Weed Risk Assessment for *Lagarosiphon major* (Ridley) Moss Authority (Hydrocharitaceae) – African oxygen weed

Michigan Department of Agriculture and Rural Development

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Version 1

Left: Underwater foliage and growth form (source: Rohan Wells, National Institute of Water and Atmospheric Research, Bugwood.org). Right: Naturally curved stems and spirally arranged leaves (source: Robert Vidéki, Doronicum Kft., Bugwood.org).

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Introduction The Michigan Department of Agriculture and Rural Development (MDARD) regulates aquatic species through a Prohibited and Restricted species list, under the authority of Michigan's Natural Resources and Environmental Protection Act (NREPA), Act 451 of 1994, Part 413 (MCL 324.41301-41305). Prohibited species are defined as species which "(i) are not native or are genetically engineered, (ii) are not naturalized in this state or, if naturalized, are not widely distributed, and further, fulfill at least one of two requirements: (A) The organism has the potential to harm human health or to severely harm natural, agricultural, or silvicultural resources and (B) Effective management or control techniques for the organism are not available." Restricted species are defined as species which "(i) are not native, and (ii) are naturalized in this state, and one or more of the following apply: (A) The organism has the potential to harm human health or to harm natural, agricultural, or silvicultural resources. (B) Effective management or control techniques for the organism are available." Per a recently signed amendment to NREPA (MCL 324.41302), MDARD will be conducting reviews of all species on the lists to ensure that the lists are as accurate as possible.

We use the United States Department of Agriculture's, Plant Protection and Quarantine (PPQ) Weed Risk Assessment (WRA) process (PPQ, 2015) to evaluate the risk potential of plants. The PPQ WRA process includes three analytical components that together describe the risk profile of a plant species (risk potential, uncertainty, and geographic potential; PPQ, 2015). At the core of the process is the predictive risk model that evaluates the baseline invasive/weed potential of a plant species using information related to its ability to establish, spread, and cause harm in natural, anthropogenic, and production systems (Koop et al., 2012). Because the predictive model is geographically and climatically neutral, it can be used to evaluate the risk of any plant species for the entire United States or for any area within it. We then use a stochastic simulation to evaluate how much the uncertainty associated with the risk analysis affects the outcomes from the predictive model. The simulation essentially evaluates what other risk scores might result if any answers in the predictive model might change. Finally, we use Geographic Information System (GIS) overlays to evaluate those areas of the United States that may be suitable for the establishment of the species. For a detailed description of the PPQ WRA process, please refer to the *PPQ Weed Risk Assessment Guidelines* (PPQ, 2015), which is available upon request.

We emphasize that our WRA process is designed to estimate the baseline—or unmitigated—risk associated with a plant species. We use evidence from anywhere in the world and in any type of system (production, anthropogenic, or natural) for the assessment, which makes our process a very broad evaluation. This is appropriate for the types of actions considered by our agency (e.g., State regulation). Furthermore, risk assessment and risk management are distinctly different phases of pest risk analysis (e.g., IPPC, 2015). Although we may use evidence about existing or proposed control programs in the assessment, the ease or difficulty of control has no bearing on the risk potential for a species. That information could be considered during the risk management (decision making) process, which is not addressed in this document.

Lagarosiphon major (Ridley) Moss – African oxygen weed

Species Information

Family: Hydrocharitaceae (Timmins & Mackenzie, 1995).

Synonyms: *Elodea crispus* (Parsons & Cuthbertson, 2001), *Lagarosiphon muscoides* (Matthews et al., 2012). These synonyms are no longer in use and were not utilized for the literature search.

Common names: Lagarosiphon (Timmins & Mackenzie, 1995); coarse oxygen weed (Csurhes & Edwards, 1998); curly waterweed (Matthews et al., 2012).

Botanical description: *Lagarosiphon major* is a rhizomatous, perennial, submerged aquatic plant that inhabits freshwater water bodies with low turbidity (Csurhes & Edwards, 1998). Stems may grow up to 5 meters in length, and are anchored at the bottom by roots from the nodes. The leaves are arranged spirally along the stem (Csurhes & Edwards, 1998). For a full botanical description, see Australia Department of the Environment (2015).

Initiation: In accordance with the Natural Resources and Environmental Protection Act Part 413, the Michigan Department of Agriculture and Rural Development was tasked with evaluating the aquatic species currently on Michigan's Prohibited and Restricted Species List (MCL 324.41302). USDA Plant Epidemiology and Risk Analysis Laboratory's (PERAL) Weed Team worked with MDARD to evaluate and review this species.

Foreign distribution: *Lagarosiphon major* is native to southern Africa (Parsons & Cuthbertson, 2001; Reynolds, 2002; Csurhes & Edwards, 1998). It is naturalized in much of Europe (de Winton et al., 2009; GBIF, 2015), including England, northern France, and Italy (Parsons & Cuthbertson, 2001), as well as New Zealand (de Winton et al., 2009; GBIF, 2015) This species is present in Australia thought not yet naturalized (McGregor & Gourley, 2002; Bowmer et al., 1995). *Lagarosiphon major* is cultivated for nursery sale in Europe, and is a common aquarium plant (Brunel, 2009).

