

## ***Myriophyllum heterophyllum***

**System:** Terrestrial

Kingdom	Phylum	Class	Order	Family
Plantae	Magnoliophyta	Magnoliopsida	Haloragales	Haloragaceae

**Common name** changeleaf parrotfeather (English), variable-leaf water milfoil (English), red foxtail (English), broad-leaved watermilfoil (English), two-leaved watermilfoil (English), broadleaf watermilfoil (English), two-leaf watermilfoil (English)

### **Synonym**

**Similar species** *Myriophyllum farwellii*, *Myriophyllum hippuroides*, *Myriophyllum humile*, *Myriophyllum verticillatum*, *Proserpinaca palustris*

### **Summary**

The aggressive growth of non-native aquatic plants is a major concern for lake managers because of high costs involved in managing their spread. Unlike Eurasian watermilfoil (*Myriophyllum spicatum*) where studies on control with herbicides, insects, microbes and other means are abundant, few studies are available on the control of variable watermilfoil (*M. heterophylla*). Myriophyllum species are notoriously difficult to identify using vegetative morphology alone - which commonly is all that is available for these highly clonal plants.



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### **Species Description**

Milfoil species are notoriously difficult to distinguish particularly in the field because of morphological similarities (Moody & Les 2010; Thum *et al.* 2006). Milfoils are often identified based on floral/reproductive characters, but these are not always available for inspection due to short flowering period and the propensity for vegetative propagation (Sculthorpe 1967, Cronk & Fennedy 2001, in Moody & Les 2010; Thum *et al.* 2006). Identification can be complicated by vegetative plasticity in *Myriophyllum* (e.g. submerged and emergent vegetative forms) and hybridisation (Thum *et al.* 2006).  
In

The overall habit of *M. heterophyllum* is described by the Washington State Noxious Weed Control Board (2007): *M. heterophyllum* is a submersed rooted macrophyte typically with both submerged and emergent leaves growing from a stout stem up to 3 mm in diameter and 100 cm in length. Stem colour ranges from dark red to brownish red.

Submerged leaves are feather-like, green and 2-5 cm long and 2-4 cm wide, dissected into 7-11 leaflets and arranged into whorls of 4-5 leaves; the highly variable emergent leaves develop during late summer and can reach 5-15 cm above the water; they are 0.4-3 cm long and 1.5-5 mm wide; inflorescence is a spike 5-35 cm long, consisting of flowers in whorls of four; flowers have 4 stamens and petals are 1.5-3 mm long; fruits are 1-1.5 mm in length, round, with 4 chambers (EPPO 2009).

## Notes

Hybrid vigor or *heterosis* has been proposed as a factor promoting invasive growth of some nonindigenous aquatic plant species, particularly those capable of spreading rapidly through clonal reproduction (Thum & Lennon 2006). Hybridisation has been shown to play a role in North American invasions with two hybrid lineages recognized (*M. spicatum* x *M. sibiricum* and *M. heterophyllum* x *M. laxum*; Moody & Les 2002, in Moody & Les 2010). However pure lineages of *M. heterophyllum* are also capable of invasive growth and it is possible that increased nutrient inputs and lake disturbances arising from increased recreational use (ie: cultural eutrophication of lakes; see Lennon *et al.* 2003, as cited in Thum & Lennon 2006) might facilitate both their spread and establishment (Thum & Lennon 2006).

## Habitat Description

*Myriophyllum heterophyllum* over-winters in the frozen lakes of cold climates and can thrive in warm water bodies (Brunel *et al.* 2010). It has been found growing under a wide range of water temperatures and chemical conditions: it can be found in calcium-rich waters, but tends to prefer acid pH waters (Brunel *et al.* 2010). It prefers fine textured sediments with high ammonium nitrogen levels (Crow & Hellquist 1983, in Department of Conservation and Recreation Massachusetts 2005) and is most commonly associated with slightly acidic waters with sediments of high organic matter content. Suitable habitats for this species include freshwater ponds, lakes, ditches, standing and slow flowing waters (Brunel *et al.* 2010). *M. heterophyllum* can grow out of water in moist soil as a small emergent plant for several months. Once flooded, it quickly transitions and grows as the submersed form (Dr. Michael Netherland, pers. comm.).\r\n

Most of the *M. heterophyllum* in Bashan Lake, East Haddam, Connecticut, United States occurred in shallow protected areas less than 3 m deep (Bugbee *et al.* 2003). It is reported by the European and Mediterranean Plant Protection Organisation (2009) to grow in waters up to 1.8 m deep but can apparently grow in water as deep as 4.5 m (Department of Conservation and Recreation Massachusetts 2005).

## Reproduction

*Myriophyllum heterophyllum* spreads primarily via clonal reproduction and fragmentation, seldom forming emergent heterophylous flower-bearing stems, and does not generate a significant seedbank (Madsen 1988, in Bugbee *et al.* 2003; McFarland *et al.* 2003, in Getsinger *et al.* 2003). Little is known about the reproductive biology of *M. heterophyllum* but many fertile specimens appear to contain viable seeds (Les & Mehrhoff 1999). Its stems serve as efficient organs for vegetative reproduction and their draping habit facilitates transport on boat trailers (Les & Mehrhoff 1999). Winter buds enable *M. heterophyllum* to overwinter in northern New Hampshire (Aiken 1981, in Les & Mehrhoff 1999).

