U.S. Fish & Wildlife Service

Parrotfeather (*Myriophyllum aquaticum*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, June 2015
Revised, April 2018
Web Version, 5/15/2018

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1 Native Range and Status in the United States

Native Range

From CABI (2018):

"*M. aquaticum* is indigenous to South America (Orchard, 1981; Sutton, 1985) where it prefers warm areas rather than hotter tropical regions: especially Argentina (as far south as northern Patagonia), Chile, Paraguay, Peru and southern Brazil, but recorded also in Uruguay, Bolivia and Colombia (Steubing et al., 1980; Claps 1991; Fernández et al., 1993; Mereles and Degen, 1993;

[Arocena] and Mazzeo, 1994; Leon et al., 1998; Maine et al., 1998; Nunez et al., 1998; Sabbatini et al., 1998; Ritter and Crow, 1999; Schessl, 1999; Pitelli et al., 2000; Schmidt-Munn and Posada, 2000; Murphy et al., 2003; Maltchik et al., 2005). Although usually benign in its native range, *M. aquaticum* can and does cause weed problems in South America (Fernandez et al., 1993). It is invasive in reservoirs in Brazil as far north as Rio de Janeiro State (e.g. Kissman and Groth, 1995; Bini et al., 1999; Pitelli et al., 2000)."

GISD (2018) lists *Myriophyllum aquaticum* as native in Argentina, Bolivia, Brazil, Chile, Ecuador, Paraguay, and Peru.

Status in the United States

Wersal et al. (2018b) list *Myriophyllum aquaticum* as present and nonindigenous in Alabama, Arizona, Arkansas, California, Delaware, District of Columbia, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Montana, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, West Virginia, and Wisconsin.

In addition to the above states, CABI (2018) lists *Myriophyllum aquaticum* as present and introduced in Connecticut, Rhode Island, and Vermont; and as present, introduced, and invasive in Maine.

In addition to the states listed by Wersal et al. (2018b) and CABI (2018), GISD (2018) lists My*riophyllum aquaticum* as alien, invasive, and established in Colorado, Nevada, New Hampshire, and Utah.

From Wersal et al. (2018a):

"In North America, the first record of parrot feather was in New Jersey (1890) on the east coast, and by 1944 it had reached Washington. The earliest specimen recorded in the United States was collected April 20, 1890, from Haddonfield, New Jersey (Nelson and Couch 1985). A Missouri collection in 1897, clearly introduced as an ornamental which escaped from aquaria and water garden cultivation, (Couch and Nelson 1985b), was probably a separate introduction rather than originating from localities on the east coast. *Myriophyllum aquaticum* was first reported in the southern New England region (southeastern New York) in 1929 (Couch and Nelson 1985b). By 1940, it was well established in southeastern New York and on Long Island (Couch and Nelson 1985b, Muenscher 1944, Ogden 1974). Couch and Nelson reported a single population of parrot feather in western Washington in 1944. Washington's parrot feather infestations are found in coastal lakes and streams and in the southwest Washington portion of the Columbia River. Parrot feather is found throughout the drainage system in the Longview/Kelso area, infests many of the drainage ditches in Wahkiakum County, and was discovered growing in the Chehalis River in 1994. Recently parrot feather was discovered in some backwater ponds along the Yakima River and also in Asotin County (Washington State Department of Ecology 2011). An herbarium specimen was collected from Skamokowa, Wahkiakum County in 1983 (Washington State Department of Ecology 2011)."

"A specimen of *M. aquaticum* (originally misidentified as *Proserpinaca* sp.) was collected in southern Connecticut (West Lake, Guilford, New Haven Co.) in 1946. However, the authors failed to detect the species in a 1993 survey of the lake (Les and Mehrhoff 1999)."

"In a Great Lakes regional study, this aquatic plant was found in 25% of the stores surveyed in Michigan and Ontario, near Lake Erie, between 2002 and 2003 (Rixon et al. 2005)."

"Among the Great Lakes states and provinces, *M. aquaticum* is prohibited in Illinois, Michigan, and Wisconsin and regulated in Minnesota. Furthermore, it is listed as a noxious weed by nine non-Great Lakes states (Alabama, Connecticut, Idaho, Maine, Massachusetts, Maryland, New Hampshire, Vermont, and Washington) (IISG 2008, [GLPANS] 2008, WIDNR 2011)."

"Possession of live parrot feather is prohibited in Illinois, Michigan, and Wisconsin; regulated in Minnesota ([GLPANS]2008, IISG 2011, WIDNR 2011)."

From Wersal et al. (2018b):

"Established in North America."

According to USDA, NRCS (2018), *Myriophyllum aquaticum* is listed as a Class C noxious weed in Alabama; a potentially invasive, banned species in Connecticut; an invasive aquatic plant in Maine; a prohibited species in Massachusetts; a Class A noxious weed in Vermont; and a Class B noxious weed and wetland and aquatic weed quarantine species in Washington.

Means of Introductions in the United States

From Wersal et al. (2018b):

"Escaped ornamental pond plant."

From Wersal et al. (2018a):

"The closest parrot feather population to the Great Lakes has been recorded from Meserve Lake, Indiana, which drains though the Pigeon River into the St. Joseph River, a tributary of Lake Michigan (Wersal 2011). Fragments of this plant are capable of transport by river currents and could also become attached to or entangled with recreational boats (e.g., propellers, trailer tires) or fishing gear. Its rhizomes are very tough and can be transported long distances on boat trailers, surviving for up to a year when kept moist and cool (Washington State Department of Ecology 2003, in Mabulu 2005)."

Remarks

No additional remarks.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2018):

"Taxonomic Status:
Current Standing: accepted"

"Kindgom Plantae
Subkingdom Viridiplantae
Infrakingdom Streptophyta
Superdivision Embryophyta
Division Tracheophyta
Subdivision Spermatophytina
Class Magnoliopsida
Superorder Saxifraganae
Order Saxifragales
Family Haloragaceae
Genus *Myriophyllum*
Species *Myriophyllum aquaticum* (Vell.) Verdc."

Size, Weight, and Age Range

From Wersal et al. (2018b):

"Size: leaves 1.5 to 5 cm, stems up to 5 feet."

Environment

From Wersal et al. (2018b):

"Although it can grow in moist soil and tolerates a wide-range of water levels, parrot feather grows most rapidly in higher water levels (but has been documented in depths up to 16 ft; Banfield 2008) and high-nutrient environments (Hussner et al. 2009; Sutton 1985; Sytsma and Anderson 1993). Parrot feather requires rooting in bottom sediments, in habitats where light can penetrate to the bottom favor growth and colonization. Parrot feather thrives under slightly alkaline conditions (pH range 6.8-8.0), prefers [water] temperatures between 16-23°C, and can withstand a water hardness level between 50-200 ppm (Federation of New Zealand Aquatic Societies, in Mabulu 2005). This species displays photosynthetic activity at pH levels of 6 to 8.5, depths of 0 to 10 meters, and [water] temperatures from 10°C to 30°C, though it can survive even broader ranges (Robinson 2003; WIDNR 2011). It can also survive frequent inundation of salt water as long as concentrations remain below 4 ppt (Sutton 1985). […] Parrot feather can survive winters in its submersed form and begin growth when water temperatures reach 7°C (Moreira et al. 1999)."

From CABI (2018):

"The weed strongly favours eutrophic conditions. It tolerates (and often displaces native species from) coastal or saline-influenced waters, to 3.3 ppt salinity. However, 10 ppt is toxic to the plant (this is particularly a problem in irrigation channel and river systems)."

"It can withstand considerable desiccation (Cook, 2004)."

Climate/Range

From Wersal et al. (2018b):

"It prefers to inhabit subtropical regions (Fernandez et al. 1993)."

"Parrot feather is not seriously affected by frost (Moreira et al. 1999); however, a hard or extended period of frost may kill emergent shoots in northern latitudes (WIDNR 2011). […] Nevertheless, invasion tends to fail in areas with severe winters, because parrot feather does not store phosphorus or carbon in its rhizomes (Mabulu 2005)."

From CABI (2018):

"It is now regarded as a major international aquatic weed, having been introduced to much of the warm-temperate to sub-tropical regions of the world (Randall, 2002)."

"[…] recorded at higher altitudes, from as high as 3250 m in Peru and 1900 m in Brazil."