U.S. distribution and status: *Lagarosiphon major* is regulated as a federal noxious weed (APHIS, 2015b), and is also regulated on a state-wide level in Illinois, Indiana, Michigan, Oklahoma, Texas, Washington, and Wisconsin (National Plant Board, 2015). This species is not known to be present in the United States (GBIF, 2015; NGRP, 2015; BONAP, 2015).

WRA area[1]: Entire United States, including territories.

1. *Lagarosiphon major* analysis

Establishment/Spread Potential *Lagarosiphon major* is an aquatic macrophyte (Timmins & Mackenzie, 1995; MPI, 2012) that forms dense mats as the species branches repeatedly at the surface of the water (Parsons & Cuthbertson, 2001; Matthews et al., 2012). *Lagarosiphon major* grows year-round in warmer climates and overwinters in colder climates (Matthews et al., 2012). It is able to produce new individuals almost immediately after maturing (Timmins & Mackenzie, 1995), as stem nodes readily fragment (Parsons & Cuthbertson, 2001) and fragments begin shoot development within a week after settling in the bottom mud (Rattray et al., 1994; Parsons & Cuthbertson, 2001). This species is tolerant of mutilation and benefits from it, as fragments can reroot and establish new plants (Parsons & Cuthbertson, 2001). These fragments may be carried on fishing nets (de Winton et al., 2009), boats and trailers, vehicles crossing fords, weed harvesters, and other maintenance equipment (Matthews et al., 2012). We had a high amount of uncertainty here in this risk element.

Risk score = 13 Uncertainty index = 0.23

Impact Potential *Lagarosiphon major* alters nutrient regimes within ecosystems, increasing phosphorus and nitrogen (Schwarz & Howard-Williams, 1993), and decreasing oxygen along a gradient (Matthews et al., 2012; Schwarz & Howard-Williams, 1993). The exclusion of light by the dense growth of this species prevents 99% of light from passing through the first 0.5 m of the water column (Csurhes & Edwards, 1998; Matthews et al., 2012). *Lagarosiphon major* alters habitat conditions where it is introduced (Caffrey et al., 2011) and the introduction of this species to areas without native canopy-forming submerged macrophytes has added this vegetative layer to natural areas (Lambertini et al., 2010; Rattray et al., 1994). Dense growth of this species blocks hydro-electric lake system (artificial lakes for hydro-electric power generation) and has been known to shut down hydroelectric facilities (Parsons & Cuthbertson, 2001; Bickel & Closs, 2008). This species is viewed as a major pest in recreational areas by residents (Huffadine, 2015). We had a low amount of uncertainty for this risk element.

Risk score = 3.2 Uncertainty index = 0.13

Geographic Potential Based on three climatic variables, we estimate that about 56 percent of the United States is suitable for the establishment of *Lagarosiphon major* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of

[1] "WRA area" is the area in relation to which the weed risk assessment is conducted [definition modified from that for "PRA area"] (IPPC, 2012).

occurrence. The map for *Lagarosiphon major* represents the joint distribution of Plant Hardiness Zones 5-13, areas with 0-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: steppe, Mediterranean, humid subtropical, marine west coast, humid continental cool summers, humid continental warm summers, subarctic, and tundra.

The area of the United States shown to be climatically suitable (Fig. 1) is likely overestimated since our analysis considered only three climatic variables. Other environmental variables, such as soil and habitat type, may further limit the areas in which this species is likely to establish. *Lagarosiphon major* displays a wide tolerance to different habitats and grows best in clear, still water. It is tolerant of low nutrient conditions, but grows best in hard water with a good nutrient supply (Matthews et al., 2012).

Entry Potential *Lagarosiphon major* has not yet been introduced to the United States (GBIF, 2015; NGRP, 2015; BONAP, 2015) and as a federal noxious weed, may not be brought into the United States (APHIS, 2015b). However, we identified several pathways by which it may enter the United States. *Lagarosiphon major* is commonly traded as an aquarium/landscaping plant in Europe (Brunel, 2009) and may potentially be introduced through the internet trade, even though it is prohibited from entry. Also, aquatic plants are often contaminants of one another within this trade (Maki & Galatowitsch, 2004; Kay & Hoyle, 2001). This species is also commonly moved as a contaminant of of boats, trailers, and fishing equipment (de Winton et al., 2009; Matthews et al., 2012).
Risk score = 0.52 Uncertainty index = 0.13

