U.S. Fish & Wildlife Service

African Elodea (*Lagarosiphon major*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, December 2022
Revised, January 2023
Web Version, 1/8/2025

Organism Type: Flowering Plant
Overall Risk Assessment Category: High

Photo: Rohan Wells. Licensed under CC BY-NC 3.0 US. Available: https://www.invasive.org/browse/detail.cfm?imgnum=1294052 (December 2022).

1 Native Range and Status in the United States

Native Range
According to CABI (2022), *Lagarosiphon major* is native to Botswana, Lesotho, South Africa, Zambia, and Zimbabwe.

Status in the United States
No records of *Lagarosiphon major* in the wild in the United States were found.

Although not available at the time of this assessment, *Lagarosiphon major* may be sold as 'Elodea crispa' via third party vendors in the United Kingdom with shipping possible to the United States as an ornamental pond and aquarium plant. The volume of this species in trade in the United States is unknown.

From Desertcart (2022):

"Imported from UK (Sizes & Specifications are based on the UK Market)."

"This lot is for 20 bunches of Elodea Crispa, also known as Laragasiphon [sic] major, curly pond weed or Goldfish Weed"

Regulations

Lagarosiphon major is a federally listed noxious weed (U.S. Department of Agriculture 2016).

Lagarosiphon major is regulated in California (CDFA 2021), Illinois (Illinois DNR 2015), Indiana (Indiana DNR 2022), Massachusetts (MDAR 2022), Michigan (Michigan Complied Laws 2022), New Hampshire (NHDES 2022), North Carolina (North Carolina DEQ 2022), Oklahoma (ODWC 2022), South Carolina Department of Natural Resources (2010), Texas (TPDW 2022), West Virginia (WVDA 2022), and Wisconsin (Wisconsin DNR 2022). Please refer back to state agency regulatory documents for details on the regulations, including restrictions on activities involving this species. While effort was made to find all applicable regulations, this list may not be comprehensive. Notably, it does not include regulations that do not explicitly name this species or its genus or family, for example, when omitted from a list of authorized species with blanket regulation for all unnamed species.

Means of Introductions within the United States

No records of *Lagarosiphon major* in the wild in the United States were found.

Remarks

This ERSS was previously published in April 2018. Revisions were completed to incorporate new information and conform to updated standards.

From CABI (2022):

"Several other species in the family Hydrocharitaceae look very similar to *L. major*, including *Egeria densa*, *Elodea canadensis*, and *Hydrilla verticillata*. However, unlike the leaves of the other species, which grow in groups or whorls circularly around the stem, the leaves of *L. major* are distinguishably alternately spiralled [sic] (Australia Natural Heritage Trust, 2003). The presence of recurved leaves and a downward curving stem towards the apex also help to distinguish *L. major* from these similar species (Scher, 2007). *L. major* is often also mislabelled [sic] as *'Elodea crispa'*, usually by those dealing with the plant in the aquarium trade."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

According to WFO (2022), *Lagarosiphon major* is the current accepted name for this species.

From ITIS (2022):

Kingdom Plantae
  Subkingdom Viridiplantae
    Infrakingdom Streptophyta
      Superdivision Embryophyta
        Division Tracheophyta
          Subdivision Spermatophytina
            Class Magnoliopsida
              Superorder Lilianae
                Order Alismatales
                  Family Hydrocharitaceae
                    Genus *Lagarosiphon*
                      Species *Lagarosiphon major* (Ridl.) Moss

From CABI (2022):

"*Lagarosiphon major* was first named *Lagarosiphon muscoides* Harvey in 1841, was revised to *L. muscoides var. major* by Ridley in 1886, and further revised to its current accepted scientific name, *L. major* (Ridl.) Moss in 1928. *L. major* is synonymous with *'Elodea crispa'*, a name that is often used by those using the plant in aquaria (Mason, 1960)."

Size, Weight, and Age Range

From CABI (2022):

"The brittle, sparsely branched stem can grow up to 20 feet long, is 3-5 mm in diameter […]"

Environment

From CABI (2022):

"It prefers the cool waters of the temperate zone, and grows best under high light intensity. *L. major* can grow to depths of 6.6 m (Coffey and Wah, 1988), but may grow to only 1 m in murky water (Australia Natural Heritage Trust, 2003)."

"*L. major* can live in a range of nutrient levels, however, in lakes with accelerated eutrophication and severely decreased water clarity, *L. major* abundance declines. *L. major* prefers high light intensity, and its best growth is recorded at 600 micro-einsteins/m2/h (Schwarz and Howard-Williams, 1993). *L. major* is able to withstand a relatively high pH, and its own photosynthetic activity has been recorded as raising pH levels to 10-10.4 in the surrounding water (CAPM-CEH, 2004). In conjunction with pH, *L. major* can survive in high alkalinity conditions as well. The optimum [water] temperature of *L. major* is 20-23°C, with a maximum temperature of approximately 25°C. *L. major* is thought to be absent below temperatures of 10°C (Australia Natural Heritage Trust, 2003)."

Climate

From CABI (2022):

"It prefers the cool waters of the temperate zone, […]"

Distribution Outside the United States

Native

According to CABI (2022), *Lagarosiphon major* is native to Botswana, Lesotho, South Africa, Zambia, and Zimbabwe.

Introduced

GISD (2022) lists *Lagarosiphon major* as alien, established, and invasive in Australia, France, Ireland, Italy, New Zealand, Reunion, Switzerland, and the United Kingdom including the Channel Islands.