Distribution Outside the United States

Native

From CABI (2018):

"*M. aquaticum* is indigenous to South America (Orchard, 1981; Sutton, 1985) where it prefers warm areas rather than hotter tropical regions: especially Argentina (as far south as northern Patagonia), Chile, Paraguay, Peru and southern Brazil, but recorded also in Uruguay, Bolivia and Colombia (Steubing et al., 1980; Claps 1991; Fernández et al., 1993; Mereles and Degen, 1993; [Arocena] and Mazzeo, 1994; Leon et al., 1998; Maine et al., 1998; Nunez et al., 1998; Sabbatini et al., 1998; Ritter and Crow, 1999; Schessl, 1999; Pitelli et al., 2000; Schmidt-Munn and Posada, 2000; Murphy et al., 2003; Maltchik et al., 2005). Although usually benign in its native range, *M. aquaticum* can and does cause weed problems in South America (Fernandez et al., 1993). It is invasive in reservoirs in Brazil as far north as Rio de Janeiro State (e.g. Kissman and Groth, 1995; Bini et al., 1999; Pitelli et al., 2000)."

GISD (2018) lists *Myriophyllum aquaticum* as native in Argentina, Bolivia, Brazil, Chile, Ecuador, Paraguay, and Peru.

Introduced

From Stiers et al. (2011):

"[…] three invasive aquatic plant species that were introduced in Belgium through the aquarium trade. *Hydrocotyle ranunculoides*, *Ludwigia grandiflora* and *Myriophyllum aquaticum* have become well established and are recognized as noxious weeds in several neighboring countries (Pot 2002; Dandelot et al. 2005, 2008; Gassmann et al. 2006; Sheppard et al. 2006; Thiébaut 2007; Hussner 2009)."

From CABI (2018):

"The weed is aggressively spreading in southern Africa, as far north as Zambia (Child, 1992; Chikwenhere, 1994, 2001; Mitchell, 1995; Ramoeli, 1995; Henderson and Cilliers, 2002; Foxcroft and Richardson, 2003; Cook, 2004; ECZ, 2004). It causes severe problems in […], New Zealand and Australia (Muyt, 2001; Champion and Clayton, 2003; Roy et al., 2004), and southern Europe (Portugal and France; Teles and Pinto da Silva, 1975; Costa et al., 1999; Moreira et al., 1999; Catarino et al., 2001; Peltre and Muller, 2002; Rebillard et al., 2002; Tabacchi and Planty-Tabacchi, 2002). It occurs and occasionally causes problems (with a trend towards increasing severity and occurrence of infestations, possibly associated with a trend towards warmer winters) in cooler regions of central Europe and the British Isles (Bank-Signon and Patzke, 1988; Dawson, 1993; Clarke and Newman, 2002; Van der Velde et al., 2002). It was designated a Rank A Invasive Alien Species (i.e., included among the 16 most invasive weeds) in Japan in 2004 (Muranaka et al., 2005)."

CABI (2018) lists *Myriophyllum aquaticum* as introduced, and invasive in Zambia, UK, Australia, and New Zealand; as introduced in Cambodia, China, Java, Malaysia, Philippines, Thailand, Vietnam, Botswana, Lesotho, Madagascar, Zimbabwe, Mexico, Nicaragua, Austria, Germany, and Ireland; as present in Taiwan, Costa Rica, and Portugal; as present with few occurrences in Israel; as widespread in South Africa and the Netherlands; and with restricted distribution in France.

DAISIE (2018) lists *Myriophyllum aquaticum* as alien and established in Belgium, Corsica, France, Germany, Great Britain, Ireland, Italy, and Portugal; as alien and status unknown Channel Islands, England, Northern Ireland, Scotland, and Wales; and as alien and not established in Romania and Spain.

According to Wersal et al. (2018a), *Myriophyllum aquaticum* is present in British Columbia, Canada.

Myriophyllum aquaticum has been verified as alien in Australia, Austria, Belgium, Cambodia, Germany, India, Ireland, Israel, Japan, Nepal, New Zealand, Portugal, South Africa, Spain, Sri Lanka, Taiwan, UK, Zambia, Zimbabwe, Kenya, and United Republic of Tanzania.

From NIES (2018):

"Import, transport and keeping are prohibited in Japan by the Invasive Alien Species Act. Import to Australia is prohibited."

Means of Introduction Outside the United States

From CABI (2018):

"*Myriophyllum* species, like most other invasive aquatic plants, are largely spread between geographically separate regions by human dispersal (mainly by the aquatic plants trade for aquaria and garden ponds (e.g. Revilla et al., 1991; Kay and Hoyle, 2001; Allison, 2003; Gregory, 2003). Once established in a new locality their spread is via a range of mechanisms. The plants are easily spread downstream in the form of vegetative fragments or seed (though the latter seems much less important than the former: e.g Sidorkewicj et al., 2000).

Plant fragments are also easily transported attached to ships or boats. In the Nile in Egypt, carriage of *Myriophyllum* fragments on ships and other river traffic is the most likely mechanism for the upstream spread of the species in recent years, as far as Aswan in Upper Egypt (Springuel and Murphy, 1991). In Canada and elsewhere, quarantine measures have been introduced involving public information campaigns and boat inspections (for example at ferry landing points on Vancouver Island, British Columbia) to try to minimize transfer of plant material to uninfested river and lake systems.

Finally, the spread of the plants via natural vectors (especially waterfowl, either via the digestive tract or attached to plumage) is always a possible means of transfer."

Short Description

From CABI (2018):

"Orchard (1981). Stout aquatic or marsh-dwelling herb; stems to 2 m long, 4-5 mm diameter near base, glaucous, rooting freely from lower nodes, glabrous. Submerged leaves in whorls of (4-)5-6, oblanceolate in outline, rounded at apex (1.7-) 3.5-4.0 cm long, (0.4-) 0.8-1.2 cm wide, pectinate, with 25-30 linear pinnae up to 0.7 cm long, the lower leaves usually decaying rapidly. Emergent leaves glaucous, in whorls of (4-) 5-6, erect near apex, spreading in lower parts, narrowly oblanceolate in outline, rounded at apex, (1.5-) 2.5-3.5 cm long, (0.4 -) 0.7-0.8 cm wide, pectinate, with (18-) 24-36 pinnae in the upper four-fifths (lower 5-7 mm of rachis naked) pinnae linear to subulate, 4.5-5.5 mm long, 0.3 mm wide, tips very shortly apiculate, slightly incurved. Numerous hydathodes at base of leaves. Plants dioecious, males much less common than female throughout introduced range. Inflorescence an indeterminate spike with flowers singly borne in axils of upper emergent leaves, subtended by 2 bracteoles. Bracteoles subulate, 1.2-1.5 mm long with (1-) 2 short teeth in the lower-third, sometimes almost trifid.

Flowers strictly unisexual. Male flowers tetramerous, sessile at first, with pedicels to 4 mm long usually developing at anthesis. Sepals 4, ovate-deltoid, 0.7-0.8 mm long, 0.3 mm wide, very weakly denticulate, smooth. Petals 4, yellow, weakly hooded and keeled, (2.3-) 2.7-3.1 mm long,

0.8-1.1 mm wide. Stamens 8; filaments 0.1 mm long at anthesis; lengthening later to up to 1.2 mm; anthers yellow, linear-oblong (1.8-) 2.0-2.7 mm long, 0.2 mm wide, non-apiculate. Styles 0.

Female flowers tetramerous, on pedicel 0.2-0.4 mm long. Sepals 4, white, deltoid, 0.4-0.5 mm long, 0.3 mm wide, denticulate with one to several small teeth on each margin, smooth. Petals 0. Stamens 0. Styles 4, clavate, 0.1-0.2 mm long, stigmas white, densely fimbriate. Ovary pyriform, 0.6-0.7 mm long, 0.6 mm wide, 4-ribbed longitudinally between sepals.

Fruit (immature) on pedicel 0.7-0.8 mm long, cylindrical to ovoid, 1.7 mm long, 1.3-1.4 (-1.7) mm diameter. Sepals are first persistent, erect, deltoid, 0.6 mm long, 0.3 mm wide, toothed towards tip, withering at maturity. Mericarps cylindrical, 1.7 mm long, 0.6-0.7 mm diameter, slightly wider towards base, apex oblique, with an indistinct thickened rim, otherwise smooth, rounded on dorsal surface."

Biology

From Wersal et al. (2018b):

"Parrot feather grows well in shallow wetlands, slow moving streams, irrigation reservoirs or canals, edges of lakes, ponds, sloughs, or backwaters (Sutton 1985)."

"Parrot feather is a dioecious species, however only pistillate (female) plants are found outside of South America. Staminate (male) plants are rare even in native populations of South America (Orchard 1981). For this reason, seed production is not known to occur (Aiken 1981) and reproduction is exclusively vegetative in North America (Orchard 1981). Reproduction occurs by fragmentation of emergent and/or submersed shoots, roots, rhizomes, or attached plant fragments (Center for Aquatic and Invasive Plants, UF/IFAS 2010; Les and Mehrhoff 1999; Mabulu 2005).