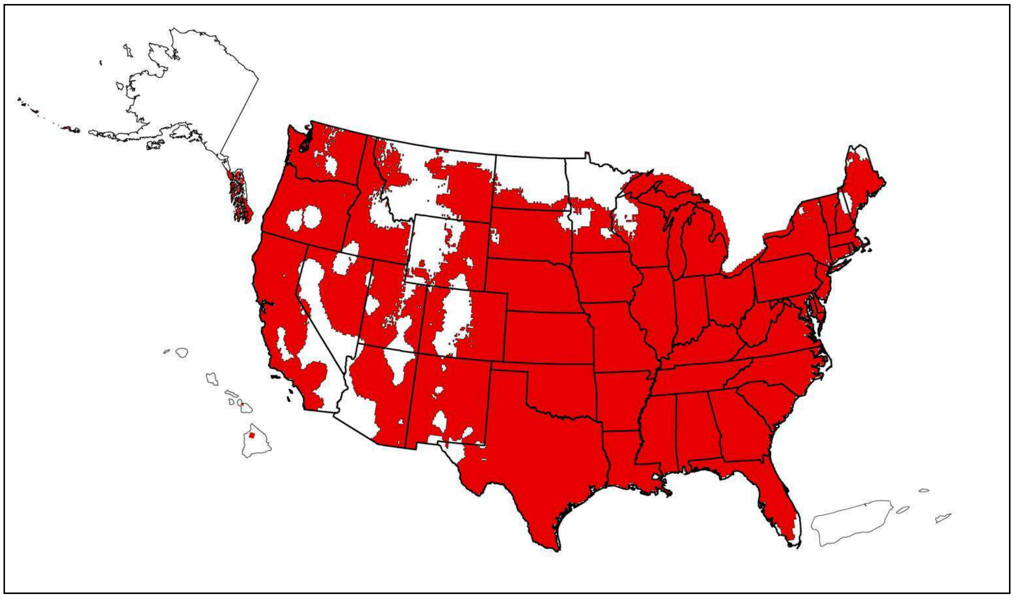

Figure 1. Predicted distribution of *Lagarosiphon major* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.

<u>2. Results</u>

Model Probabilities: P(Major Invader) = 73.8%
P(Minor Invader) = 25.2%
P(Non-Invader) = 0.11%

Risk Result = High Risk

Secondary Screening = Not applicable

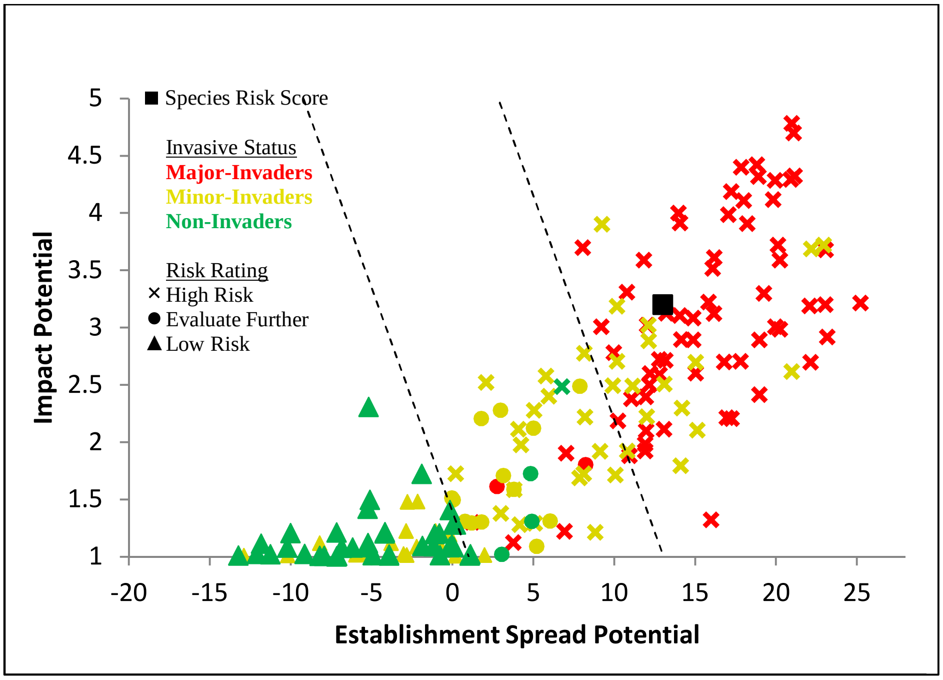

Figure 2. *Lagarosiphon major* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

