Brazilian Waterweed (*Egeria densa*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, May 2015
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1 Native Range and Status in the United States

Native Range

From Pfingsten et al. (2018):

"South America (central Minas Gerais region of Brazil, coast of Argentina, and coast of Uruguay) (Cook and Urmi-König 1984)"

From Yarrow et al. (2009):

"The original distribution of *Egeria densa* ranges from the central Minas Gerais region of Brazil to the coastal areas of Uruguay and Argentina. It is common in the Paraná basin of Argentina."

Status in the United States

According to USDA, NRCS (2018) *Egeria densa* is a class C noxious weed in Alabama, a potentially invasive and banned species in Connecticut, an invasive aquatic plant in Maine, prohibited in Massachusetts, a "B" designated weed and quarantine species in Oregon, an invasive aquatic plant and plant pest in South Carolina, a class A noxious weed in Vermont, and a class B noxious weed, wetland and aquatic weed quarantine species in Washington.

GISD (2018) lists *Egeria densa* as alien, invasive, and established in Puerto Rico, Alabama, Arizona, Arkansas, California, Connecticut, Delaware, Florida, Georgia, Hawaii, Illinois, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, Nebraska, New Hampshire, New Hersey, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia, and Washington.

From Pfingsten et al. (2018):

"The first report of *E. densa* in the United States was 1893 in Millneck, Long Island, New York (Weatherby 1932; Cook and Urmi-König 1984).
Alabama - Alabama, Chattahoochee, Choctawhatchee (Anderson 2009), Black Warrior-Tombigbee, Mobile Bay-Tombigbee (Haynes 1980), and Middle Tennessee-Elk (University of Alabama Biodiversity and Systematics 2007) drainages
Arizona - Little Colorado, Salt (Arizona State University 2003), San Pedro-Wilcox, and Santa Cruz (University of Arizona Herbarium 2008) drainages
Arkansas - Lower Arkansas-Fourche La Fave, Lower Ouachita, and Upper Ouachita drainages (Smith 1988)
California - Central California Coastal, Laguna-San Diego Coastal, Lower Sacramento, Mono-Owens Lakes, San Joaquin, Upper Sacramento (Regents of the University of California 2015), Northern California Coastal, San Francisco Bay, Santa Ana, and Tulare-Buena Vista Lakes (Consortium of California Herbaria 2014) drainages
Colorado - eastern Colorado (Flora of North America Editorial Committee 1993)
Connecticut - Lower Connecticut, Saugatuck, Shetucket (IPANE 2001), Quinnipiac (Gibbons 2011), and Thames (University of Connecticut 2011) drainages
Delaware - Brandywine-Christina (Hong-Wa 2000), Broadkill-Smyrna, and Nanticoke (Aquatic Resources Education Center 1995) drainages
Florida - Apalachicola, Southern Florida, St. Johns, Tampa Bay (University of Florida Herbarium 2016), Aucilla-Waccasassa, Kissimmee, St. Marys-Satilla, Suwannee (Robert Kipker, FL DEP, pers. comm.), Florida Panhandle Coastal, Ochlockonee (Anderson 2009), and Peace (Central Michigan University 2007) drainages
Georgia - Altamaha, Savannah (Thomaston 1984), Flint, and Middle Tennessee-Hiwassee (Anderson 2009) drainages
Hawaii - Islands of Hawaii (Cook and Urmi-König 1984), Kauai, Maui, and Oahu (Bernice Pauahi Bishop Museum 2015)