Parrot feather has an annual growth pattern, forming shoots in spring from overwintering rhizomes as water temperature increases. Rhizomes provide support for adventitious roots and buoyancy for emergent summer growth. Flowers usually appear in spring, or in fall for some plants. The plant usually dies back to its rhizomes in the autumn (Mabulu 2005)."

From CABI (2018):

"Warm, shallow water and eutrophic conditions favour growth of *M. aquaticum* (Sutton, 1985). It can withstand considerable desiccation (Cook, 2004). Its stems may float out over the surface to form dense tangled rafts of plant material, from which the emergent shoots arise to give an impenetrable weed problem. Small fragments root easily in mud to establish new colonies: vegetative propagation seems to be much more important than seed production as a means of dispersal (e.g. Sidorkewicj et al., 2000). Indeed in most of its introduced range male plants appear to be absent, and the plant's rapid non-sexual dispersal (via stem fragments) is all the more remarkable. Barko and Smart (1981) demonstrated luxury uptake of nitrogen and phosphorus from sediments by *M. aquaticum*, a characteristic feature of highly competitive plants adapted to life in productive environments (Murphy, 1995). Concentration of phosphorus and biomass reserves in the emergent shoots was shown by Sytsma and Anderson (1993). [Rejmánková] (1992) confirmed this strongly competitive, productive growth strategy for *M.*

aquaticum. The plant also shows some degree of stress-tolerance, for example in tolerating moderate salinity stress (Haller et al., 1974) and is noted for its ability to tolerate disturbance caused by mechanical cutting. Its established-phase life strategy is probably C-CSR, using Grime's (1979) terminology."

Human Uses

From CABI (2018):

"Cattle and waterfowl graze the shoots, […]"

From GISD (2018):

"Until *Myriophyllum aquaticum* was included on the national list of plants banned from sale and distribution under the Biosecurity Act (1993), it had often been cultivated in ornamental garden ponds from which it has escaped, […]"

From Wersal et al. (2018a):

"Parrot feather has been an ornamental favorite in hanging baskets, fountains, and aquaria for more than a century due to its blue-green color, feather-like leaves, oxygenating properties, and cascading pattern of growth (Les 2002, Les and Mehrhoff 1999). Often sold under incorrect names, introductions of this species are usually attributed to the water garden and aquarium trades (Davis 1996, IFAS 2010, Les 2002, Les and Mehroff 1999)."

"Parrot feather is of growing interest for environmental remediation of soil and water contaminated with chlorinated solvents, trinitrotoluene (TNT), and other nitrogenated explosive/aromatic compounds, but this is currently a technology in limited, experimental use (Medina et al. 2000, Nwoko 2010)."

Diseases

From CABI (2018):

"Fungi such as *Rhizoctonia solani* are known to damage the plant only marginally (Joyner and Freeman, 1973) and it is rare to observe populations of the plant in other than vigorous green healthy growth, suggesting a high degree of natural resistance to disease and herbivorous organisms. However, *Pythium carolinianaum* has been found in the USA to cause stem collapse in parrot-feather plants (Bernhardt and Duniway, 1984)."

Threat to Humans

From GISD (2013):

"[*Myriophyllum aquatiucm* can] cause drowning of humans and animals. It also provides a breeding place for disease-carrying mosquitoes and snails (Henderson & Cilliers, 2002)."

3 Impacts of Introductions

From Stiers et al. (2011):

"Uninvaded ponds harboured in total 17 different families [of invertebrates] compared to 10, 9 and 14 families for *H. ranunculoides*, *L. grandiflora* and *M. aquaticum* invaded ponds respectively."

"Our study provides qualitative evidence that sites invaded by *H. ranunculoides*, *L. grandiflora* and *M. aquaticum* have a negative impact on both native plants and macroinvertebrates. Each of the invasive species significantly reduced native plant species richness, with fewer species in heavily invaded plots."

"In contrast, *H. ranunculoides*, *L. grandiflora* and *M. aquaticum* also invade sites with a high conservation interest. Rare (*Utricularia vulgaris*) and vulnerable (*Hydrocharis morsus-ranae*) red list species were absent in heavily invaded plots (Van Landuyt et al. 2006)."

"Our results on invertebrates showed that *H. ranunculoides*, *L. grandiflora* and *M. aquaticum* cover negatively affected invertebrate taxa richness and abundance in all ponds and the latter even in invaded ponds only."

From Wersal et al. (2018b):

"Dense infestations can rapidly overtake small ponds and sloughs, impeding water flow resulting in increased flood duration and intensity. Parrotfeather may also out-compete more desirable native macrophytes. Little information exists on the direct impact that parrotfeather has on fish and wildlife. Dense beds of parrotfeather have resulted in reductions in dissolved oxygen in the water column, which may be detrimental to fish (Fonseca 1984 cited in Moreira et al. 1999). Parrotfeather growth can inhibit the growth of more desirable plant species such as pondweeds and coontail (Ferreira and Moreira 1994), which are readily utilized by waterfowl as food items (Wersal et al. 2005). A strong correlation was determined between the density of parrotfeather growth and the presence of mosquito eggs and larvae (Orr and Resh 1989), which may lead to increases in mosquito born diseases that could infect wildlife and humans."

From Wersal et al. (2018a):

"Floating mats of *M. aquaticum* have been measured at up to 26 kg of fresh weight in Europe and are capable of reducing the oxygen content of the water below to <1 mg O2L-1, which can be detrimental to fish (Fonseca 1984 cited in Moreira et al. 1999, Hussner 2008 in Hussner 2009). In Germany, the infestation of these mats created anoxic, shaded conditions in shallow waters, and appeared to be correlated with a decline in native macrophyte diversity (Hussner 2008 in Hussner 2009)."

"Cardwell et al. (2002) found that *M. aquaticum* accumulated the highest overall levels of metals (zinc, cadmium, copper, and lead) in its tissues of all 15 aquatic plants that underwent testing. While this suggests that *M. aquaticum* could be used as an important indicator species (see

below), the consumption of *M. aquaticum* by grazers could increase the bioaccumulation of heavy metals in the food web."

"One account by South African farmers also reported that tobacco crops gained a red tint (reducing the sale value of the crop) when irrigated with water from an area colonized by *M. aquaticum* roots (Cilliers 1999)."

From Swearingen and Bargeron (2016):

"In more southern regions, this plant forms monocultures that clog waterways, impeding recreational and commercial boating activities. These monocultures also disrupt the growth of native aquatic plants and provide breeding areas for mosquitoes. […] Control of this plant is extremely costly."

From CABI (2018):

"*M. aquaticum* acts as a rice weed in Indonesia and Cambodia, […]"

"Anderson (1993) outlines the various ways in which aquatic weeds such as *M. aquaticum* can have detrimental impacts. These include interference with flow of irrigation water, transport, hydro-electric power production, fisheries, recreation, and increased risk of health hazards. Some specific problems reported for *M. aquaticum* include: interference with fisheries in South Africa (Jacot-Guillarmod, 1979); major problems for hydroelectric power production and forestry development in Argentina ([Fernández] et al., 1993); increased incidence of mosquitoes in California (Anderson, 1993).

A 1985 survey of Californian waters suffering *M. aquaticum* problems (Anderson, 1993) found the direct control expenditure on this weed was US $215 000 over a 2-year period. Anderson (1993) estimated the total annual expenditure on aquatic weed control in the western USA to be in the region of US $50 million.

Major problems of blockage of waterways and lakes by *M. aquaticum* are prevalent, including spread in southwestern Europe, especially in areas of France such as the Landes region, and several rivers and associated irrigation areas in Portugal (Peltre et al., 2002; Dutartre, 2003).

Cook (2004) states that should male plants of *M. aquaticum* (not yet reported) be imported into southern Africa "it could well become a very noxious weed". It appears to be spreading rapidly in southern Africa even by means of vegetative propagation alone (Nel et al., 2004).
There are reports of the species being of value for wastewater treatment in constructed wetlands, for example in New Zealand (e.g. Tanner, 2000)."

From GISD (2018):

"Apart from invading rivers, lakes and dams, *Myriophyllum aquaticum* parrot s *[sic]* feather is also known to invade the shallow parts of most water bodies in southern Africa. It can hinder stream flow, clog water inlets, interfere with fishing and fish culture, navigation and cause

drowning of humans and animals. It also provides a breeding place for disease-carrying mosquitoes and snails (Henderson & Cilliers, 2002).”