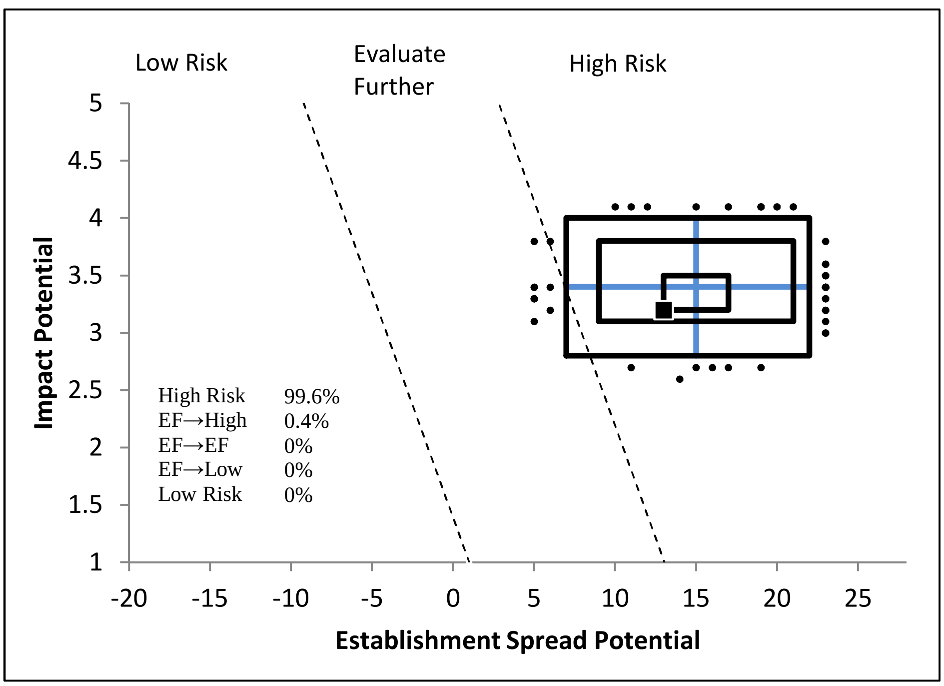

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *Lagarosiphon major*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Lagarosiphon major* is High Risk (Figure 2). *Langarosiphon major* shares traits in common with other major invaders (Fig. 2) used to develop and validate the PPQ WRA model. Our uncertainty analysis shows that 99.8% of the simulated outcomes also resulted in a rating of High Risk, indicating that our conclusion is robust (Figure 3). Once this species becomes established, control of the species is extremely difficult (Csurhes & Edwards, 1998) and complete eradication would be nearly impossible, as the herbicides that can effectively control *L. major* have serious environmental side effects (Australia Department of the Environment, 2012). In the United Kingdom, estimated yearly economic cost of *L. major* is £1,173,214 (approximately $1,640,131), and controlling *L. major* costs approximately £1,000 (approximately $1,118) per hectare (Matthews et al., 2012). There are currently no known biocontrol measures for this species (McGregor & Gourley, 2002). This species is controlled by national and local government groups (Caffrey et al., 2011; Clayton, 2006) but also citizen groups that are concerned about its impacts. For example, some resisdents living on Lake Dunstan New Zealand have come together to control *L. major* in recreational areas (Huffadine, 2015).

