in size and it likely has been present for at least 3 years.

If you find no Eurasian watermilfoil during a shoreline or boat survey, the water body may not be infested or it could be newly infested. The only definitive survey technique for newly infested waters is to have divers trained in Eurasian watermilfoil detection survey the priority areas identified in the risk assessment. Divers can discover Eurasian watermilfoil at earlier stages in the invasion process than is possible using a shoreline and boat survey.

Management

Prevention

Education—Educating boaters to remove all plant material from their boats and trailers before leaving a lake or pond should curtail the introduction of Eurasian watermilfoil to new waters. Providing wash stations at boat ramps will also reduce the chance of new introductions.

Bottom modification—Bottom modification may prevent the establishment of Eurasian watermilfoil, particularly at boat ramps in areas of high recreational boating. Bottom modification normally consists of laying sand or gravel at the bottom of the ramp or boat launch area to prevent the rooting of any plant fragments that fall from trailers or boats as they enter or exit the lake. A fabric laid across the bottom also can prevent plants from emerging and from taking root. Fabric barriers cost $0.55 to $0.95 per square foot of fabric, installed. A barrier coverage time of 8 weeks can eliminate Eurasian watermilfoil with the least impact on native plants. If sediment deposits of 1.5 inches or deeper cover the fabric, plants can root on top of the fabric, so the fabric must be kept clean to remain effective.

Regulation—County governments could institute regulations that would minimize the possibility of introduction and spread of Eurasian watermilfoil in newly created lakes and ponds. Counties could also develop weed-free standards for aquatic ornamentals sold for planting into ponds or lakes.

Mechanical Control

Several mechanical methods have been used to control Eurasian watermilfoil, but only a few are useful when the goal is removal of plants. Several mowers temporarily clear water channels for boating and swimming. Mowing, however, presents a problem if eradication is a goal because mowing creates plant fragments that are able to travel with water currents to new areas.

Diver hand pulling is a useful method of mechanical removal, but it requires divers trained to work in murky conditions to locate plants. A diver can easily handle one stem per square yard. However, as density and acreage increase, it becomes increasingly difficult and costly to remove plants. Higher plant density slows diver movement because it increases the turbidity of the water. Divers are unable to see clearly in the more turbid water, so hand pulling takes longer. Costs increase with increases in plant density and height (table 3).

Table 3. Estimated per-acre time and cost for diver hand pulling, based on plant height and density, 2000.

Plant height (feet)	Dense 6 plants/ square yard	Moderate 1 plant/ square yard	Light 1 plant/ 10 square yards	Scattered 1 plant/ 100 square yards
1	7 hours; $560/acre	5 hours; $400/acre	3 hours; $240/acre	1 hour; $80/acre
3	12 hours; $960/acre	6.5 hours; $520/acre	4.5 hours; $360/acre	2 hours; $160/acre
6	24 hours; $1,920/acre	10 hours; $800/acre	6 hours; $480/acre	3 hours; $240/acre
10[a]	30 hours; $2,400/acre	20 hours; $1,600/acre	8 hours; $640/acre	4 hours; $320/acre

Note: Hours and costs based on diver cost of $80/hour, including two divers and one top crew. Left of the dotted line indicates where herbicidal control is less expensive than diver hand pulling.
[a]Add 40-60% to the costs listed in the last row if plants are over 10 feet tall.

Table 4. Restrictions to herbicide use, cost of herbicide (2007 estimate), and type of herbicide used in aquatic systems for Eurasian watermilfoil control.