“In Washington, the Longview Diking District estimates that it spends $50,000 a year on parrot feather control in drainage ditches.”

4 Global Distribution

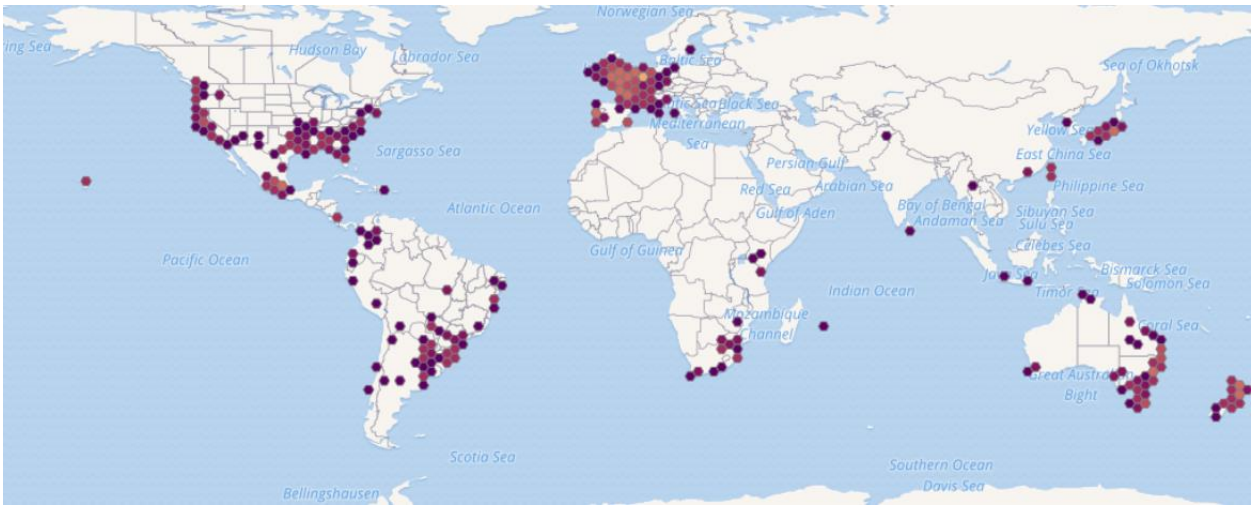

Figure 1. Known global distribution of *Myriophyllum aquaticum*. Map from GBIF Secretariat (2018).

5 Distribution Within the United States

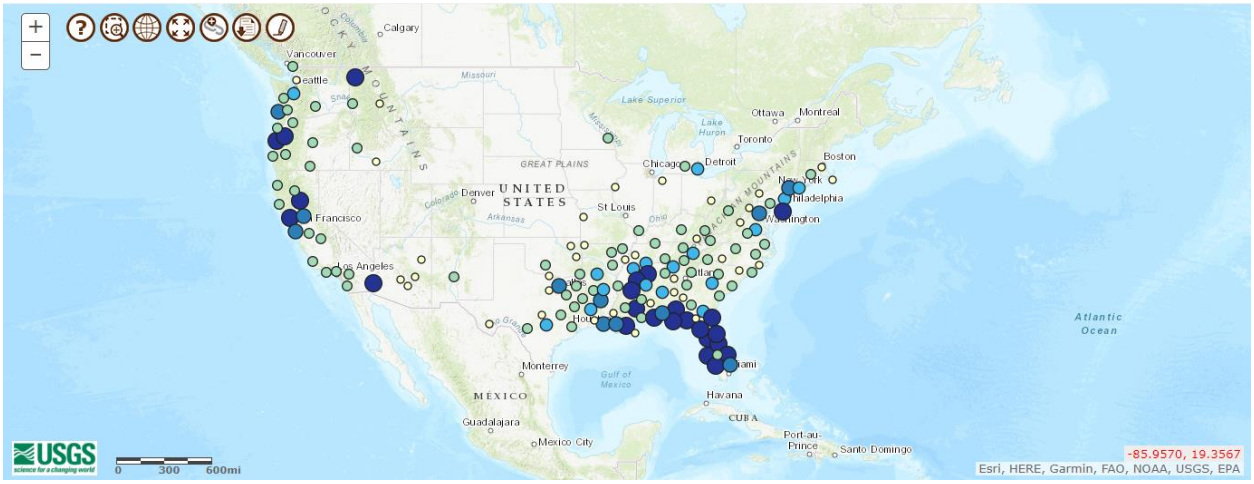

Figure 2. Known distribution of *Myriophyllum aquaticum* in the contiguous United States. Map from Wersal et al. (2018b).

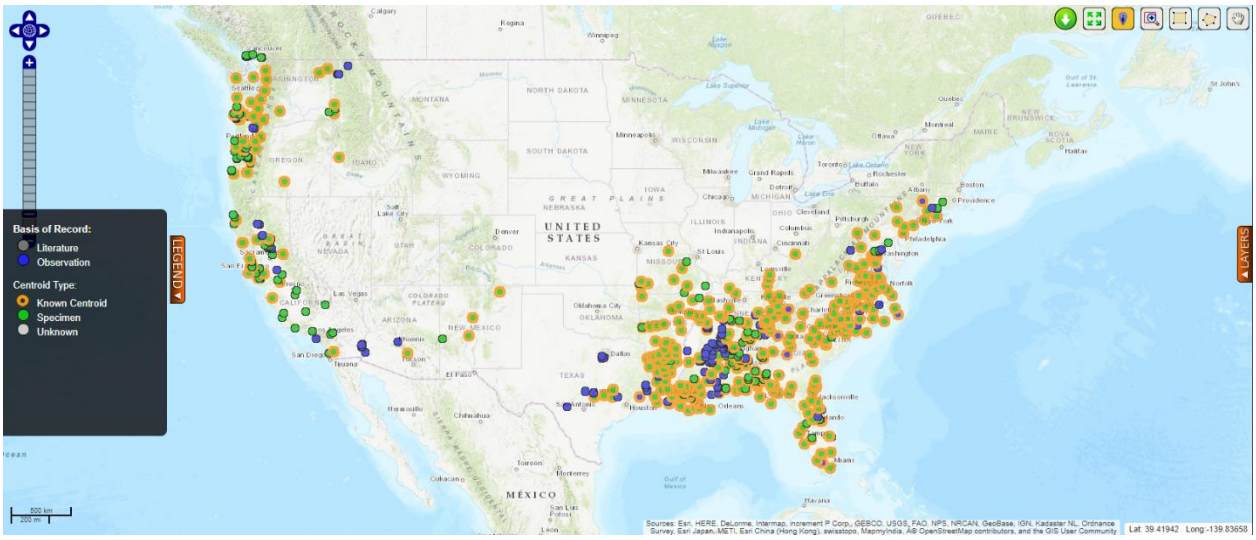

Figure 3. Additional known distribution of *Myriophyllum aquaticum* in the contiguous United States. Map from BISON (2018).

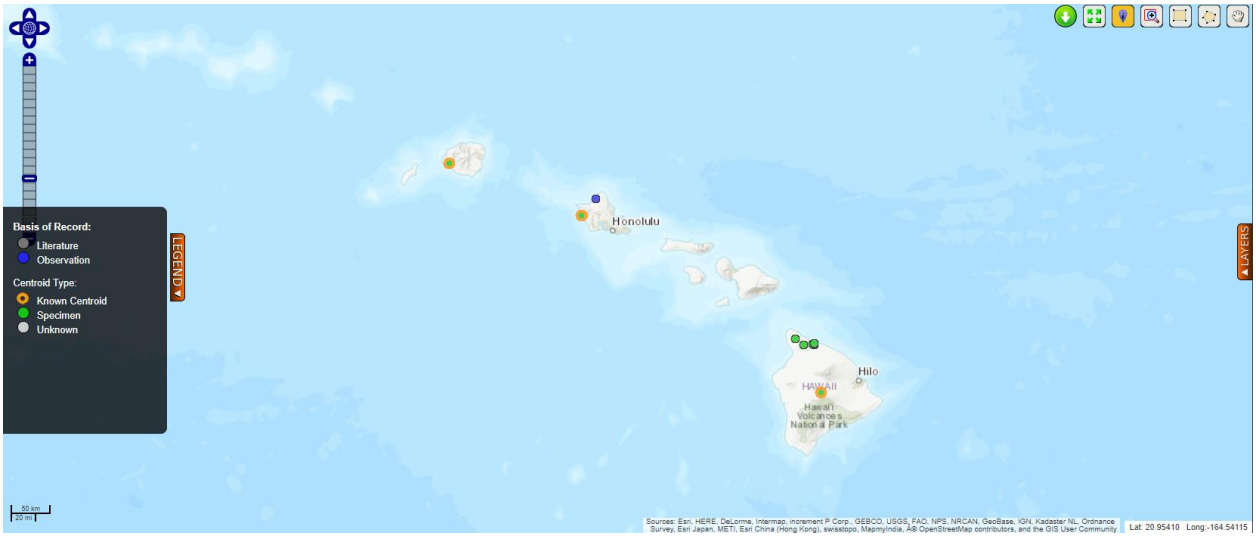

Figure 4. Known distribution of *Myriophyllum aquaticum* in Hawaii. Map from BISON (2018).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Myriophyllum aquaticum* was high for the vast majority of the contiguous United States. The far northern Plains States, northern Minnesota, and much of Maine had a medium match. There are already established populations of *M. aquaticum* in much of the United States. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous U.S. was 0.990, high. All states in the contiguous United States had high individual Climate 6 scores.