Idaho - small pond in the University of Idaho Arboretum of Palouse drainage (Warnick 2008) and a private pond in Boise of Lower Boise drainage (Center for Invasive Species and Ecosystem Health 2015)
Illinois - Lower Ohio, Wabash (Illinois Natural History Survey 2008), Upper Illinois (Michigan State University 2015), and Upper Mississippi-Meramec (Illinois Natural History Survey 2003) drainages
Indiana - Lower Ohio-Salt (Taylor 2009), and Patoka-White (Aquatic Control, Inc. 2007) drainages
Kansas - private pond in Lawrence of Lower Kansas drainage (University of Kansas Biodiversity Institute 2008)
Kentucky - Lower Levisa (Center for Invasive Species and Ecosystem Health 2015), North Fork Kentucky (Jeff Herod, USFWS, pers. comm.), Lower Ohio-Salt (Beal and Thieret 1986), and Upper Cumberland (David Taylor, Daniel Boone National Forest, pers. comm.) drainages
Louisiana - Lake Pontchartrain (Thomas and Allen 1993), Atchafalaya-Vermillion (Anderson 2009), Calcasieu-Mermentau, Lower Ouachita, Lower Red (University of Connecticut 2011), Central Louisiana Coastal (Montz 1980), and Red-Saline (Sanders and Mangrum 1973) drainages
Maryland - Lower Chesapeake (Hong-Wa 2000), Potomac, and Upper Chesapeake (Smithsonian Institution 2014) drainages
Massachusetts - pond by the Memorial Park in Abington of Massachusetts-Rhode Island Coastal drainage (Countryman 1970), and Groton of Merrimack drainage (University of Connecticut 2011)
Minnesota - Powderhorn Lake in south Minneapolis of Upper Mississippi-Crow-Rum drainage (Minnesota Department of Natural Resources 2007)
Mississippi - retention pond in D'Iberville of the Mississippi Coastal drainage (Mike Pursley, MS DMR, pers. comm.), and private pond in Carriere of the Lower Pearl drainage (Madsen 2010)
Missouri - Chariton (Missouri Botanical Garden 2007), Osage, Upper White, and Upper **Mississippi**-Meramec (Padgett 2001) drainages
Nebraska - Hall County (McGregor et al. 1977)
New Hampshire - Nutt Pond in Manchester of Merrimack drainage (New Hampshire Department of Environmental Services 2015)
New Jersey - Twin Rivers in Hightstown of Lower Hudson drainage (Charles Gilbery, Allied Biological, Inc., pers. comm.)
New Mexico - Wall Lake in Gila National Forest of Upper Gila drainage (Center for Environmental Studies 2015)
New York - Long Island (iMapInvasives 2015), Lower Hudson (New York Botanical Garden 2015), Upper Delaware (Scott Kishbaugh, NY DEC, pers. comm.), and Upper Hudson (Weldy and Werier 2005) drainages
North Carolina - Albemarle-Chowan (Angela Poovey, NC DWNR, pers. comm.), Cape Fear (Anderson 2009), Neuse, Onslow Bay, Pamlico, Roanoke, and Santee (Radford et al. 1968) drainages
Oklahoma - Cache (Anderson 2009), and West Cache (Cook and Urmi-König 1984) drainages, and Carter, Choctaw, Hughes, and Murray Counties (Nelson and Couch 1985)
Oregon - Lower Columbia, Northern Oregon Coastal, Southern Oregon Coastal, Willamette (Oregon State University 2016), and Middle Columbia (ODA 2007) drainages

Pennsylvania - Crosswicks-Neshaminy, Lower Delaware, and Schuylkill drainages (Pennsylvania Flora Database 2011)
Rhode Island - Arnold Pond of Quinebaug drainage (University of Connecticut 2011), and Arnolds Pond, Hundred Acre Pond of the Pawcatuck-Wood drainage (DeGoosh 2009)
South Carolina - Edisto-South Carolina Coastal (University of Florida Herbarium 2016), Santee (Getsinger and Dillon 1984), Lower Pee Dee, and Savannah (University of Alabama Biodiversity and Systematics 2007) drainages
Tennessee - Hatchie-Obion (Robinson and Shanks 1959), French Broad-Holston, Lower Cumberland, Lower Tennessee, Middle Tennessee-Hiwassee, Upper Cumberland (Austin Peay State University Center for Field Biology 1997), and Upper Tennessee (Anderson 2009) drainages
Texas - Big Cypress-Sulphur, Neches, Sabine (Helton and Hartmann 1996), Guadalupe (Lemke 1989), and Upper Trinity (Chetta Owens, USACE, pers. comm.) drainages
Utah - [non-specific] (Cook and Urmi-König 1984)
Vermont – private pond in Vernon of Middle Connecticut drainage (University of Connecticut 2011), and Townshend of West drainage (Countryman 1970)
Virginia - Albemarle-Chowan, French Broad-Holston, James, Kanawha, Lower Chesapeake, Middle New (Harvill et al. 1977), Potomac (Smithsonian Institution 2014), and Roanoke (Dodd-Williams et al. 2008) drainages
Washington - Lower Columbia (Parsons 2005), Puget Sound (University of Washington 2007), and Washington Coastal (Parsons 1996) drainages
West Virginia - private pond near Buckhannon of Tygart Valley drainage (Robynn Shannon, Fairmont State Univ., pers. comm.)"