CABI (2022) lists *Lagarosiphon major* as present, introduced, and invasive in France, Belgium, New Zealand and the Mascarene Islands (Mauritius, Réunion, Rodrigues); as present and introduced in Germany, Hungary, Ireland, Italy, Netherlands, Portugal, Spain, Switzerland, and United Kingdom; and as present only in captivity/cultivation in Australia.

From GISD (2018):

"It naturalised in a dam near Melbourne [Australia] in 1977 but was removed (Parsons and Cuthbertson 1992)."

"*L. major* is a declared plant under Queensland legislation. Declaration requires landholders to control declared pests on the land and waters under their control. Local Government may serve a notice upon a landholder requiring control of declared pests (The State of Queensland, 2004)."

From CABI (2018):

"*L. major* was introduced to New Zealand in the 1950s, and has naturalized in many freshwater lakes in the country. *L. major* was first recorded in Britain in 1944, and was first reported in Germany and Ireland in 1966. In southern Australia, *L. major* has been found and eradicated from a few small dams, and it is currently not known to be naturalized (Australia Natural Heritage Trust, 2003)."

"*L. major* was first reported as being naturalized in New Zealand in 1950, and by 1957 the population had grown to nuisance levels in Lake Rotorua."

"*L. major* was first recorded in a chalk pit in Britain in 1944, and has since spread to several other locations throughout Europe. *L. major* was first recorded both in Germany and Ireland in 1966, and its introductions were intentional horticultural and ornamental releases (NOBANIS, 2005; BioChange, 2007). In Ireland, the occurrence of *L. major* between 1987-1999 was recorded as being present in 7 hectads (1 hectad = 10km X 10km) (BioChange, 2007), though many additional *L. major* occurrences have been reported during the last five years (NBGI, 2007)."

"There are currently no naturalized populations of *L. major* in Australia, but there have been small invasions near Melbourne in Victoria, and Newcastle in New South Wales that were eradicated in the 1970s. These introductions were believed to have been plants that had originated in aquariums or ponds. In addition, there is a record of a cultivated specimen near Queensland in 1990 (Australia Natural Heritage Trust, 2003)."

Kadono (2004) lists *Lagarosiphon major* as having been observed in the wild in Japan.

Means of Introduction Outside the United States

From CABI (2022):

"It is believed that *L. major* was intentionally introduced to Lake Rotorua [New Zealand] with the intention of improving the oxygen levels (Cronk and Fuller, 1995) […]. *L. major* spread to Lake Taupo around 1966, and was probably introduced to the lake by recreational boat traffic (Cronk and Fuller, 1995)."

"[…] its introductions [in Europe] were intentional horticultural and ornamental releases (NOBANIS, 2005; BioChange, 2007)."

"These introductions [in Australia] were believed to have been plants that had originated in aquariums or ponds."

"*L. major* can be spread accidentally to new locations by the movement of boats, trailers, nets, sea planes, and other recreational equipment between water bodies (McGregor and Gourlay, 2002; Australia Natural Heritage Trust, 2003). It is also possible for *L. major* to be a 'hitchhiker' plant with other species ordered through water garden catalogues. *L. major* can also be accidentally introduced by flooding of ornamental ponds into surrounding natural waterways. *L. major* has also been introduced through hobbyists emptying unwanted aquarium species directly into surrounding waterways."

Short Description

From CABI (2022):

"L. major is a dioecious, perennial submerged aquatic plant with adventitious roots and rhizomes that attach the plant to the substrate. The brittle, sparsely branched stem can grow up to 20 feet long, is 3-5 mm in diameter and curves like a 'J' towards the base. The dark green leaves are alternately spiralled [sic] around the stem, though often crowded towards the stem tip. The leaves are minutely toothed, 5-20 mm long, 2-3 mm wide and generally have tapered tips that curve

down towards the stem, though in low alkalinity waters the leaves can appear straight (Australia Natural Heritage Trust, 2003). The female flower is very small, with three transparently white/pink petals that are attached to a filament-like stalk above the water's surface. Only the female plant is known outside of its native range. The fruit is a beaked capsule, containing approximately nine seeds, each seed being approximately 1/8 inch long (UFL-CAIP, 2001)."

Biology

From CABI (2022):

"In these regions [native range], *L. major* is naturally found in high mountain freshwater streams and ponds (Cronk and Fuller, 1995)."

"*L. major* prefers lakes, reservoirs, and slow moving rivers with silty or sandy bottoms. *L. major* is also known to occur in wetlands, water courses, riparian zones (ISSG, 2006), canals and drainage ditches (CAPM-CEH, 2004)."

"*L. major* is a dioecious plant, which refers to a species in which the male and female reproductive organs occur on different individuals. *L. major* has the ability to reproduce by both vegetative and sexual means, though only vegetative reproduction has been observed outside of its native range."

"In the Northern hemisphere, *L. major* becomes dormant in the winter and emerges in the spring from rhizomes and shoots. *L. major* is capable of producing two types of flowers; the male flowers break free from the plant and float along the water's surface, while the female flowers remain attached to the plant by long, filament-like stalks. All populations of *L. major* outside of its native range have consisted of plants with only female flowers, and male flowers, fruits, and seeds have not been recorded outside of Africa. Female flowers appear from summer to early autumn, and the overall growth of *L. major* decreases as day length and light intensity decreases (Australia Natural Heritage Trust, 2003)."