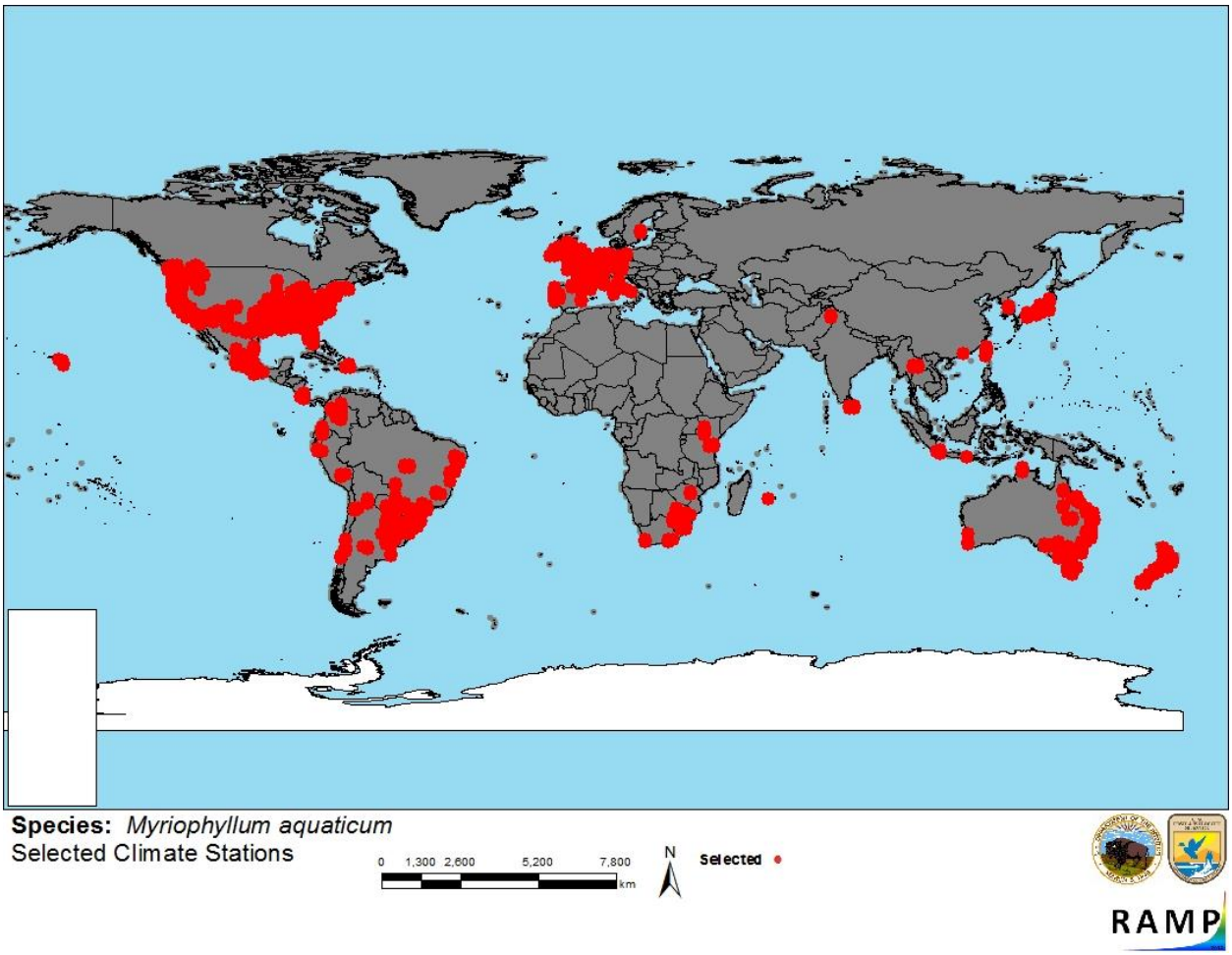

Figure 5. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Myriophyllum aquaticum* climate matching. Source locations from BISON (2018), GBIF Secretariat (2018), and Wersal et al. (2018b).

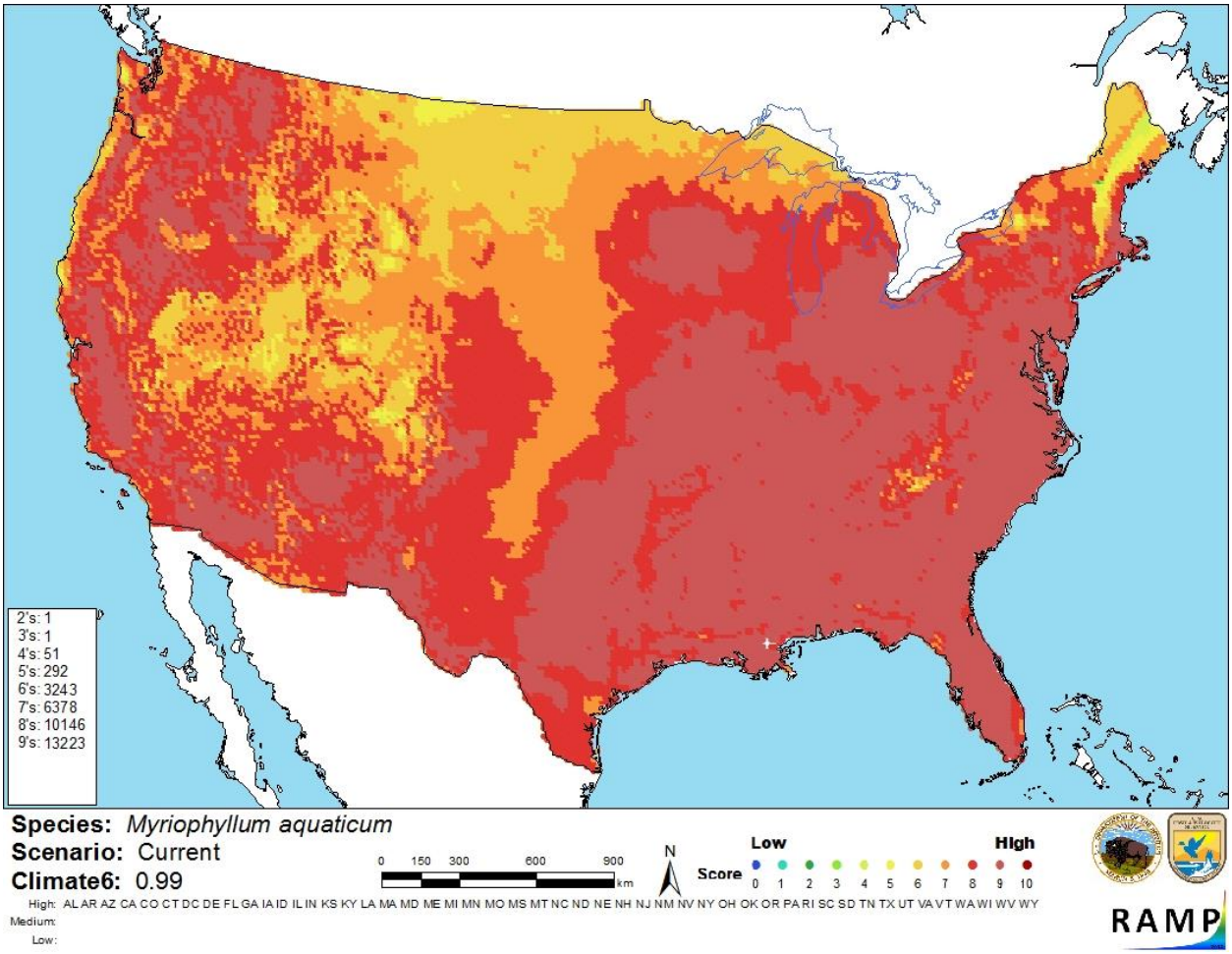

Figure 6. Map of RAMP (Sanders et al. 2014) climate matches for *Myriophyllum aquaticum* in the contiguous United States based on source locations reported by BISON (2018), GBIF Secretariat (2018), and Wersal et al. (2018b). 0 = Lowest match, 10 = Highest match.