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Appendix A. Weed risk assessment for *Lagarosiphon major* (Ridley) Moss (Hydrocharitaceae). Below is all of the evidence and associated references used to evaluate the risk potential of this taxon. We also include the answer, uncertainty rating, and score for each question. The Excel file, where this assessment was conducted, is available upon request.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 [What is the taxon's establishment and spread status outside its native range? (a) Introduced elsewhere =>75 years ago but not escaped; (b) Introduced <75 years ago but not escaped; (c) Never moved beyond its native range; (d) Escaped/Casual; (e) Naturalized; (f) Invasive; (?) Unknown]	f - negl	5	*Lagarosiphon major* is a native of southern Africa (Parsons & Cuthbertson, 2001; Reynolds, 2002; Csurhes & Edwards, 1998). It is naturalized in much of Europe (Parsons & Cuthbertson, 2001; de Winton et al., 2009) and New Zealand (de Winton et al., 2009), but not yet in Australia (McGregor & Gourley, 2002; Bowmer et al., 1995). Since the introduction of *L. major* to New Zealand waters in 1950, it has spread to twelve regions and expanded its range within each region substantially (de Winton et al., 2009). *Lagarosiphon major* was able to spread to all points of Lake Taupo, a 237.8 mi^2 lake in New Zealand, within two years (Howard-Williams & Davies, 1988). Between 2003-2012, *L. major* had spread to occupy 31 km^2 of water bodies in the Netherlands (Matthews et al., 2012). Alternate answers for the Monte Carlo simulation are both "e."
ES-2 (Is the species highly domesticated)	n - mod	0	We found no evidence that this species is highly domesticated or has been bred for traits associated with reduced weed potential.
ES-3 (Weedy congeners)	n - mod	0	The genus *Lagarosiphon* contains nine species (Symoens & Triest, 1983). We found no evidence that any congeners are considered significant weeds in any system (Randall, 2012). *Lagarosiphon major* is the only species of the genus *Lagarosiphon* that has been cultivated and introduced elsewhere (Matthews et al., 2012).
ES-4 (Shade tolerant at some stage of its life cycle)	y - low	1	*Lagarosiphon major* is considered to be a shade-adapatedspecies (Parsons & Cuthbertson, 2001). Maximum photosynthesis for *L. major* occurs around 2-4 m depth (McCullough, 1997). As this species is a submerged aquatic plant (Csurhes & Edwards, 1998; Timmins & Mackenzie, 1995), we are answered yes, with low uncertainty.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - low	0	This species is not a vine, nor does it form tightly appressed basal rosettes. *Lagarosiphon major* is an herbaceous, submerged aquatic macrophyte (Matthews et al., 2012; Timmins & Mackenzie, 1995).
ES-6 (Forms dense thickets, patches, or populations)	y - negl	2	*Lagarosiphon major* forms dense stands (Parsons & Cuthbertson, 2001) and mats (MPI, 2012). It branches repeatedly to produce extremely dense mats on and below the surface of the water (Matthews et al., 2012).
ES-7 (Aquatic)	y - negl	1	*Lagarosiphon major* is a submerged macrophyte (Timmins & Mackenzie, 1995; MPI, 2012) that can grow in water as deep as 6.5m (Csurhes & Edwards, 1998).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-8 (Grass)	n - negl	0	*Lagarosiphon major* is not a grass; rather, it is a member of the family Hydrocharitaceae (Timmins & Mackenzie, 1995; Symoens & Triest, 1983).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no evidence that this species fixes nitrogen. Further, this species is not in a plant family known to have N-fixing capabilities (Martin and Dowd, 1990; Symoens & Triest, 1983; Timmins & Mackenzie, 1995), and it is not a woody plant. This species is an herbaceous submerged macrophyte (Symoens & Triest, 1983; Timmins & Mackenzie, 1995)
ES-10 (Does it produce viable seeds or spores)	y - high	1	Provided both male and female plants are present, reproduction can occur (Csurhes & Edwards, 1998). Because we were unable to find any other evidence pertaining to seed production for *L. major*, we answered yes, with high uncertainty.
ES-11 (Self-compatible or apomictic)	n - low	-1	*Lagarosiphon major* is a dioecious species (Lambertini et al., 2010) where male and female flowers occur on separate plants (Parsons & Cuthbertson, 2001; Csurhes & Edwards, 1998). Consequently it is not self-compatible. However, because it is unknown if it can produce seeds apomictically, we answered with low uncertainty.
ES-12 (Requires specialist pollinators)	n - negl	0	We found no evidence that *Lagarosiphon major* requires specialized pollinators. In fact, it exhibits "Male flower-epihydrophily" (Tanaka et al., 2004), where the male flower detaches from the parent plant and floats to initiate direct contact with female stigmas (Symoens & Triest, 1983).
ES-13 [What is the taxon's minimum generation time? (a) less than a year with multiple generations per year; (b) 1 year, usually annuals; (c) 2 or 3 years; (d) more than 3 years; or (?) unknown]	b - low	2	*Lagarosiphon major* is an aquatic perennial (Symoens & Triest, 1983) that reproduces both sexually and vegetatively. Because we found no information on generation time via sexual reproduction, we focused on vegetative reproduction. In this species, stem nodes naturally fragment (Parsons & Cuthbertson, 2001) and fragmentation begins almost immediately after maturation (Timmins & Mackenzie, 1995). Fragments begin shoot development within a week after settling in soil (Rattray et al., 1994). In warmer locations, *L. major* grows year-round, while in colder areas, plants sink to the bottom of the water body until temperatures are warm enough to sustain growth (Matthews et al., 2012). Alternate answers for the Monte Carlo simulation are "c." and "a"
ES-14 (Prolific reproduction)	? - max	0	We found no information about seed production of *L. major*, so we answered unknown.
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - negl	1	*Lagarosiphon major* is spread via fishing nets (de Winton et al., 2009), boats and trailers, fishing equipment, vehicles crossing fords, weed harvesters, and other maintenance equipment (Matthews et al., 2012).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	? - max	0	We found no direct evidence of this type of dispersal. However, plants within the aquarium trade are often contaminants of one another (Maki & Galatowitsch,

Question ID	Answer - Uncertainty	Score	Notes (and references)
			2004; Kay & Hoyle, 2001). Because this type of dispersal seems possible for *L. major*, we answered unknown.
ES-17 (Number of natural dispersal vectors)	1	-2	Relevant fruit and seed traits for questions ES-17a through ES-17e: The fruit is a beaked capsule, 4-5 mm in length (Weber, 2003) containing approximately nine seeds, which are approximately 3 mm long (Matthews et al., 2012). Also, stems of *L. major* readily break at nodes (Parsons & Cuthbertson, 2001), and fragments may become rooted in suitable substrate and begin new shoot growth within a week of settling (Clayton, 2006).
ES-17a (Wind dispersal)	n - negl		Neither seeds nor propagules appear to have mechanisms for this form of dispersal. Seeds float on the surface of water to disperse (Symoens & Triest, 1983).
ES-17b (Water dispersal)	y - negl		This species spreads via water dispersed seed (Csurhes & Edwards, 1998); seeds float on the surface of water, and eventually sink and germinate (Symoens & Triest, 1983). There is also downstream dispersal of vegetative fragments (de Winton et al., 2009).
ES-17c (Bird dispersal)	? - max		*Lagarosiphon major* is dispersed rarely, if at all by birds (Matthews et al., 2012), but this form of transport is a possible mechanism of dispersal (Inland Fisheries Ireland, 2015; West Coast Regional Council, 2015). Scientific literature focuses exclusively on water-mediated dispersal, and there appears to be no consideration for bird dispersal. Therefore, we answered unknown, as it seems possible that fragments may be moved by birds, particularly by the swans that feed on *L. major* in some areas (Howard-Williams & Davies, 1988).
ES-17d (Animal external dispersal)	? - max		We found no evidence that *L. major* is dispersed in this manner; however, this method of dispersal does not appear to have been considered for this species. Because it seems possible that vegetative fragments may become lodged in the fur of aquatic mammals, we answered unknown for this question. .
ES-17e (Animal internal dispersal)	n - mod		We found no evidence of this form of dispersal and have no reason to believe that vegetative fragments or seeds would survive digestion.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	? - max	-1	We found no evidence that this species forms a persistent seed bank. The seed production of this species is not well studied, so we are answering unknown.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - negl	1	Vegetative fragments can move long distances in stream flow before sinking to the bottom mud and producing adventitious roots, which form new plants (Parsons & Cuthbertson, 2001). Fragments become rooted (Matthews et al., 2012), and these rooted fragments begin shoot development within a week after settling (Rattray et al., 1994).
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	We found no evidence this species is resistant to herbicides. Furthermore, it is not listed by Heap (2013) as a weed that is resistant to herbicides. *Lagarosiphon*