Human Uses

From GISD (2022):

"Davies et al. (2003) demonstrated that, '*L. major* and other aquatic species grown in small outdoor tanks can be used successfully to assess the effects of crop-protection products on nontarget aquatic flora.'"

"Chapman and Coffey (1971) reviewed the possible utilization by harvesting for stock food in New Zealand lakes. Though harvesting was considered practicable the use of the plants as fodder was thought to be unsuitable because of the content of arsenic accumulated by the plants from the thermal waters that enter the lakes. Arsenic in amounts of 35–75 ppm dry weight are common, and extreme values up to 2 000 ppm have been recorded. It is possible in other countries that the use of plants as fodder could be practical."

From CABI (2022):

"*L. major* has been intentionally planted as an 'oxygenator' or ornamental in different water bodies throughout its current distribution. The trade of this plant as an ornamental through the internet and mail order has greatly increased its availability and ease of spread into new environments (Australia Natural Heritage Trust, 2003)."

"Ornamental plants of *L. major*, often sold under the name *'Elodea crispa'*, are sold for aquariums and ponds, though the specific economic value of this particular species in the ornamental plant trade is unknown. *L. major* was also once sold as capable of 'water purification', though the continuance of this practice is unknown (NBGI, 2007)."

Diseases

From CABI (2022):

"McGregor and Gourlay (2002) report the nematode *Aphelenchoides fragariae* attacking the apical tips of *L. major*. *Nymphula nitens* has also been reported as feeding on several aquatic weeds, though it is not specific to *L. major*."

Threat to Humans

No information was found on threat to humans for *Lagarosiphon major*.

3 Impacts of Introductions

From Matthews et al. (2012):

"The major adverse impacts of Curly Waterweed (*Lagarosiphon major*) are related to interference and exploitation competition. In the heavily colonised Lough Corrib, Ireland the impact on native and other non-native species has been dramatic. Assuming that the surrounding lakes of Lough Corrib feature a similar species composition to that that existed in Lough Corrib prior to *L. major* invasion, characteristic dense meadows of charophyte vegetation, mixed with tall stands of *Myriophyllum spicatum*, *Elodea canadensis* and a range of *Potamogeton* species have been lost (Caffrey & Acavedo, 2007). These impacts have also been observed in other locations where *L. major* has invaded. Following the invasion of Lake Taupo in New Zealand, the number of native species decreased markedly, the most noticeable decrease occurring at 4 m depth. Moreover, large weed beds of *L. major* attracted herbivorous birds and detritivores such as swans and crayfish which also adversely affect the native flora (Howard-Williams & Davies, 1988). The replacement of an established invasive weed, by another from the same family has previously been thought to be of little consequence. However, in New Zealand, *L. major* was able to grow taller and denser than *E. canadensis*, with the result that biodiversity was further reduced and surface-reaching weed beds posed even greater interference to water body usage (Champion & Clayton, 2000). In other locations, however, *L. major* has proven to be less aggressive. In some areas of New Zealand *L. major* has been displaced by other species and may co-exist with native species (McGregor & Gourley, 2002)."

"Low light levels and the deep, often anoxic mud deposits that exist beneath the *L. major* canopy make it very difficult for other aquatic plant species to exist (Caffrey & Acavedo, 2007). One of the main physical habitat modification is due to the canopy formed by *L. major*. Where mature surface-reaching stands have become established, the canopy is able to shade out, and competitively exclude, even tall submerged species […]. It has been demonstrated that as little as 1% sunlight can penetrate a canopy of 0.5 m deep (Schwarz & Howard-Williams, 1993). The presence of dense stands of macrophytes can have a number of other effects including changes in nutrient availability and resource pools. *L. major* presence increases dissolved reactive phosphorous and dissolved inorganic nitrogen and results in changes in temperature and dissolved oxygen level (Schwarz & Howard-Williams, 1993; Department of Primary Industries, 2011)."

"Colonisation of Lough Corrib in the west of Ireland by *L. major* has led to changes in the survival and composition of fish species that could have major impacts on the Brown Trout and Salmon fishery (Caffrey, 2009)."

"Significant changes in abundance and species composition within the macroinvertebrate community have been observed following invasion by *L. major*. Particular differences have been noted in the abundance of sedentary taxa, including Chironomidae and Mollusca. The most notable difference, however, reflected the significant increase in the abundance of certain macroinvertebrate groups e.g. Chironomidae (Caffrey & Acavedo, 2007). This observation has been repeated in other studies. In Lake Wanaka, a large alpine New Zealand lake, *L. major* and *E. canadensis* contributed to greater standing stocks and productivity of epiphyton. Invertebrate communities were less dense (1890/m2 vs 4030/m2) and less diverse (richness = 9 vs 12). Invertebrate communities in native beds were dominated by snails, oligochaetes, and nematodes, whereas chironomids, snails, and caddisflies were dominant in non-native beds (Kelly & Hawes, 2005). However, other literature evidence contradicts these observations. Biggs and Malthus (1982) conducted research into the preference of macroinvertebrate groups for native and nonnative macrophytes. There appeared to be no preference by the invertebrate fauna (in terms of either numbers of taxa, abundance, or biomass) for either native plants or the non-native *L. major* as a habitat."