The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

Certainty of this assessment is high. Information on the biology, invasion history and impacts of this species is available, with some peer-reviewed literature. There is enough information available to describe the risks posed by this species.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Parrotfeather (*Myriophyllum aquaticum*) is an aquatic plant native to parts of South America. The history of invasiveness is high. It has been introduced throughout much of the world, primarily via the aquatic plant trade. *M. aquaticum* is transported by water currents, boats, and waterfowl (which feed on it) and is capable of surviving up to a year when kept moist and cool. It can withstand eutrophic conditions, desiccation, moderate salinity, and mechanical cutting. Reproduction in the United States is believed to be primarily, if not exclusively, vegetative. The species can outcompete native plants, reduce biodiversity, alter macroinvertebrate communities, clog waterways used for navigation and irrigation, and provide increased breeding habitat for mosquitoes. It is listed as prohibited or a noxious weed, or regulated in at least 13 states. It is included on the national list of plants banned from sale and distribution under the Biosecurity Act. Climate matching indicated the contiguous United States has a high climate match. There are already established *M. aquaticum* populations in much of the United States but not everywhere the climate match indicated there was suitable climate. The certainty of the assessment is high. The overall risk assessment category is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information:** There are already established populations along both coasts and in the south of the contiguous United States.
- **Overall Risk Assessment Category: High**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

BISON. 2018. Biodiversity Information Serving Our Nation (BISON). U.S. Geological Survey. Available: https://bison.usgs.gov. (April 2018).

CABI. 2018. *Myriophyllum aquaticum* (parrot's feather) [original text by K. Murphy]. *In* Invasive Species Compendium. CAB International, Wallingford, U.K. Available: http://www.cabi.org/isc/datasheet/34939. (April 2018).

DAISIE European Invasive Alien Species Gateway. 2018. *Myriophyllum aquaticum*. Available: http://www.europe-aliens.org/speciesFactsheet.do?speciesId=9151. (April 2018).

GBIF Secretariat. 2018. GBIF backbone taxonomy: *Myriophyllum aquaticum* Verdc. Global Biodiversity Information Facility, Copenhagen. Available: http://www.gbif.org/species/5361785. (April 2018).

GISD (Global Invasive Species Database). 2018. Species profile: *Myriophyllum aquaticum*. Invasive Species Specialist Group, Gland, Switzerland. Available: http://www.iucngisd.org/gisd/speciesname/Channa+argus. (April 2018).

ITIS (Integrated Taxonomic Information System). 2018. *Myriophyllum aquaticum* (Vell.) Verdc. Integrated Taxonomic Information System, Reston, Virginia. Available: http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=503904. (April 2018).

NIES (National Institute for Environmental Studies). 2018. *Myriophyllum aquaticum*. *In* Invasive species of Japan. National Research and Development Agency, National Institute for Environmental Studies, Tsukuba, Japan. Available: http://www.nies.go.jp/biodiversity/invasive/DB/detail/80250e.html. (April 2018).

Sanders, S., C. Castiglione, and M. Hoff. 2014. Risk assessment mapping program: RAMP. U.S. Fish and Wildlife Service.

Stiers, I., N. Crohain, G. Josens, and L. Triest. 2011. Impact of three aquatic invasive species on native plants and macroinvertebrates in temperate ponds. Biological Invasions 13:2715–2726.

Swearingen, J., and C. Bargeron. 2016. Invasive Plant Atlas of the United States. University of Georgia Center for Invasive Species and Ecosystem Health. Available: http://www.invasiveplantatlas.org/. (April 2018).

USDA, NRCS. 2018. *Myriophyllum aquaticum* (Vell.) Verdc. The PLANTS database. National Plant Data Team, Greensboro, North Carolina. Available: https://plants.usda.gov/core/profile?symbol=MYAQ2. (April 2018).

Wersal, R. M., E. Baker, J. Larson, K. Dettloff, and A. J. Fusaro. 2018a. *Myriophyllum aquaticum* (Vell.) Verdc. U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, Florida, and NOAA Great Lakes Aquatic Nonindigenous Species Information System, Ann Arbor, Michigan. Available: https://nas.er.usgs.gov/queries/greatLakes/FactSheet.aspx?SpeciesID=14&Potential=Y&Type=2&HUCNumber=DGreatLakes. (April 2018).

Wersal, R. M., E. Baker, J. Larson, K. Dettloff, A. J. Fusaro, D. D. Thayer, and I. A. Pfingsten. 2018b. *Myriophyllum aquaticum* (Vell.) Verdc. U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, Florida. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=235. (April 2018).

10 References Quoted But Not Accessed

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

Aiken, S. G. 1981. A conspectus of *Myriophyllum* (Haloragaceae) in North America. Brittonia 33:57–69.

Allison. 2003. [Source material did not give full citation for this reference.]

Anderson, L. W. J. 1993. Aquatic weed problems and management in the western United States and Canada. Pages 371–391 *in* A. H. Pieterse, and K. J. Murphy, editors. Aquatic weeds, 2nd edition. Oxford Scientific Press, Oxford, UK.

Arocena, R., and N. Mazzeo. 1994. Aquatic macrophytes from an urban creek in Uruguay and their relationship with water quality. Revista de Biología Tropical 42(3):723–728.

Banfield, S. 2008. Aquatic vegetation management plan 2008-2012: Meserve Lake, Steuben County. [Source material did not give full citation for this reference.]

Bank-Signon, I., and E. Patzke. 1988. *Myriophyllum aquat*icum (Velloso) Verdcourt in the "Blue Lake" (TK 5204/4) at Langenbroich, Rhineland. Decheniana 141:108–109.

Barko, J. W., and R. M. Smart. 1981. Sediment-based nutrition of submersed macrophytes. Aquatic Botany 10(4):339–352.

Bernhardt, E. A., and J. M. Duniway. 1984. Endemic diseases of aquatic weeds in California. Phytopathology 72:986.

Bini, L. M., S. M. Thomaz, K. J. Murphy, and A. F. M. Camargo. 1999. Aquatic macrophyte distribution in relation to water and sediment conditions in the Itaipu Reservoir, Brazil. Hydrobiologia 415:147–154.

Biosecurity Act. 1993. [Source material did not give full citation for this reference.]

Cardwell, A. J., D. W. Hawker, and M. Greenway. 2002. Metal accumulation in aquatic macrophytes from southeast Queensland, Australia. Chemosphere 48:653–663.

Catarino, L., I. Moreira, T. Ferreira, and M. C. Duarte. 2001. Plantas aquaticas: infestantes de valas e canais. ISA Press, Instituto Superior De Agronomia, Lisboa, Portugal.

Center for Aquatic and Invasive Plants, UF/IFAS. 2010. *Myriophyllum aquaticum*. Available: http://plants.ifas.ufl.edu/plant-directory/myriophyllum-aquaticum/.

Champion, P. D., and J. S. Clayton. 2003. The evaluation and management of aquatic weeds in New Zealand. Pages 429–434 *in* L. Child, J. H. Brock, G. Brundu, K. Prach, K. Pysek, P. M. Wade, and M. Williamson, editors. Plant invasions: ecological threats and management solutions. Backhuys Publishers, Leiden, Netherlands.

Chikwenhere, G. P. 1994. Biological control of water lettuce in various impoundments of Zimbabwe. Journal of Aquatic Plant Management 32:27–29.

Chikwenhere, G. P. 2001. Current strategies for the management of water hyacinth on the Manyame River System in Zimbabwe. Pages 105–108 *in* Biological and integrated control of water hyacinth: *Eichhornia crassipes*. Proceedings of the Second Meeting of the Global Working Group for the Biological and Integrated Control of Water Hyacinth, Beijing, China, 2000.

Child, S. 1992. Judiciary action for the control of aquatic weeds in Botswana. Southern African Regional Commission for the Conservation and Utilization of the Soil. 17th Regular Meeting of the Sub-Committee for Aquatic Weeds. Dept. Of Water Affairs, Botswana, Pretoria, South Africa.

Cilliers, C. J. 1999. *Lysathia* n.sp. (Coleoptera: Chrysomelidae), a host-specific beetle for control of the aquatic weed *Myriohphyllum aquaticum* (Haloragaceae) in South Africa. Hydrobiologia 415:271–276.