Question ID	Answer - Uncertainty	Score	Notes (and references)
			major is susceptible to herbicides containing terbutryn and/or dichlobenil (Matthews et al., 2012)
ES-21 (Number of cold hardiness zones suitable for its survival)	9	0	
ES-22 (Number of climate types suitable for its survival)	7	2	
ES-23 (Number of precipitation bands suitable for its survival)	9	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - low	0	We found no evidence that this species is allelopathic.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that this species is parasitic. Furthermore, *Lagarosiphon major* does not belong to a family known to contain parasitic plants (Heide-Jorgensen, 2008; Timmins & Mackenzie, 1995).
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	y - negl	0.4	Dense growth of the plant can block light penetration into waterways (Csurhes & Edwards, 1998), and *L. major* canopies are able to shade out the water column, with less than 1% of light able to pass through canopies 0.5 m deep (Matthews et al., 2012; Schwarz & Howard-Williams, 1993). Dissolved oxygen gradients under a *L. major* bed showed decreasing levels of oxygen when approaching the bottom of the water column (Schwarz & Howard-Williams, 1993); this creates deposits of anoxic mud beneath *L. major* canopy (Matthews et al., 2012; Schwarz & Howard-Williams, 1993). *Lagarosiphon major* beds show an increase in dissolved phosphorus and nitrogen of 2-40 times or 3-30 times (respectively) greater than the surrounding open water (Schwarz & Howard-Williams, 1993).
Imp-N2 (Changes habitat structure)	y - low	0.2	*Lagarosiphon major* alters habitat structure through the formation of dense mats at or near the surface of the water where it is introduced (Caffrey et al., 2011). For example, in New Zealand, native submerged aquatic plants do not form a canopy at or near the surface of the water , but *L. major* does form it when it establishes in natural areas (Lambertini et al., 2010; Rattray et al., 1994).
Imp-N3 (Changes species diversity)	y - negl	0.2	Heavy infestations of *Lagarosiphon major* deplete oxygen levels in water, killing fish (Parsons & Cuthbertson, 2001). *Lagarosiphon major* displaces all other submerged macrophytes from approximately 1-6 m depth and produces a tall monospecific bed (Timmins & Mackenzie, 1995). Increased grazing by swans and crayfish within *L. major* beds have contributed to the decline of native aquatic plants; grazing swans uproot native macrophytes, while crayfish feed on characean (green algae) meadows and deep water bryophytes (Howard-Williams & Davies, 1988). Invertebrate communities were less dense and less diverse within *L. major* beds, and dominated by different species than in

Question ID	Answer - Uncertainty	Score	Notes (and references)
			beds of native vegetation (Matthews et al., 2012). In Ireland, *L. major* beds favor fish populations of pike, perch, and cyprinid fish, and native wild brown trout and Atlantic salmon populations are depressed (Caffrey et al., 2011).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	y - low	0.1	*Lagarosiphon major* is likely to affect T&E species if it were to be introduced to United States waterways. *Lagarosiphon major* alters the nutrient content of the water column which it inhabits; it increases dissolved phosphorus and nitrogen (Schwarz & Howard-Williams, 1993), while decreasing dissolved oxygen along a gradient to anoxic conditions in the sediment (Matthews et al., 2012; Schwarz & Howard-Williams, 1993). Coupled with the plant's ability to block 99% of sunlight (Matthews et al., 2012; Schwarz & Howard-Williams, 1993), these nutrient alterations, particularly depleted oxygen levels, shade out and outcompete other native macrophytes (Timmins & Mackenzie, 1995) while also killing fish (Parsons & Cuthbertson, 2001). Further, *L. major* disrupts aquatic food webs by depressing invertebrate populations (Matthews et al., 2012) and favoring vertebrate species that do not typically dominate an area (Caffrey et al., 2011). These combined effects are likely to have a negative effect within an area containing T&E species.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	y - mod	0.1	*Lagarosiphon major* has not yet been introduced to the United States (BONAP, 2014; GBIF, 2015; NGRP, 2015), but has the potential to establish in much of the southeastern and Pacific coast United States (GBIF, 2015) that are listed as globally outstanding ecoregions (Ricketts et. al, 1999). Given the impacts of this species as discussed in Imp-N1-N3, these effects are likely to alter the wildlife and vegetation of globally outstanding ecoregions, and so we are answering yes.
Imp-N6 [What is the taxon's weed status in natural systems? (a) Taxon not a weed; (b) taxon a weed but no evidence of control; (c) taxon a weed and evidence of control efforts]	c - low	0.6	*Lagarosiphon major* is considered an environmental weed in many non-native regions, including Australia (Australia Department of the Environment, 2012), Ireland (Caffrey et al., 2011), New Zealand (Howell, 2008), and Tasmania (Queensland Government, 2011). Mechanical harvesting in Lough Corrib, Ireland (a natural waterway) resulted in 10% regrowth of *L. major* in 7 months. The harvesting reduced coverage by 75% less a year after cutting (Caffrey et al., 2011). Control efforts in Lake Wanaka, New Zealand, utilized hand pulling and targeted suction dredging for *L. major* populations within native macrophyte beds (Clayton, 2006). Alternate answers for the Monte Carlo simulation are both "b."
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	y - negl	0.1	In 1968, a *L. major* infestation blocked intakes and caused the closure of New Zealand's Aratiatia hydro-electric station (Parsons & Cuthbertson, 2001). At another hydro-electric site in New Zealand, Lake