"In its native range (South Africa) as well as in introduced areas prolific growth of *L. major* can interfere with commercial navigation and water-based recreation (Centre for Ecology and Hydrology, 2004; Caffrey & Acavedo, 2007). Swimming maybe impossible in areas of dense weed growth […] and the snarling of weeds in outboard motors may put recreational boaters at risk (Caffrey & Acavedo, 2007). Storms can tear the weed loose and deposit large masses of rotting vegetation on beaches, spoiling their amenity value; and effect power stations (Brown, 1975; Rowe and Hill, 1989). Water velocity is slowed in dense beds of aquatic plants, particularly in those where there is a canopy and under-storey (Frodge et al., 1990). Large beds of *L. major* may increase the risk of flow impedance as the discharge capacity of an invaded water body is reduced (Department of Primary Industries, 2011). Extensive growth can block the turbine screens of hydro-electric power stations in quantities too great for the cleaning machinery to clear, causing temporary shutdowns, economic losses and power shortages (Chapman et al., 1974)."

"In the United Kingdom the estimated yearly economic cost of *L. major* alone is 1,173,214 Pounds or approximately 1,466,400 Euros (Hulme, 2012). Controlling *L. major* by mechanical means was estimated to be 1,000 pounds or 1,250 Euros per hectare per year assuming that each 10 km square contains at least 1 hectare of plants (GB Non-Native Species Secretariat, 2011)."

From GISD (2022):

"In New Zealand, the plant has blocked intakes of hydro-electric systems and has formed dense floating mats in deep-water reservoirs and other water bodies."

"James et al. (1999) report that, '*L. major* has been reported to be actively displacing *E*[*lodea*] *nuttallii* and appears to be competitively superior to *Elodea* spp. in at least some habitats.'"

"The small adverse affect [sic] *L. major* has on some recreational use of Lake Dunstan is more than offset by the environmental benefits it provides as shelter and feeding areas for a range of aquatic fauna."

From CABI (2022):

"*L. major* alters the chemical composition of the water body by creating stressful conditions of high pH and low carbon dioxide (James et al., 1999). The photosynthesis of *L. major* has been recorded as raising surrounding pH to levels over 10, and has the ability to raise levels to 10.4, (the limit of bicarbonate uptake) in small water bodies (CAPM-CEH, 2004). These high pH levels inhibit other native species from effectively photosynthesizing, giving *L. major* a competitive advantage."

"[…] the dense mats of vegetation that are characteristic of this species when introduced outside of its native range actually decrease the oxygen levels by limiting water circulation and increased decomposition of dead plants. Dense mats of *L. major* also have the ability to change water hydrology and quality, negatively affecting the ecosystem in which it occurs."

"*L. major* reduces biodiversity by competing with and displacing native vegetation, and is capable of changing the fauna and flora of an ecosystem. *L. major* has out-competed native species wherever it has colonized, due in part to its ability to out-compete submerged vegetation for light and photosynthesize in the inhospitable, stress-inducing water conditions that it creates. In particular, *L. major* has out competed *Myriophyllum* spp., *Potamogeton* spp., (Rattray et al., 1994), and *Elodea* spp. (James et al., 1999). Decomposing mats of *L. major* also have the ability to cause fish kills by creating low oxygen levels in the water."

"*L. major* can form dense mats that impede recreational activities such as boating, fishing, swimming, water skiing, canoeing, and kayaking. In addition, unsightly mats of vegetation decrease aesthetic values. These declines in recreational and aesthetic values can decrease tourism, which can be a major source of income within the community."

According to U.S. Department of Agriculture (2016), *Lagarosiphon major* is a federally listed noxious weed. The importation, possession, and/or trade of *L. major* is regulated in the following States: California (CDFA 2021), Illinois (Illinois DNR 2015), Indiana (Indiana DNR 2022), Massachusetts (MDAR 2022), Michigan (Michigan Compiled Laws 2022), Minnesota (Minnesota DNR 2022), North Carolina (North Carolina DEQ 2022), New Hampshire (NHDES 2022 Oklahoma (ODWC 2022), South Carolina (SCDNR 2010), Texas (TPDW 2022), Wisconsin (Wisconsin DNR 2022), and West Virginia (WVDA 2022). See section 1.

4 History of Invasiveness

Lagarosiphon major has been introduced and established beyond its native range throughout Europe and in parts of Japan, Australia, and New Zealand through international trade for aquarium purposes. There were no records found quantifying *L. major* in trade, partly due to this species being mislabeled as 'Elodea crispa' within the trade industry. There is peer-reviewed evidence of negative impacts caused by introductions of *L. major*, including the displacement of native aquatic vegetation and alteration of fish and macroinvertebrate communities. Introductions of *L. major* have also led to reported economic impacts, including obstruction of hydroelectrical intakes and restriction of recreational activities. The History of Invasiveness category for *L. major* is therefore classified as High.

5 Global Distribution

Figure 1. Reported global distribution of *Lagarosiphon major*. Map from GBIF Secretariat (2022). Observations are reported from Europe, southern Africa, Japan, Australia, and New Zealand. Observations along the eastern coast of Australia were excluded from the climate match as they were found to be from cultivation sites or ornamental ponds and do not represent established populations of *L. major*. The observation on the southern coast of Australia was not used in the climate match as it does not represent a recently or currently established population. The observations in the country of Georgia were excluded from the climate match as the existence of an established population could not be corroborated.