Claps, M. C. 1991. Phytomicrofauna of pampasic lotic environments (Argentina). Hydrobiologia 220:137–145.

Clarke, S., and J. R. Newman. 2002. Assessment of alien invasive aquatic weeds in the UK. Pages 142–145 *in* H. S. Jacob, J. Dodd, and J. H. Moore, editors.13th Australian Weeds Conference: weeds "threats now and forever?", Perth, Western Australia. Plant Protection Society of Western Australia, Victoria Park, Australia.

Cook, C. D. K. 2004. Aquatic and wetland plants of Southern Africa. Backhuys Publishers, Leiden, The Netherlands.

Costa, J. C., J. Capelo, M. D. E. Santo, M. Lousã, A. Monteiro, S. Mesquita, M. T. Vasconcelos, and I. Moreira. 1999. Plant communities of the lagoons of the Portuguese Coastal Superdistrict - a multivariate approach. Hydrobiologia 415:67–75.

Couch and Nelson. 1985b. [Source material did not give full citation for this reference.]

Dandelot, S., R. Verlaque, A. Dutartre, and A. Cazaubon. 2005. Ecological, dynamic and taxonomic problems due to *Ludwigia* (Onagraceae) in France. Hydrobiologia 551:131–136

Dandelot, S., C. Robles, N. Pech, A. Cazaubon, and R. Verlaque. 2008. Allelopathic potential of two invasive alien *Ludwigia* spp. Aquatic Botany 88:311–316.

Davis. 1996. [Source material did not give full citation for this reference].

Dawson, F. H. 1993. Comparison of the rates of naturalisation of the invasive alien aquatics, *Crassula helmsii* and *Myriophyllum aquaticum*. BSBI News 63:47–48.

Dutartre, A. 2003. Recent evolutions of the aquatic plant communities of the lakes and ponds in the Landes (France). Pages 59–79 *in* Actes - European Symposium - Management And Conservation of Lake Littoral Vegetation 2002, Le Bourget-Du-Lac, Savoie, France.

ECZ. 2004. Implementation of invasive plant prevention and control programmes in Zambia. Environmental Council of Zambia, Lusaka.

Fernández, O. A., D. L. Sutton, V. H. Lallana, M. R. Sabbatini, and J. H. Irigoyen. 1993. Aquatic weed problems and management in South and Central America. Pages 406–425 *in* A. H. Pieterse, and K. J. Murphy, editors. Aquatic weeds, 2nd edition. Oxford University Press, Oxford, U.K.

Ferreira and Moreira. 1994. [Source material did not give full citation for this reference.]

Foxcroft, L. C., and D. M. Richardson. 2003. Managing alien plant invasions in the Kruger National Park, South Africa. Pages 385–403 *in* L. Child, J. H. Brock, G. Brundu, K. Prach, K. Pysek, P. M. Wade, and M. Williamson. Plant invasions: ecological threats and management solutions. Backhuys Publishers, Leiden, Netherlands.

Gassmann, A., M. J. W. Cock, R. Shaw, and C. R. Evans. 2006. The potential for biological control of invasive alien aquatic weeds in Europe: a review. Hydrobiologia 570:217–222.

Great Lakes Panel on Aquatic Nuisance Species (GLPANS). 2008. Prohibited species in the Great Lakes Region. Report November 2008.

Gregory, P. 2003. Attack of the aliens (aquatic invasive plants, that is!). Watch out ... some plants are more than just another pretty face! Aquatic Gardener 16(4):29–34.

Grime, J. P. 1979. Plant strategies and vegetation processes. John Wiley, Chichester, UK.

Haller, W. T., D. L. Sutton, and W. C. Barlow. 1974. Effects of salinity on growth of several aquatic macrophytes. Ecology 55:891–894.

Henderson, L., and C. J. Cilliers. 2002. Invasive aquatic plants. Plant Protection Research Institute, Handbook 16, Pretoria, South Africa.

Hussner, A. 2009. Growth and photosynthesis of four invasive aquatic plant species in Europe. Weed Research 49:506–515.

Hussner, A., C. Meyer, and J. Busch. 2009. The influence of water level and nutrient availability on growth and root system development of *Myriophyllum aquaticum*. Weed Research 49:73–80.

IISG. 2008. [Source material did not give full citation for this reference.]

IISG (Illinois-Indiana Sea Grant). 2011. Sea Grant database of aquatic species regulations. Available: http://www.iiseagrant.org/speciesregs/index1.asp?commonName=parrot%27s+feather. (October 2011).

Jacot-Guillarmod. 1979. [Source material did not give full citation for this reference.]

Joyner, B. G., and T. E. Freeman. 1973. Pathogenicity of *Rhizoctonia solani* to aquatic plants. Phytopathology 63:681–685.

Kay, S. H., and S. T. Hoyle. 2001. Mail order, the Internet, and invasive aquatic weeds. Journal of Aquatic Plant Management 39:88–91.

Kissman, K. G., and D. Groth. 1995. Plantas Infestantes e Nocivas: Tomo III. BASF S.A., Sao Paulo, Brazil.

Leon, B., K. R. Young, and A. Cano. 1998. Uso actual de la flora y vegetacion en los humedales de la Costa Central del Peru. Pages 191–204 *in* A. Cano, and K. R. Young, editors. Los Pantanos de Villa, Biologia y Conservacion. Museo de Historia Natural, UNMSM, Serie De Divulgacion 11, Lima, Peru. (In Spanish.)

Les. 2002. [Source material did not give full citation for this reference.]

Les, D. H., and L. J. Mehrhoff. 1999. Introduction of nonindigenous aquatic vascular plants in southern New England: a historical perspective. Biological Invasions 1(2):281–300.

Mabulu, L. Y. 2005. *Myriophyllum aquaticum* (aquatic plant). Global Invasive Species Database. Available: http://www.issg.org/database/species/ecology.asp?si=401&fr=1&sts=sss&lang=EN.

Maine, M. A., M. C. Panigatti, and M. J. Pizzaro. 1998. Role of macrophytes in phosphorus removal in Parana Medio wetlands. Polish Archives of Hydrobiology 45(1):23–24.

Maltchik, L., G. R. de Oliveira, A. S. Rolon, and C. Stenert. 2005. Diversity and stability of aquatic macrophyte community in three shallow lakes associated to a floodplain system in the South of Brazil. Interciencia 30(3):166–170.

Medina, V. F., S. L. Larson, A. E. Bergstedt, and S. C. McCutcheon. 2000. Phyto-removal of trinitrotoluene from water with batch kinetic studies. Water Resources 34(10): 2713–2722.

Mereles, F., and R. Degen. 1993. Page on Haloragaceae. *In* Flora del Paraguay, 19. Conservatoire Jardin Botaniques, Ville De Geneve, Missouri Botanical Garden.

Mitchell. 1995. [Source material did not give full citation for this reference.]

Moreira, I., T. Ferreira, A. Monteiro, L. Catarino, and T. Vasconcelos. 1999. Aquatic weeds and their management in Portugal: insights and the international context. Hydrobiologia 415:229–234.

Moreira, I., A. Monteira, and T. Ferreira. 1999. Biology and control of parrotfeather (*Myriophyllum aquaticum*) in Portugal. Ecology, Environment and Conservation 5:171–179.

Muenscher, W. G. 1944. Aquatic plants of the United States. Comstock Publishing, Ithaca, New York.

Muranaka, T., J. Ishii, S. Miyawaki, and I. Washitani. 2005. Vascular plants to be designated as Invasive Alien Species according to the Invasive Alien Species Act of Japan. Japanese Journal of Conservation Ecology 10(1):19–33.

Murphy, K. J. 1995. Aquatic weeds. Pages 71–80 *in* W. A. Nierenberg, editor. Encyclopedia of environmental biology, volume 1. Academic Press, San Diego, California.

Murphy, K. J., G. Dickinson, S. M. Thomaz, L. M. Bini, K. Dick, K. Greaves, M. P. Kennedy, S. Livingstone, H. McFerran, J. M. Milne, J. Oldroyd, and R. A. Wingfield. 2003. Aquatic plant communities and predictors of diversity in a sub-tropical river floodplain: the upper Rio Paraná, Brazil. Aquatic Botany 77(4):257–276.

Muyt, A. 2001. Bush invaders of South-East Australia: a guide to the identification and control of environmental weeds found in South-East Australia. R. G. and F. J. Richardson, Meredith, Australia.