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			Dunstan, *L. major* occupies nearly 100% of the littoral zone and forms a continuous, monospecific belt along the shoreline of the 30 km^2 lake (Bickel & Closs, 2008). Thick infestations in this lake block water intake valves and affect the availability of power (Otago Regional Council, 2009).
Imp-A2 (Changes or limits recreational use of an area)	y - negl	0.1	Storms can tear the weed loose and deposit rotting vegetation on beaches, destroying amenity value. Long stems impede swimming and boating (McGregor & Gourley, 2002). Aesthetic values and recreational activities such as boating, water-skiing and swimming are adversely affected by *L. major* (Otago Regional Council, 2009).
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - mod	0	We found no evidence that this species affects ornamental vegetation, or is considered weedy in aquatic gardens.
Imp-A4 [What is the taxon's weed status in anthropogenic systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	c - negl	0.4	Residents of Cromwell, New Zealand, on Lake Dunstan, have actively pushed Land Information New Zealand to control *L. major* populations on Lake Dunstan for aesthetic and recreational purposes (Huffadine, 2015). Hand removal and suction dredging is used to manage *L. major* in Lake Wanaka, New Zealand, a popular tourist and water sports recreational site. In 2005, removal efforts targeted a boat ramp and two boat access sites (Clayton, 2006). Partial, short-term lowering of the water level of hydro-electric dams in midsummer, during a period of reduced power requirement, has also given good control in Australia (Parsons & Cuthbertson, 2001). Alternate answers for the Monte Carlo simulation are both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - mod	0	We found no evidence that *L. major* affects crop yield.
Imp-P2 (Lowers commodity value)	n - mod	0	We found no evidence that *L. major* affects commodity value.
Imp-P3 (Is it likely to impact trade?)	? - max	0.2	Plants within the aquaria trade are often contaminants of one another (Maki & Galatowitsch, 2004; Kay & Hoyle, 2001), and this species is readily available for trade throughout Europe (Brunel, 2009). Additionally, the countries of Australia, Korea, and Nauru require phytosanitary certificates declaring incoming shipments to be free of *L. major* (APHIS, 2015a). We are answering unknown, as we were unable to find evidence that *L. major* follows a pathway of trade.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - mod	0.1	We found no evidence that this species affects water quality.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - mod	0	We found no evidence that *L. major* is toxic to animals.

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Imp-P6 [What is the taxon's weed status in production systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	a - mod	0	We found no evidence that *L. major* is considered a weed of production systems, or that it is specifically being controlled in these areas. Matthews et al. (2012) notes that "winter and summer drainage is effective in areas of low ecological value such as artificial channels and reservoirs," but we found no evidence of any group or organization taking such measures within production systems. Alternate answers for the Monte Carlo simulation are both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2015).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z4 (Zone 4)	n - low	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z5 (Zone 5)	y - low	N/A	New Zealand and Germany.
Geo-Z6 (Zone 6)	y - negl	N/A	New Zealand and Germany.
Geo-Z7 (Zone 7)	y - negl	N/A	France and Germany.
Geo-Z8 (Zone 8)	y - negl	N/A	New Zealand, Australia, the United Kingdom, France, Belgium, and the Netherlands.
Geo-Z9 (Zone 9)	y - negl	N/A	South Africa, New Zealand, Australia, Japan, Ireland, the United Kingdom, and France.
Geo-Z10 (Zone 10)	y - negl	N/A	South Africa, New Zealand, Australia, Ireland, the United Kingdom, Portugal, and France.
Geo-Z11 (Zone 11)	y - negl	N/A	New Zealand and Portugal.
Geo-Z12 (Zone 12)	y - low	N/A	Several points in New Zealand.
Geo-Z13 (Zone 13)	y - low	N/A	A few points in South Africa.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	We found no evidence that it occurs in this climate class.
Geo-C2 (Tropical savanna)	n - negl	N/A	We found no evidence that it occurs in this climate class.
Geo-C3 (Steppe)	y - low	N/A	A few points in South Africa.
Geo-C4 (Desert)	n - low	N/A	We found no evidence that it occurs in this climate class.
Geo-C5 (Mediterranean)	y - negl	N/A	South Africa, Portugal, and France.
Geo-C6 (Humid subtropical)	y - negl	N/A	South Africa, Australia, and Japan.
Geo-C7 (Marine west coast)	y - negl	N/A	South Africa, Australia, New Zealand, Ireland, the United Kingdom, France, Belgium, the Netherlands, and Germany.
Geo-C8 (Humid cont. warm sum.)	y - low	N/A	The climate qualifications for the humid subtropical region and the marine west coast region, where this species is known to occur, are identical to those of the humid continental warm summers region, with one