"Established in all states listed above."

From Morgan et al. (2018):

"The sale and transport of *E. densa* is prohibited in Illinois, Indiana, Michigan, Minnesota, and Wisconsin (Great Lakes Panel [on] Aquatic Nuisance Species 2012); but there are no regulations on the sale or transport of *E. densa* in New York, Ohio, Ontario, Pennsylvania, or Quebec. A survey performed from 2002 to 2003 on aquarium and pet stores near Lakes Erie and Ontario found that 35% of stores surveyed sold *E. densa* (Rixon et al. 2005)."

From GISD (2018):

"*E. densa* until 1996 was commonly sold in Washington pet stores under the name 'anacharis' as an aquarium species. *E. densa* was firts [sic] offered for sale in the United States in 1915, where it was recommended as a good \"oxygenator\" plant (The Washington State Department of Ecology, 2003)."

Means of Introductions in the United States

From Swearingen and Bargeron (2016):

"This plant was first introduced into the United States in the late 1800s as an aquarium plant."

Remarks
From Pfingsten et al. (2018):

"*Egeria densa* can be detected using digital imagery, though this ability is highly specialized and pertains to populations near the water surface (Mandvikar and Liu 2004; Jenifer Parsons, WA Dept. of Ecology, pers. comm.). It is often sold in the name "Anachris" and is advertised to aquarium customers as an oxygenator. It is on Oregon's and Washington's quarantine lists as Class B noxious weeds, thus illegal to sell or ship to those states (Hamel and Parsons 2001; ODA 2015; W[S]DA 2015)."

"Nonindigenous *E. densa* populations in Río Cruces, Chile have similar genotypes as populations in Western Oregon, suggesting that the two populations experienced similar bottlenecking events at introduction, or there is a lack of genetic diversity in the native population (Carter and Sytsma 2001)."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing
From ITIS (2018):

"Taxonomic Status:
Current Standing: accepted"

"Kingdom Plantae
 Subkingdom Viridiplantae
  Infrakingdom Streptophyta
   Superdivision Embryophyta
    Division Tracheophyta
     Subdivision Spermatophytina
      Class Magnoliopsida
       Superorder Lilianae
        Order Alismatales
         Family Hydrocharitaceae
          Genus *Egeria*
           Species *Egeria densa* Planch."

From Pfingsten et al. (2018):

"Synonyms and Other Names: *Anacharis densa* (Planch.) Victorin, *Elodea densa* (Planch.) Caspary, *Philotria densa* (Planch.) Small & St. John, leafy elodea, dense waterweed, Brazilian elodea"

From CABI (2018):

"The classification of this species as *Egeria densa* was established by Planchon in 1849 when he created the genus. Later, it was moved to the genus *Elodea* where it remained for a long time, and even today this binomial, *Elodea densa*, can be found in some publications. It is generally accepted at present that the original classification as part of the genus *Egeria*, shall be maintained."

Size, Weight, and Age Range

From Pfingsten et al. (2018):

"3-5 m long, up to 8 cm diameter (Cook and Urmi-König 1984)."