Nel, J. L., D. M. Richardson, M. Rouget, T. N. Mgidi, N. Mdzeke, D. C. le Maitre, B. W. van Wilgen, L. Schonegevel, L. Henderson, and S. Neser. 2004. A proposed classification of invasive alien plant species in South Africa: towards prioritizing species and areas for management action. South African Journal of Science 100(1/2):53–64.

Nelson, E. N., and R. W. Couch. 1985. History of the introduction and distribution of *Myriophyllum aquaticum* in North America. Proceeding, 1st International Symposium on watermilfoil (*Myriophyllum spicatum*) and Related Haloragaceae Species. Vancouver.

Nunez, C. O., J. J. Cantero, and L. Petryna. 1998. Hydrophytes from the south of the Province of Cordoba. Rev. Universidad Nacional de Rio Cuarto 18(1):37–82.

Nwoko, C. O. 2010. Trends in phytoremediation of toxic elemental and organic pollutants. African Journal of Biotechnology 9(37):6010–6016.

Ogden, J. 1974. The reproductive strategy of higher plants. II. The reproductive strategy of *Tussilago farfara* L. Journal of Ecology 62:291324.

Orchard, A. E. 1981. A revision of South American *Myriophyllum* (Haloragaceae), and its repercussions on some Australian and North American species. Brunonia 4:27–65.

Orr, B. K., and V. H. Resh. 1989. Experimental test of the influence of aquatic macrophyte cover on the survival of *Anopheles* larvae. Journal of the American Mosquito Control Association 5:579–585.

Peltre, M. C., A. Dutartre, J. Barbe, J. Haury, S. Muller, and M. Ollivier. 2002. Aquatic plant proliferations in France: biological and ecological features of the main species and favourable environments. ii. Impact on ecosystems and interest for plant management. Bull. Fr. Peche. Piscic, 365/366:259–280.

Peltre, M. C., and S. Muller. 2002. Distribution of spreading aquatic plants on the French hydrographic system in 2000. Pages 427–430 *in* A. Dutartre, and M. H. Montel, editors. Proceedings 11th European Weed Research Society International Symposium on Aquatic Weeds, Moliets et Maa, France.

Pitelli, R. A., G. F. Nachtigal, A. M. Pereira, and R. Borsari. 2000. Macrophytes population changes in Santana Reservoir, Rio de Janeiro, Brazil: five years of history. Aquatic Plant Management Society, Fortieth Annual Meeting, San Diego, California.

Pot, R. 2002. Invasion and management of Floating Pennywort (*Hydrocotyle ranunculoides* L.f.) and some other alien species in the Netherlands. *In* Proceedings 11th European Weed Research Society International Symposium on Aquatic Weeds, Moliets et Maa, France.

Ramoeli, P. S. 1995. Lesotho - country's progress report. *In* 20th Meeting SARCCUS Subcommittee for Aquatic Weeds, Lesotho. Ministry of Agriculture, Water and Rural Development, Department Water Affairs, Namibia.

Randall, R. P. 2002. A global compendium of weeds. [Source material did not give full citation for this reference.]

Rebillard, J. P., A. Dutartre, A. Fare, and J. M. Ferroni. 2002. Management of the development of aquatic plants in the Adour-Garonne River Basin (South-West of France). Pages 307–310 *in* A. Dutartre, and M. H. Montel, editors. Proceedings 11th European Weed Research Society International Symposium on Aquatic Weeds, Moliets et Maa, France.

Rejmánková, E. 1992. Ecology of creeping macrophytes with special reference to *Ludwigia peploides* (H. B. K.) Raven. Aquatic Botany 43(3):283–299.

Revilla, E. P., S. S. Sastroutomo, and M. A. A. Rahim. 1991. Survey on aquarium plants of quarantine importance and their associated nematodes. BIOTROP Special Publication 40:205–215.

Ritter, N. P., and G. E. Crow. 1999. First record of *Myriophyllum aquaticum* (Haloragaceae) in Bolivia. Ecología en Bolivia 32:37–39.

Rixon, C. A. M., I. C. Duggan, N. M. N. Bergeron, A. Ricciardi, and H. J. MacIsaac. 2005. Invasion risks posed by the aquarium trade and live fish markets on the Laurentian Great Lakes. Biodiversity and Conservation 14:1365–1381.

Robinson. 2003. [Source material did not give full citation for this reference.]

Roy, B., I. Popay, P. Champion, T. James, and A. Rahman. 2004. An illustrated guide to common weeds of New Zealand, 2nd edition. New Zealand Plant Protection Society, Rotorua, New Zealand.

Sabbatini, M. R., K. J. Murphy, and J. H. Irigoyen. 1998. Vegetation-environment relationships in irrigation channel systems of southern Argentina. Aquatic Botany 60:119–133.

Schessl, M. 1999. Floristic composition and structure of floodplain vegetation in the northern Pantanal of Mato Grosso, Brazil. Phyton (Horn) 39(2):303–336.

Schmidt-Mumm, U., and J. A. Posada. 2000. Adiciones a las Haloragaceae de Colombia: Proserpinaca Palustris. Caldasia 22(1):146–149.

Sheppard, A. W., R. H. Shaw, and R. Sforza. 2006. Top 20 environmental weeds for classical biological control in Europe: a review of opportunities, regulations and other barriers to adoption. Weed Research 46:93–117.

Sidorkewicj, N. S., M. R. Sabbatini, and J. H. Irigoyen. 2000. The spread of *Myriophyllum elatinoides* Gaudich. and *M. aquaticum* (Vell.) Verd. from stem fragments. Pages 224–225 *in* A. Legere, editor. Abstracts, 3rd International Weed Science Congress, Foz Do Iguassu, Brazil.

Springuel and Murphy. 1991. [Source material did not give full citation for this reference.]

Steubing, L., C. Ramirez, and M. Alberdi. 1980. Energy content of water and bog plant associations in the region of Valdivia (Chile). Vegetatio 43:153–161.

Sutton, D. L. 1985. Biology and ecology of *Myriophyllum aquaticum*. Proceeding, 1st International Symposium on watermilfoil (*Myriophyllum spicatum*) and Related Haloragaceae Species. Vancouver.

Sytsma, M. D., and L. W. J. Anderson. 1993. Biomass, nitrogen, and phosphorus allocation in parrotfeather (*Myriophyllum aquaticum*). Journal of Aquatic Plant Management 31:244–248.

Tabacchi, E., and A. M. Planty-Tabacchi. 2002. Changes in alien and native weedy vegetation along rivers: what's new? Pages 439–442 *in* A. Dutartre, and M. H. Montel, editors. Proceedings 11th European Weed Research Society International Symposium on Aquatic Weeds, Moliets et Maa, France.

Tanner, C. C. 2000. Plant establishment and management in constructed wastewater treatment wetlands. Water & Wastes in New Zealand 115:28–33.

Teles, A. N., and A. R. Pinto da Silva. 1975. A "pinheirinha" (*Myriophyllum aquaticum* (Vell.) Verde, uma agressiva infestante aquática. Agronomia lusitania 36:307–323.

Thiébaut, G. 2007. Invasion success of non-indigenous aquatic and semi-aquatic plants in their native and introduced ranges. A comparison between their invasiveness in North America and France. Biological Invasions 9:1–12.

Van der Velde, G., I. Nagelkerken, S. Rajagopal, and A. bij de Vaate. 2002. Invasions by alien species in inland freshwater bodies in western Europe: the Rhine delta. Pages 360–372 *in* E. Leppäkoski, S. Gollasch, and S. Olenin, editors. Invasive aquatic species of Europe - distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, Netherlands.

Van Landuyt, W., L. Vanhecke, and I. Hoste. 2006. Rode Lijst van de vaatplanten van Vlaanderen en het Brussels Hoofdstedelijk Gewest. *In* W. Van Landuyt, editor. Atlas van de Flora van Vlaanderen en het Brussels Gewest. Instituut voor Natuur- en Bosonderzoek en Nationale Plantentuin van België, Brussel

Washington State Department of Ecology. 2011. Non-native invasive freshwater plants: parrotfeather (*Myriophyllum aquaticum*), technical information. Washington State Department of Ecology, Olympia.

Wersal. 2011. [Source material did not give full citation for this reference.]

Wersal, R. M., B. R. McMillan, and J. D. Madsen. 2005. Food habits of dabbling ducks during fall migration in a prairie pothole system, Heron Lake, Minnesota. Canadian Field Naturalist 119:546–550.

WIDNR (Wisconsin Department of Natural Resources). 2011. Aquatic invasive species literature review. Available: http://dnr.wi.gov/invasives/classification/pdfs/Myriophyllum%20aquaticum.pdf. (October 2011).