6 Distribution Within the United States

No records of *Lagarosiphon major* in the wild in the United States were found.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Lagarosiphon major* was generally medium to high for the contiguous United States with areas of high match found in the Northeast, Great Lakes region, Appalachia, Ohio River Basin, southern Midwest, and Southwest. Smaller areas of high match were also found in the Southeast, Rocky Mountains, central and southern California, and in the lowland areas between the Cascade Mountains and coastal mountains in the Pacific Northwest. Low matches were restricted to the Sierra and Cascade Mountains and coastal Pacific Northwest. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.756, indicating that Yes, there is establishment concern for this species. The Climate 6 score is calculated as: (count of target points with scores $\geq$ 6)/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024).

Projected climate matches in the contiguous United States under future climate scenarios are available for *Lagarosiphon major* (see Appendix). These projected climate matches are provided as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.

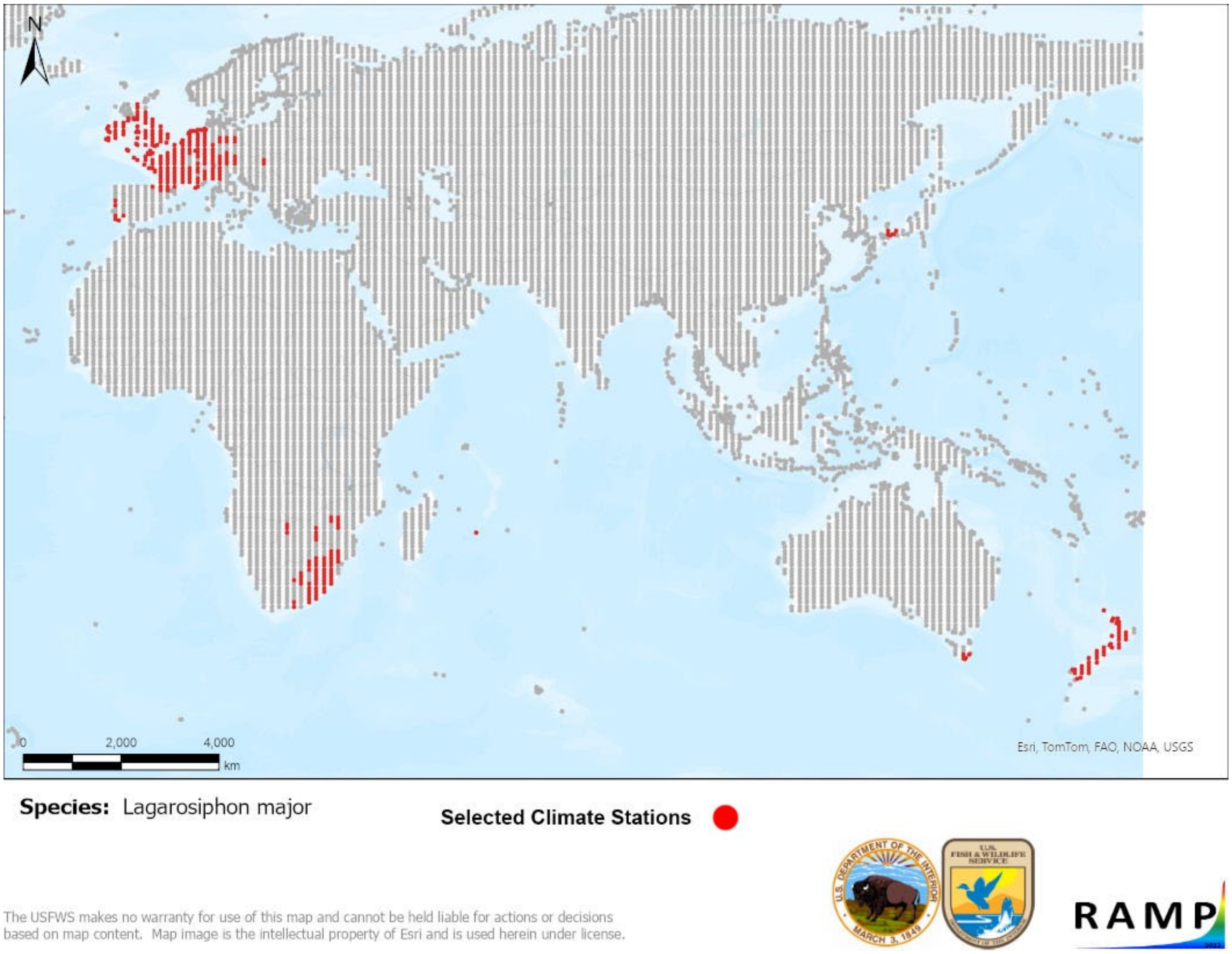

Figure 2. RAMP (Sanders et al. 2023) source map showing weather stations in Europe, Africa, Asia, and Oceania selected as source locations (red; Ireland, United Kingdom, Spain, Portugal, France, Belgium, The Netherlands, Switzerland, Austria, Italy, Hungary, Germany, South Africa, Botswana, Lesotho, Zimbabwe, Mozambique, Réunion Island, Japan, southern Australia, and New Zealand) and non-source locations (gray) for *Lagarosiphon major* climate matching. Source locations from GBIF Secretariat (2022). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