Environment

From Morgan et al. (2018):

"*Egeria densa* can inhabit waters with a wide range of temperatures, low CO2 levels, and low light levels. […] The plant can overwinter as seeds, dormant shoots, or semi-dormant shoots until temperatures rise above 15°C (Parsons and Cuthbertson 2001). *Egeria densa* exhibits the C4 pathway and utilizes HCO3-; thus it is able to photosynthesize in waters with low CO2 levels (Casati et al. 2000). *Egeria densa* can tolerate high phosphorous levels, but is susceptible to iron deficiency (Parsons and Cuthbertson 2001). This species has a low light requirement and can thrive in turbid environments (Parsons and Cuthbertson 2001). Optimal light intensity is about 100 lux. *Egeria densa* cannot tolerate high light intensities or high levels of ultra-violet and blue light, as it experiences chlorophyll damage to light levels of 1250 lux. *Egeria densa* cannot tolerate high UV-B radiation, as it can damage the enzymes involved in photosynthesis and can reduce photosynthetic capacity (Casati et al. 2002)."

From Yarrow et al. (2009):

"For *E. densa*, it appears that growth is relatively constant in the range between 16 °C and 28 °C [water temperature] (Barko & Smart 1981). Although gross photosynthesis increases over this range, respiration also increases, notably above 16 °C, limiting biomass production. At 32 °C, this species showed morphological changes such as reduced shoot number and length and displayed a net photosynthetic rate significantly lower than that observed at 16 °C. This would indicate that the species reaches an upper temperature bound for optimal growth above 32 °C. However, Haramoto & Ikusima (1988) indicate that when this species demonstrates summer-type growth, it can thrive at 35 °C. Most species of macrophyte die or become dormant at temperatures below 3 °C (Lacoul & Freedman 2006). *E. densa* appears to have some degree of tolerance for cold waters: it can survive winter in a ditch under a cap of ice (Haramoto & Ikusima 1988). However, freezing is lethal (Leslie, 1992)."

Climate/Range

From Yarrow et al. (2009):

"Currently, this species is naturalized in […] subtropical and temperate regions (Fig. 2 [in source material])."

From GISD (2018):

"Pierini and Thomaz (2004) state that, […] "*E. densa* is primarily invasive in temperate environments.[…]""

Distribution Outside the United States

Native

From Pfingsten et al. (2018):

"South America (central Minas Gerais region of Brazil, coast of Argentina, and coast of Uruguay) (Cook and Urmi-König 1984)"

From Yarrow et al. (2009):

"The original distribution of *Egeria densa* ranges from the central Minas Gerais region of Brazil to the coastal areas of Uruguay and Argentina. It is common in the Paraná basin of Argentina."

Introduced

GISD (2018) lists *Egeria densa* as alien, invasive, and established in Australia, Chile, Denmark, France, Tahiti Island (French Polynesia), Germany, Japan, New Zealand, South Africa, and Swaziland.

CABI (2018) lists *Egeria densa* as present with no status in the Republic of Georgia, Indonesia, Nepal, Turkey, Chile, Paraguay, Belgium, Hungary, Russian Federation, and Spain. *E. densa* is listed as introduced in Mexico, Costa Rica, Nicaragua, Bolivia, Colombia, and Australia. *E. densa* is listed as introduced and invasive in Cuba, France, Germany, Italy, Netherlands, Switzerland, UK, Cook Islands, French Polynesia, and New Zealand.

DAISIE (2018) lists *Egeria densa* as alien and established in Austria, Azores, Belgium, the European part of Russia, France, Germany, Great Britain, Italy, Spain, Switzerland, and Turkey. *E. densa* is listed as alien and not established in Hungary. *E. densa* is listed as alien and status unknown in England, Ireland, and Wales.

NOBANIS (2018) lists *Egeria densa* as established and invasive in Belgium and the European part of Russia; as established and potentially invasive in Iceland and the Netherlands.

Pagad et al. (2018) lists *Egeria densa* as alien in Australia, Austria, Belgium, Bolivia, Canada, Chile, Colombia, Cook Islands, Costa Rica, Cuba, Czech Republic, France, Germany, Iceland, Ireland, Japan, Mexico, New Zealand, Nicaragua, Portugal, Russian Federation, Slovakia, South

Africa, Spain, Sri Lanka, Swaziland, Switzerland, Taiwan, Turkey, United Kingdom, Zimbabwe, Kenya, and Uganda.