Question ID	Answer - Uncertainty	Score	Notes (and references)
			difference: the coldest months of the humid subtropical region and the marine west coast region fall between -3°C and 18°C, while the coldest months of the humid continental warm summers region fall below -3°C (Arnfield, 2015). Given that *L. major* is known to occur in areas where the coldest temperatures fall between -28.9 °C to -23.3 °C (GBIF, 2015) we believe it is likely that this species can occur in humid continental warm summer regions.
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	France, Italy.
Geo-C10 (Subarctic)	y - low	N/A	A few points in France.
Geo-C11 (Tundra)	y - mod	N/A	A few points in France.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that it occurs in this climate class.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	y - low	N/A	A few point in South Africa.
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	South Africa, Portugal.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	South Africa, Portugal, New Zealand, Australia, the United Kingdom, France.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	South Africa, New Zealand, Ireland, the United Kingdom, France, Germany, Australia, Japan, Belgium, the Netherlands.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	South Africa, New Zealand, Ireland, the United Kingdom, France, Germany.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	New Zealand, Ireland, the United Kingdom, France, Germany.
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	New Zealand, Ireland, the United Kingdom, France, Germany.
Geo-R8 (70-80 inches; 178-203 cm)	y - low	N/A	A few points in the United Kingdom.
Geo-R9 (80-90 inches; 203-229 cm)	y - low	N/A	A few points in Germany.
Geo-R10 (90-100 inches; 229-254 cm)	y - high	N/A	We answered yes for this precipitation band given that this is a submerged aquatic species, and there is no reason not to expect it to be able to occur in regions receiving this amount of precipitation.
Geo-R11 (100+ inches; 254+ cm)	y - high	N/A	We answered yes for this precipitation band given that this is a submerged aquatic species, and there is no reason not to expect it to be able to occur in regions receiving this amount of precipitation.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - mod	0	*Lagarosiphon major* has not yet been introduced to the United States (GBIF, 2015; NGRP, 2015; BONAP, 2015).
Ent-2 (Plant proposed for entry, or entry is imminent)	n - low	0	As a federal noxious weed, *L. major* may not be brought into the United States (APHIS, 2015b).
Ent-3 (Human value & cultivation/trade status)	d - negl	0.5	*Lagarosiphon major* was analyzed as an imported species into Europe by the European and Mediterranean Plant Protection Organization (Brunel, 2009). This species is readily available from online

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			retailers, particularly within the United Kingdom.
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	n - low		We found no evidence that this species is present in any of these areas (GBIF, 2015; ISSG, 2015).
Ent-4b (Contaminant of plant propagative material (except seeds))	? - max		Plants within the aquairum trade are often contaminants of one another (Maki & Galatowitsch, 2004; Kay & Hoyle, 2001). While we found no specific evidence that *L. major* can move as a contaminant, propagules are traded freely within the aquaria and water garden trade of Europe (Brunel, 2009), and it is possible that *L. major* may be a contaminant of some other traded aquatic plant.
Ent-4c (Contaminant of seeds for planting)	n - low	0	We found no evidence that this species is a seed contaminant. As an aquatic species that reproduces exclusively asexually outside of its native range (Lambertini et al., 2010; Csurhes & Edwards, 1998), *L. major* seems unlikely to be a seed contaminant.
Ent-4d (Contaminant of ballast water)	n - mod	0	We found no evidence that *L. major* contaminates ballast water.
Ent-4e (Contaminant of aquarium plants or other aquarium products)	? - max		*Lagarosiphon major* continues to be traded as an aquarium species throughout Europe (Brunel, 2009). Aquatic plant propagules are common contaminants of the aquarium trade (Maki & Galatowitsch, 2004; Kay & Hoyle, 2001). Without direct evidence of contamination, we answered unknown.
Ent-4f (Contaminant of landscape products)	n - mod		We found no evidence that this species contaminates landscape products.
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	y - negl	0.02	Transfer is known with fishing activities and equipment, with *L. major* known to be spread via fishing nets (de Winton et al., 2009). Spread between water bodies via boats and trailers, fishing equipment, vehicles crossing fords, weed harvesters, and other maintenance equipment (Matthews et al., 2012).
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	n - mod	0	We found no evidence that *L. major* contaminates consumption commodities.
Ent-4i (Contaminant of some other pathway)	? - max		Unknown
Ent-5 (Likely to enter through natural dispersal)	n - mod	0	Because *L. major* has not established in a neighboring country, we are answering no.