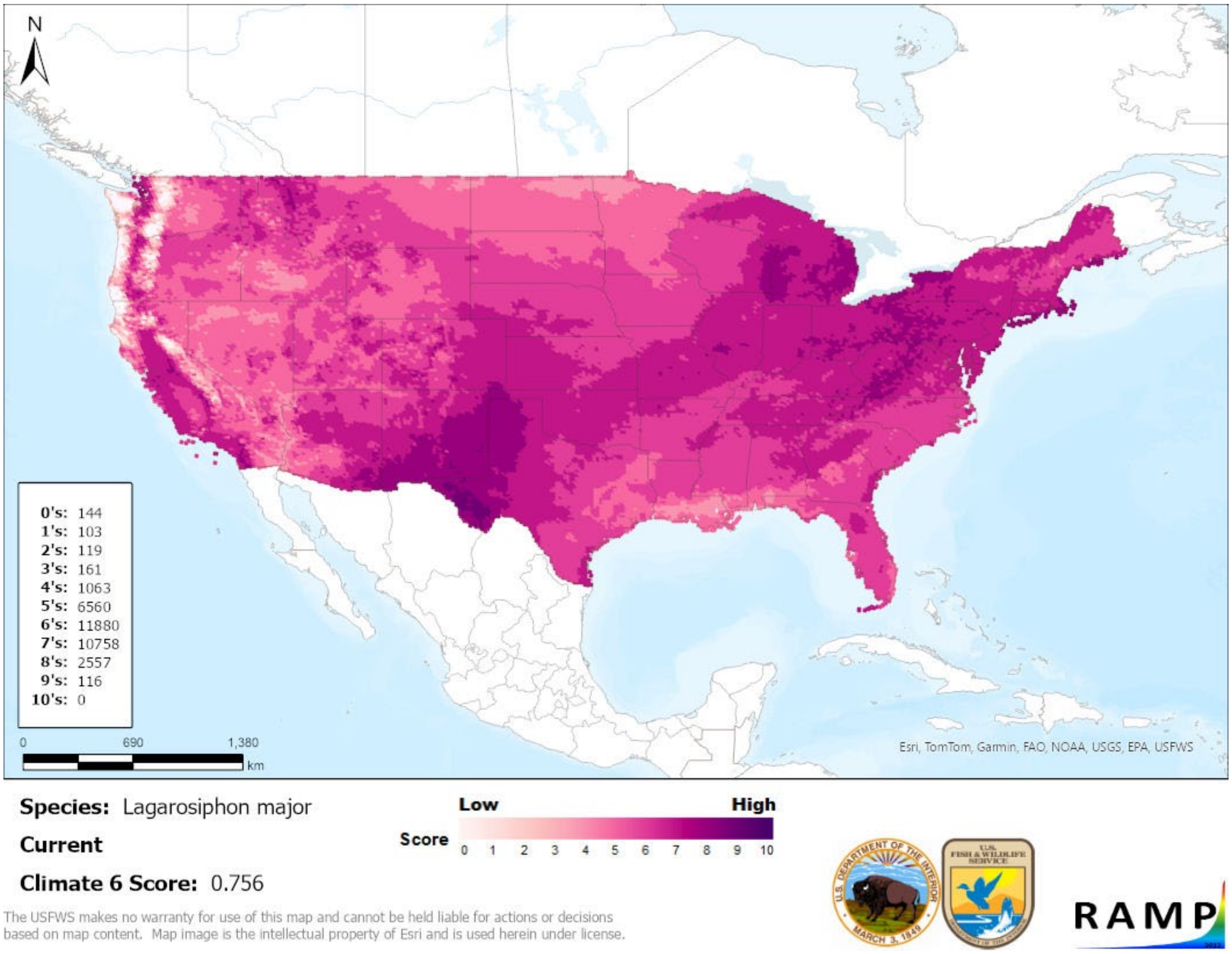

Figure 3. Map of RAMP (Sanders et al. 2023) climate matches for *Lagarosiphon major* in the contiguous United States based on source locations reported by GBIF Secretariat (2022). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Lagarosiphon major* is classified as High. Information on the biology, distribution, invasion history, and negative impacts of introduction is available for this species from peer reviewed literature. There is enough information available to describe the risks posed by this species.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Lagarosiphon major, African Elodea, is an aquatic plant that is native to southern Africa and has been introduced to and become established in Europe, Japan, and New Zealand. It has also been introduced in eastern Australia. This aquatic species prefers lakes, reservoirs, and slow-moving rivers with silty and sandy substrates. *L. major* is a dioecious species, however only female plants have been found outside of its native range. *L. major* has been used as an ornamental plant in the aquarium industry which has led to introduction of this species through trade. Despite no occurrences of this species in the wild found in the United States, *L. major* is federally listed as a noxious weed and is regulated by several States. Introduced populations of *L. major* have negatively impacted native aquatic flora and fauna, and water quality; and impacts to local economies and infrastructure have also been reported. The history of invasiveness for *L. major* is High. The climate matching analysis for the contiguous United States indicates establishment concern for this species. Areas of high match occurred in the Northeast, Great Lakes region, Ohio River basin, Rio Grande basin, Appalachia, and in parts of California. The Certainty of Assessment for this ERSS is classified as High due to the amount of information regarding this species' biology, invasion history, and negative impacts of introduction. The Overall Risk Assessment Category for *L. major* in the contiguous United States is High.