From Pfingsten et al. (2018):

"*Egeria densa* has invaded New Zealand (Coffey and Clayton 1986), Japan (Haramoto and Ikusima 1988; Hamabata and Kobayashi 2002), Chile (Cook and Urmi-König 1984) and Australia (Roberts et al. 1999) and numerous areas across Europe (Dutartre et al. 1999). *Egeria densa* is declared a weed in Argentina (Walsh et al. 2013) and in Tasmania, Australia (Parsons and Cuthbertson 2001). *Egeria densa* has been reported in Bogakain Lake, Bangladesh in 2010 (Alfasane et al. 2010)."

From Wasowivz et al. (2014):

"Here we report the spread of two invasive, aquatic plants, *Vallisneria spiralis* L. and *Egeria densa* Planch., to the subarctic and arctic areas of Iceland, facilitated by the occurrence of a novel habitat: geothermally heated water bodies."

From GISD (2018):

"Growns et al. (2003) report that, more than 70% of the biomass of aquatic macrophytes in the Hawkesbury-Nepean River system comprised an alien macrophyte, *Egeria densa*."

"Dutartre et al. 1999 report that, *E. densa* was first observed in France in 1960. Feuillade reported it in a reservoir in the Manche in Western Normandy."

"*Egeria densa* was probably introduced to some rivers of Tahiti with dumped aquarium water, is now invasive in Tahiti's only freshwater lake, Lake Vaihiria (Meyer, pers. comm., 2007). The species has been declared a Species that threatens biodiversity (CM 65 Order of 23 January 2006)."

"Decree No. 65 CM of January 23, 2006 [French Polynesia] presents a list of 35 invasive plants declared to be Species that threaten biodiversity, one of which is *Egeria densa*. These plants are subject to a ban on new imports, propagation and planting, and prohibition of transfer from one island to another of any whole plant, fragment of plant, cutting, fruit or seed."

"Hamabata and Kobayashi (2002) state that, Another [*sic*] water weed, *Egeria densa*, appeared in Lake Biwa [Japan] in 1969 (Miura 1980), and its distribution peaked during the 1970s when the submerged plant zone in the southern basin was covered exclusively by this species (Tanimizu & Miura 1976)."

"*E. densa* has been designated as a Total Control and Surveillance Pest by the Auckland Regional Pest Management Pest Management Strategy 2002-2007."

"*E. densa* is designated as an Unwanted Organism by Environment Canterbury. Please see the Pest management strategy Part II 3.1 for defintions [*sic*] of classification of pests."

"*E. densa* has been designated as a Total control pest by the the [*sic*] Tasman-Nelson Regional Pest Management Strategy. The strategy has its effect over the combined area that lies within the administrative boundaries of the Tasman District Council and Nelson City Council. The objective of the strategy is to eradicate known infestations of *E. densa* in the Tasman-Nelson region by 2006."

"*E. densa* is classified as a "Potential Plant Pest" by Environment Waikato, which means it is recognised as a potentially invasive weed in the Waikato Region."

"*E. densa* is designated as an aquatic pest plant by the West Coast Pest Plants Management Strategy."

From NIES (2018):

"Keeping of this species in Saga Pref. [Japan] are controled [*sic*] by a prefectural ordinance."

Means of Introduction Outside the United States

From GISD (2018)

"*Egeria densa* was probably introduced to some rivers of Tahiti with dumped aquarium water, […]."

From Pfingsten et al. (2018):

"Introduced world-wide through the aquarium trade - sold widely as good "oxygenator" plant and dispersed secondarily by boat trailers and vegetative dispersal downstream.
This species may be transported by hitchhiking on recreational gear; *E. densa* grows in thick mats that can become entangled on boat propellers and trailer wheels, or can be captured in bilge water (Washington State Department of Ecology 2013). Attached fragments can be transported between water bodies. *Egeria densa* is not known to be taken up in ballast water. As a popular ornamental plant, *E. densa* is planted in water gardens (Indiana Department of Natural Resources 2013), however, there is not enough information available to determine the frequency of *E. densa* plantings."

From CABI (2018):

"*E. densa* is spread by moving waters which carry whole plants or stem fragments to new locations. It is also possible that animals may also unintentionally carry stem fragments. […] The principal cause of new introductions is, however, from the careless disposal of aquarium contents, including *E. densa*, into local watercourses."