Herbicide	Wildlife toxicity	Potable water use delay (days)	Irrigation delay (days)	Herbicide movement	Cost[a] ($/acre)
2,4-D (Navigate, Savage, Aqua-Kleen)	Invertebrates	21	21	Translocates	$265 to $672
Diquat (Reward)	Safe	3	3	Contact	$247 to $344
Endothall (Aquathol Super K Granule)	Fish	3	5	Contact	$266 to $427
Fluridone (Sonar, Avast)	Safe	0[b]	7 or 30[c]	Translocates	$231 to $860
Triclopyr (Renovate 3, Renovate OTF)	Slightly toxic to aquatic organisms on an acute basis	Until concentration drops to 0.4 ppm or less	120 or when concentration drops to 1.0 ppb or less	Translocates	$475 to $1048

[a]Cost estimates are based on 5 ft. water depth and include application costs ($150/acre); additional administrative costs including notices, mailings, and water samples may apply.
[b]See label for restrictions for use around potable water intakes.
[c]Irrigation delay is 7 days for lakes, 30 days for ponds.

Control with Herbicides

Herbicide use in aquatic systems requires consideration of many factors to ensure that public health is protected and that injury to non-target aquatic organisms is minimized (table 4). Safety to aquatic organisms varies with the herbicide. With all herbicides, however, take into account the effect of decaying plant material on oxygen levels. Plants killed by herbicides begin to decompose, a process that removes oxygen from the water. If too much oxygen is removed, aquatic organisms can suffocate.

Most herbicide labels detail how to apply herbicide to reduce the possibility of oxygen loss. For example, applying herbicide to less than one-half of the surface area of the water body will prevent oxygen deprivation.

Additional regulations will likely affect the ability to use herbicides in water, notably those related to the National Pollution Discharge Elimination System (NDPES), which may require permitting through the Clean Water Act. For more information, contact the Idaho Department of Agriculture, Idaho Department of Water Resources, and Idaho Department of Environmental Quality.

2,4-D—2,4-D is a translocating herbicide sold as Navigate, Savage, and Aqua-Kleen. These formulations include both liquids and granules. Both types of formulation will sink, but the granules will penetrate waters where a thermocline forms a barrier to liquid formulations. The herbicide is most effective if applied in spring or early summer. Best control is realized with two applications, one in spring and the other in late summer. Effects of the herbicide are visible within 14 days of application, and plants die within 4 to 6 weeks.

Diquat—Diquat is a contact herbicide so foliage that comes into contact with the herbicide is the only portion of the plant affected. Contacted foliage dies quickly, but plants may resprout, recovering in a few weeks to a few months.

Endothall—Endothall is a contact herbicide so only foliage in contact with the herbicide will die. It is fast acting; foliage dies within 1 to 2 weeks. Plants may recover after a few weeks to several months.

Fluridone—Fluridone is a slow-acting, translocating herbicide that is sold as Sonar 4AS and Sonar 5P or Sonar 5 RP. Apply fluridone in the spring or early summer for best results in still water. The concentration effective for Eurasian watermilfoil control must be maintained for up to 8 weeks since the herbicide is very slow acting.

Glyphosate—Glyphosate is a translocating herbicide that is applied to the floating or emergent foliage and is sold under the trade name Rodeo. The herbicide is not effective in water because soil and organic particles floating in the water bind to the herbicide.

Triclopyr—Triclopyr is a relatively fast-acting and selective translocating herbicide. Triclopyr is sold as Renovate 3 and Renovate OTF. These formulations include both liquids and granules.

Optimal control is obtained with spring or early summer applications when submersed weeds are actively growing. In areas of greater water exchange, or when treating target areas of ½ acre or smaller, higher rates and repeat applications may be required. Symptoms of herbicide damage to foliage are visible within 4 days of application, and plants die within 1 to several weeks.

Biological control

Several biological control agents have been considered for Eurasian watermilfoil control including a native chironomid larva, *Cricotopus myriophylli*, a native North American freshwater weevil, *Euhrychiopsis lecontei*, and a naturalized pyralid caterpillar, *Acentria ephemerella*. Large, well established populations of insects are required to serve as an effective control. Factors currently limiting population densities include predation by sunfish (*Lepomis* spp.).

The herbivorous grass carp (*Ctenopharyngodon idella*) has also been studied for its potential use as a biological control. Although a sterile, triploid grass carp was developed that will eat Eurasian watermilfoil, the plant is not a highly palatable or preferred food source for this fish.

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