## General Impacts

Aquatic plant invasions often lead to a loss of native plant diversity, decreased property values, high economic costs, alteration of sediment and nutrient processing, disturbance to natural wildlife habitat and interference with recreation (Thum & Lennon 2010). *M. heterophyllum* is an aggressive invader that can grow up to one inch per day under optimal conditions (NH-DES 2002, in Glomski & Netherland 2008). *M. heterophyllum* grows rapidly to form dense vegetative mats that reduce sunlight and reduce water movement (EPPO 2009). When decomposing it reduces water quality and available oxygen which may harm fish and other aquatic organisms (EPPO 2009). Thick mats often out-competing native vegetation, clog boat motors and deter people from water-related activities (Bailey *et al.* 2008).\r\n

In the northeastern United States Native submersed monocots such as pondweeds (*Potamogeton* spp.) and horned pondweed (*Zannichellia palustris*) and native dicots such as alternate-flowered watermilfoil (*M. alterniflorum*) and Farwell's watermilfoil (*M. farwellii*) may require protection from competition from invasive species (New Hampshire Natural Heritage Inventory 1998, in Getsinger *et al.* 2003).\r\n

## Management Info

The aggressive growth of non-native aquatic plants are major concerns for lake managers because of high costs involved (Pimentel *et al.* 2000, in Thum *et al.* 2006). Unlike Eurasian *M. spicatum* where studies on control with herbicides, insects, microbes and other means are abundant, few studies are available on the control of *M. heterophyllum* (Bugbee *et al.* 2003).

Preventative measures: Preventative management efforts have focused on the establishment of laws that require removing plant debris from boats and trailers (Thum & Lennon 2006). \r\n

Early detection and treatment is critical for limiting the spread of invasive aquatic plants (Moody & Les 2007, in Thum & Lennon 2010). However many taxa in this clade display high plasticity and similarity in vegetative form. Thum and colleagues (2006) developed a restriction enzyme assay that distinguished *M. heterophyllum* from native milfoils (Thum *et al.* 2006). Also a DNA marker has been used to differentiate the invasive *M. heterophyllum* and its hybrid *M. heterophyllum* x *M. laxum* from native taxa (Moody & Les 2010). \r\n

Models that predict the likelihood of invasion are required to aid the prioritisation of monitoring, and reduce associated time and costs. It was found that *M. heterophyllum* occurs almost exclusively in "higher order" lakes characterised as large, low elevation systems with relatively high pH, alkalinity and conductivity in New Hampshire (Thum & Lennon 2010).

The Department of Conservation and Recreation Massachusetts (2005) has produced an informative document entitled [Rapid Response Plan for Variable Milfoil in Massachusetts](#).

Manual: Hand-pulling or tarping may control infestations (Washington State Noxious Weed Control Board 2007). Hand removal and benthic mat use were more effective than cutting at eight infested lake sites in Maine (Bailey *et al.* 2008). Benthic mats are an appropriate option for thick extensive infestations, whereas hand removal is more cost-effective and more efficient in areas with small high-density infestations or for selective removal of sparse infestations in native macrophytic strands.

Physical: Drawdown can also be used to control *M. heterophyllum* where applicable if it is extensive enough to prevent re-growth from seeds (EPPO 2009). This control method could have a negative impact on native plants and animals (EPPO 2009). \r\n\r\n

Chemical: Similar to fluridone newer chemicals tend to be enzyme-specific compounds with a reduced impacts on non-target species (Getsinger *et al.* 2008). Diquat dibromide (Reward) and 2,4-D (Aqua Kleen and Navigate) are currently approved for use in most states in North America (Washington State Noxious Weed Control Board 2007). Triclopyr may be another option. Results from Getsinger *et al.* (2003) suggest that triclopyr may be efficacious against *M. heterophyllum* in the field over a wide range of concentrations and exposure times.

Glomski and Netherland (2007) found that diquat at 370 µg ai L-1 for 30 hours provided good control (85%) of *M. heterophyllum* and that all rates and exposures of carfentrazone significantly reduced *M. heterophyllum* biomass, however, shoot regrowth from root crowns required follow-up applications. Fluridone and penoxsulam were also reported to control *M. heterophyllum* at rates as low as 5 and 10 µg ai L-1 respectively (Glomski & Netherland 2008). \r\n

Biocontrol: Sheldon and Creed (2003) found that the North American weevil *Euhrychiopsis lecontei* being used as a biological control agent for Eurasian watermilfoil (*M. spicatum*) is a specialist herbivore which will have little impact on the survival of *M. heterophyllum*.

## Pathway

Dispersal by motorboats and boat trailers has been largely blamed for the spread of nonindigenous milfoils (Smith and Barko 1990, in Thum & Lennon 2006). In one study, Minnesota authorities found aquatic plants on 23% of all boats inspected (Bratager *et al.* 1996, in Department of Conservation and Recreation Massachusetts 2005). *M. heterophyllum* is used for ornamental purposes in ponds (EPPO 2009). Specimens of *M. heterophyllum* were probably distributed in the aquarium plant trade under a variety of names (Les & Mehrhoff 1999). Tricker (1897) and Bissett (1907) specifically recommended *M. heterophyllum* as a species for aquarium and water garden culture (as cited in Les & Mehrhoff 1999). *M. heterophyllum* is believed to have been introduced between United States waters by way of discarded aquarium plants into lake waters (Halstead *et al.* 2003).

## Principal source:

**Compiler:** National Biological Information Infrastructure (NBII) & IUCN/SSC Invasive Species Specialist Group (ISSG)

**Review:** LeeAnn M. Glomski, U.S. Army Engineer Research and Development Center

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## ALIEN RANGE

[1] AUSTRIA	[1] BELGIUM
[1] EUROPE	[4] GERMANY
[1] MEDITERRANEAN AREA	[1] NETHERLANDS
[1] SPAIN	[7] UNITED STATES

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