Short Description

From Swearingen and Bargeron (2016):

"Appearance
Egeria densa is a submersed aquatic plant that invades freshwater systems throughout much of the United States. Often confused with hydrilla, *Egeria densa* has a smooth midrib on the underside of the leaf, whereas hydrilla has small teeth.
Foliage
The finely serrated leaves are usually less than 1 in. (2.5 cm) long and occur in whorls of 3-6.
[…]
Fruit
Outside of its native habitat, *Egeria densa* only reproduces vegetatively. Special double nodal regions can produce lateral buds, branches and roots. Only a double node can produce a new plant when it breaks off from the parent plant."

From Pfingsten et al. (2018):

"Leaves and stems are generally bright green (often dark green when below the surface), and the short internodes give it a very leafy appearance. Leaves which are minutely serrated (needing magnification) and linear, are 1-3 cm long, up to 5mm broad, and found in whorls of four to eight. The lowest leaves may be opposite or in whorls of 3; middle and upper leaves are in whorls of 4 to 8. Stems are erect, cylindrical, simple or branched, and grow until they reach the surface of the water where they form dense mats. Flowers (18-25 mm diameter) have three petals which are white and float on or rise just above the water's surface on a slender peduncle. Slender roots are unbranched and typically a white to pale color. Adventitious roots are freely produced from double nodes on the stem (Washington State Department of Ecology 2003). It can be distinguished from *Hydrilla verticillata* (L.f.) Royle by the absence of turions (dormant buds from above ground stems) and tubers (dormant buds from below ground stems), and by the presence of showy white flowers that are produced above the water surface (Hoshovsky and Anderson 2001). It is usually rooted in the bottom mud, but can be found as a free-floating mat or as fragments with stems near the surface of the water."

From CABI (2018):

"Leaves sessile, lanceolate, […], apex rounded or acute, […], intensely green when receiving natural light, more pale in aquaria. […] From the axils of some leaves arise spathes and from their interior emerge floral peduncles 2-6 cm long, that expose solitary flowers ca. 2 cm above the water surface. Male flowers are in groups of 2-4, from one spathe, the perianth formed by a calyx of 3 green sepals, corolas with 3 white petals, 10-15 mm long, stamens 9. Female flowers one per spathe, perianth like that of males, ovary unilocular formed by 3 carpels, androecium only residual with 3 yellow staminodes. Fruits are berry-like, ovate, 7-8 mm long and 3 mm wide with membranaceous and transparent pericarp. Seeds numerous, fusiform, 7-8 mm long, with a 2 mm filament present at the end."

Biology

From Pfingsten et al. (2018):

"*Egeria densa* is an aquatic plant in the waterweed family that inhabits mild to warm freshwaters, such as slow flowing streams of warm, temperate, and tropical regions (Parsons and Cuthbertson 2001). It occurs at depths as deep as 7 m. It grows in thick mats of intertwining stems (Parsons and Cuthbertson 2001), which alter the light and nutrients available to the biota where it occurs (Yarrow et al. 2009), acting as an ecosystem engineer (Jones et al. 1994). *Egeria densa* can inhabit waters with a wide range of temperatures, low CO2 levels, and low light levels. This species can survive in waters with temperatures of 3-35°C (Yarrow et al. 2009). The plant can overwinter as seeds (although female plants are not found in the U.S.), dormant shoots, or semi-dormant shoots until temperatures rise above 15°C (Parsons and Cuthbertson 2001). *Egeria densa* exhibits the C4 pathway and utilizes HCO3-; thus it is able to photosynthesize in waters with low CO2 levels (Casati et al. 2000). *Egeria densa* can tolerate high phosphorous levels, but is susceptible to iron deficiency (Parsons and Cuthbertson 2001)."

"This species has a low light requirement and can thrive in turbid environments (Parsons and Cuthbertson 2001). Optimal light intensity is about 100 lux. *Egeria densa* cannot tolerate high light intensities or high levels of ultra-violet and blue light, as it experiences chlorophyll damage to light levels of 1250 lux. *Egeria densa* cannot tolerate high UV-B radiation, as it can damage the enzymes involved in photosynthesis and can reduce photosynthetic capacity (Casati et al. 2002)."