Assessment Elements

- **History of Invasiveness (see section 4): High**
- **Establishment Concern (see section 7): Yes**
- **Certainty of Assessment (see section 8): High**
- **Remarks, Important additional information: *L. major* regularly mislabeled as 'Elodea crispa' in the trade industry.**
- **Overall Risk Assessment Category: High**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in section 11.

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Appendix

Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by GBIF Secretariat (2022).

Under the future climate scenarios (figure A1), areas within the Great Lakes and Southwest had high matches. The areas of high match reduced in size from time step 2055 to 2085. Areas of low match continued to be found along the Sierra and Cascade mountain ranges and coastal Pacific Northwest under all scenarios. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.414 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.716 (model: MPI-ESM1-2-HR, SSP5, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.756, figure 3) falls above the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Under one or more time step and climate scenarios, areas within the Colorado Plateau and Northern Plains saw a moderate increase in the climate match relative to current conditions. No large increases were observed regardless of time step and climate scenarios. Under one or more time step and climate scenarios, areas within the Appalachian Range, Mid-Atlantic, and inland Southeast saw a large decrease in the climate match relative to current conditions. Additionally, areas within California, the Great Basin, Great Lakes, Gulf Coast, Northeast, Southern Atlantic Coast, Southern Florida, Southern Plains, Southwest, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. Additional, very small areas of large or moderate change may be visible on the maps (figure A3). The degree of change increased with time.

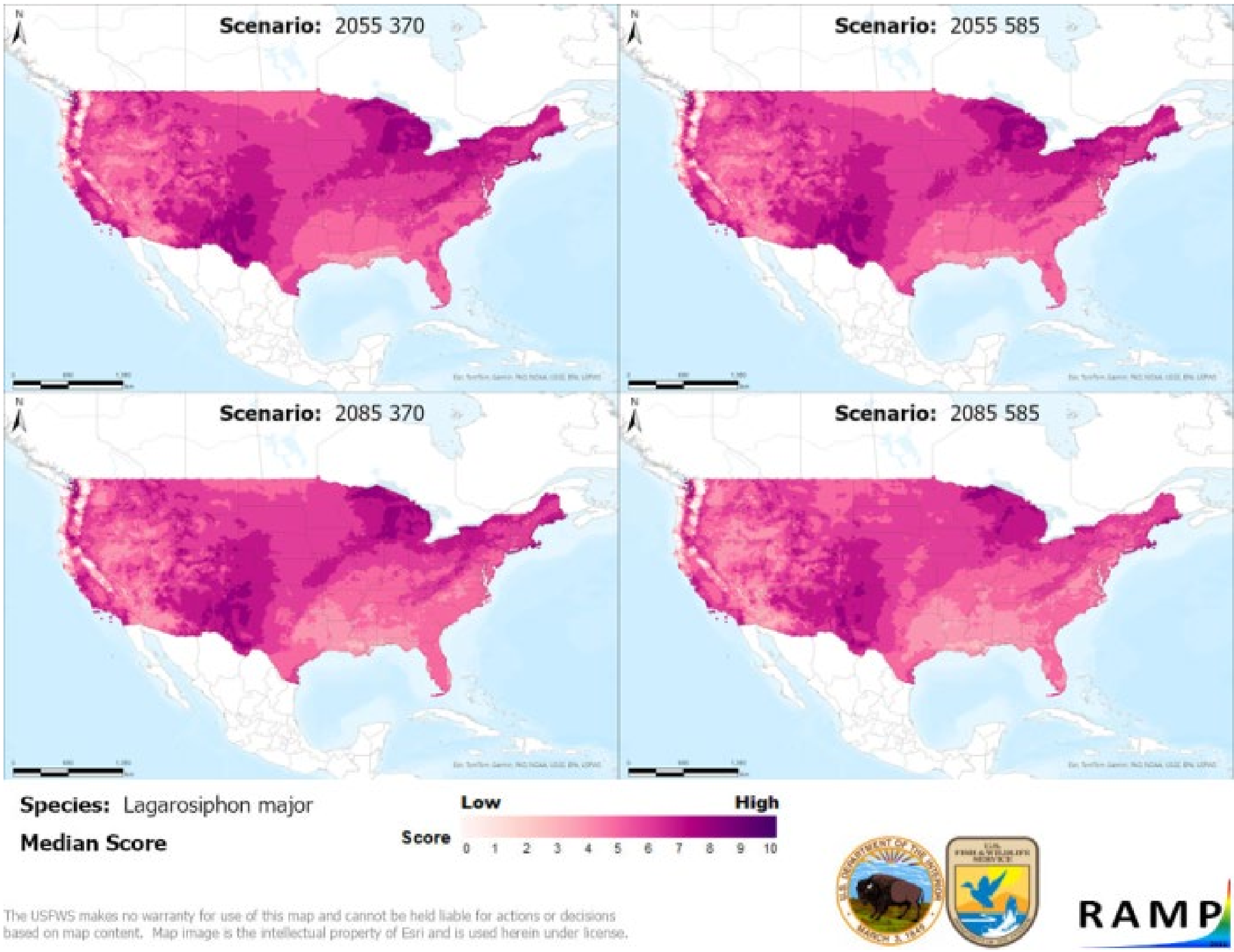

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Lagarosiphon major* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2022). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