"Flowers float above the water surface and are pollinated by insects (Parsons and Cuthbertson 2001). It reproduces asexually in Australia (Parsons and Cuthbertson 2001) and in the U.S. (Hoshovsky and Anderson 2001), where only the male plant has established. *Egeria densa* is capable of vegetative fragmentation; stems of at least two nodes can break off from the parent colony and disperse by stream flow (Parsons and Cuthberson 2001). Stem fragments that break off can take root in bottom mud or grow as free-floating mats (Hoshovsky and Anderson 2001). Fragmentation can occur as a result of the mechanical shearing of water flows, wave action, waterfowl activity, and boating."

From CABI (2018):

"Physiology and Phenology

E. densa is a plant with a great capacity of photosynthesizing when illuminated and releases great quantities of oxygen, which can be observed by small bubbles forming on the leaves."

From Yarrow et al. (2009):

"Haramoto & Ikusima (1988) calculated a relative growth rate (RGR) of 0.049 day-1 at 20.7° C. At a high altitude reservoir in Colombia, Carrillo et al. (2006) reported an average in situ RGR of 0.017 day-1 (range 0.003-0.035) at an average temperature of 15-17 °C. Pistori et al. (2004) found that RGR ranged from 0.009-0.063 day-1 over a period of 44 days and that *E. densa* showed a logistic growth curve under laboratory conditions."

From GISD (2018):

“In North America the Washington State Department of Ecology (2003) states that, […] "[…] Getsinger describes the life cycle of *Egeria densa* in Lake Marion, South Carolina as follows: Two major growth flushes occur in spring and fall. Each of these flushes are followed by periods of senescence, with a loss of biomass through sloughing and decay of tips and branches. Flowers are produced in late spring and again in the fall. The intensity of flowering varies from year to year. During the summer, profuse branching forms a canopy. The branches form dense, tangled mats on the water's surface. […]" In Japan the following Life cycle stages were noted in a scientific study by Haramoto and Ikusima (1998): […] "The seasonal activity of photosynthesis and respiration was measured in March, August and December. The optimum temperature of net photosynthesis of the summer-type plants reached a high 35°C similar to that of the C4 plant. The compensation for light intensity at 35°C was 340 lux. Each photosynthesis-temperature curve suggested that *Egeria* had the ability to adapt to the seasonal changes in temperature in the natural habitat. The maximum starch concentrations reached 25.4% in the leaf and 22.6% in the stem in December. The shortage in the balance of organic matter for over-wintering was found to be maintained by stored starch in the leaf and the stem. […]""

“The Washington State Department of Ecology (2003) states that, […] "[…] Specialized nodal regions described as double nodes occur at intervals of 6 to 12 nodes along a shoot. A double node consists of 2 single nodes separated by a greatly shortened internode. Double nodes produce lateral buds, branches, and adventitious roots. Only shoot fragments of *E. densa*, which contain double node regions, can develop into new plants. The plant fragments readily and each fragment containing a double node has the potential to develop into a new plant. Plant root crowns also develop from double nodes along an old shoot. When a shoot sinks to the bottom during fall and winter senescence, a new root crown may develop at one or several double nodes along the new shoot. *Egeria densa* lacks specialized storage organs such as rhizomes or tubers and stores carbohydrates in stem tissues. […]"”

Human Uses

From GISD (2018):

“*E. densa* has been introduced worldwide through the aquarium trade. *E. densa* until 1996 was commonly sold in Washington pet stores under the name 'anacharis' as an aquarium species. *E. densa* was firts [sic] offered for sale in the United States in 1915, where it was recommended as a good […]"oxygenator[…]" plant (The Washington State Department of Ecology, 2003). Lara et al. (2002) states that, […]"Among the higher aquatic plants, *E. densa* has been the preferred material for a number of different studies in plant physiology. […] These properties, together with the leaf polarity displayed by *E. densa*, represent an advantage for different kinds of research and make this species one of the model organisms of the plant kingdom for experiments, such as electro-physiology.[…]"”

From Morgan et al. (2018):

"*Egeria densa* is also utilized in plant biology classes for students to study photosynthesis (Berkel[e]y 2014)."