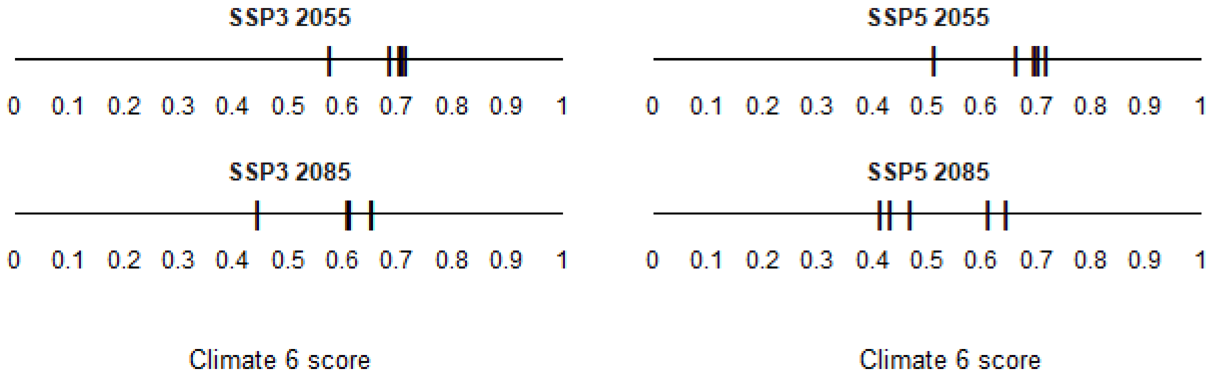

Figure A2. Comparison of projected future Climate 6 scores for *Lagarosiphon major* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.

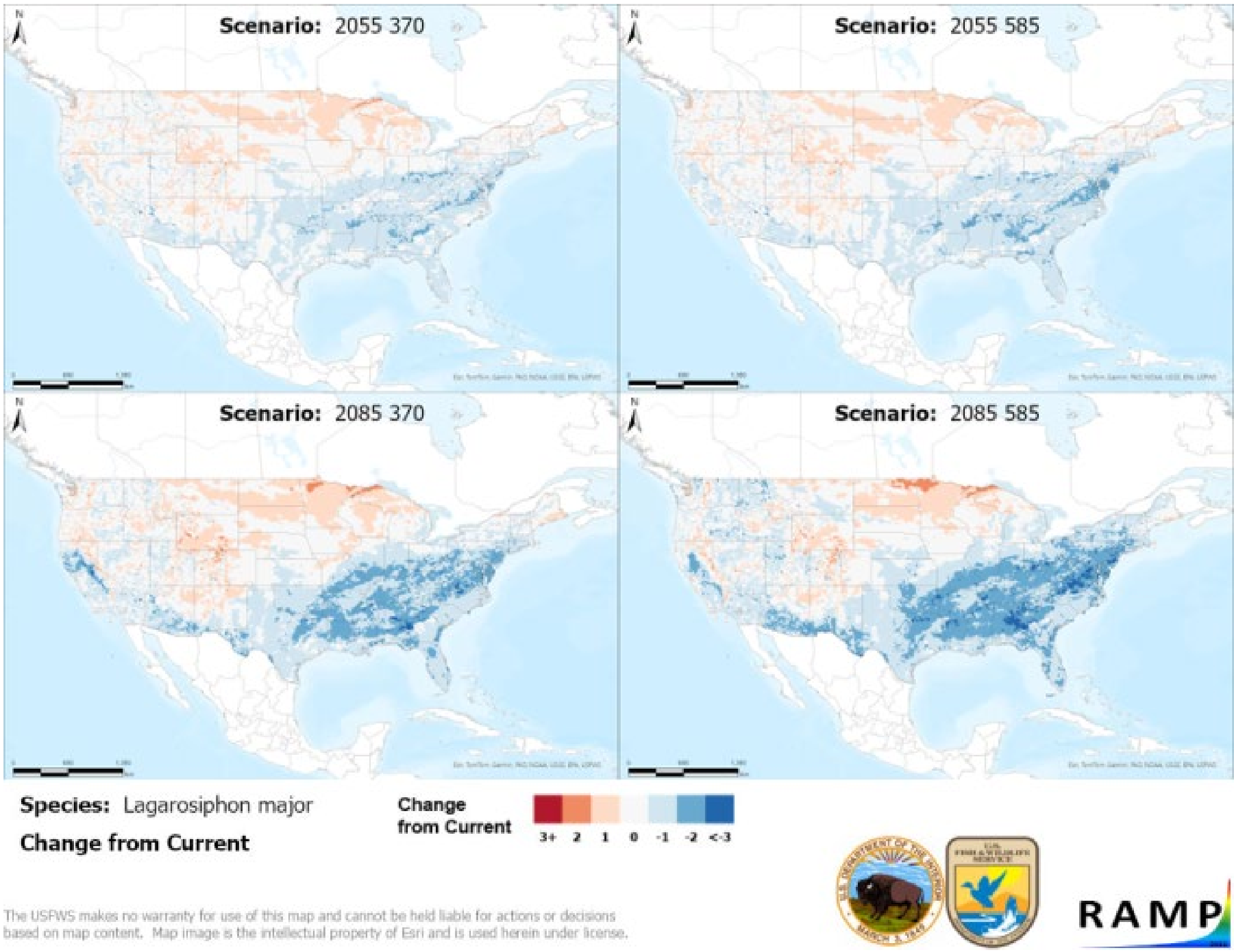

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 3) and the median target point score for future climate scenarios (figure A1) for *Lagarosiphon major* based on source locations reported by GBIF Secretariat (2022). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

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