Diseases

No information on parasites or pathogens of *Egeria densa* was available.

Threat to Humans

From CABI (2018):

"*E. densa* is an environmental weed not affecting cultivated crops to any extent, though may impact on agriculture by the blockage of irrigation channels."

From Morgan et al. (2018):

"*Egeria densa* may pose a risk to human safety. In 2006, police reports indicate that *E. densa* may have contributed to the death of a physician in San Joaquin County, who drowned after becoming entangled in the "tentacle-like Delta weeds trap" in attempts to save his nephew (Breitler 2006, Victorian DPI 2013)."

3 Impacts of Introductions

From Wasowivz et al. (2014):

"*E. densa* has already started to displace the natural vegetation and is now the dominant aquatic plant there [Iceland], reproducing by fragmentation and often forming dense monotypic stands, especially during the winter when other aquatic plants are dormant (Þórðarson, 2010).

From Santos et al. (2011):

"*E. densa* has been observed to cause this type of sequential replacement [invasion meltdown (Simberloff and Holle 1999)] of aquatic species in New Zealand lakes (Wells et al. 1997), in the River Erft (Germany) (Hussner and Losch 2005), and in France (Thiebaut 2007). In each case, in shallow water *E. densa* displaced other submersed aquatic plant species after it became established."

From Yarrow et al. (2009):

"As an invasive species, *E. densa* can negatively affect ecosystem functions and services. For example, large quantities of *E. densa* biomass frequently cause problems with irrigation systems and hydroelectric generation infrastructure (Thomaz & Bini 1998, Roberts et al. 1999). The dense canopies of *E. densa* favor mono-specific stands which can lower biodiversity through competition and exclusion (Roberts et al. 1999). The presence of invasive submerged macrophytes in New Zealand led to significant decrease in size and diversity of the sediment seed bank. This in turn can decrease the resilience of aquatic system to disturbances that could remove the one or few dominant species (Winton & Clayton 1996)."

"Interestingly, much of the research on the genus *Egeria* in Brazil deals with its expansion into reservoirs and problems with blockage of hydroelectric equipment (Thomaz & Bini 1998, Barreto et al. 2000). As an example, there are now over 130 dams with a height over 10 m in the upper Paraná River basin (Thomaz & Bini 1998). *E. densa* and *E. najas* have expanded into many of the reservoirs created by these dams (Pelicice & Agostinho 2006)."

"E. densa removed from plots in the shallows of a Brazilian reservoir regained its original biomass in about three months, even when removal was repeated five times consecutively (Oliveira et al. 2005)."

From Pfingsten et al. (2018):

"Dense stands of *E. densa* may restrict water movement, trap sediment, and cause fluctuations in water quality (Hoshovsky and Anderson 2001; Parsons and Cuthbertson 2001). Severe infestations may impair recreational uses of a water body including navigation, fishing, swimming, and water skiing. In Brazil, *E. densa* (as well as *E. najas*, *Ceratophyllum demersum*, and *Eichhornia crassipes*) have severely infested hydropower reservoirs. It was estimated that 48,000 cubic meters of aquatic weeds were removed from water intake structures in Jupia Reservoir (Marcondes et al. 2000)."

From Morgan et al. (2018):

"*Egeria densa* acts as an ecosystem engineer by preventing the resuspension of sediments and controlling light and nutrient availability (Yarrow et al. 2009). The dense growth of *E. densa* can retard water flow and reduce turbidity (Parsons and Cuthbertson 2001). This species can reduce the abundance and diversity of native plant seeds in lake bottoms due to increased sediment accumulation under its weed beds (Hoshovsky and Anderson 2001). *Egeria densa* removes nutrients from the water column, thereby decreasing the standing stock of phytoplankton (Yarrow et al. 2009)."

"*Egeria densa* can outcompete native species. In Duck Lake, Washington, *E. densa* displaced native stonewart, elodea, and pondweed in a period of 3 years (Washington State Department of Ecology 2013). In Hawkesbury-Negean River, Australia, evidence suggests that *E. densa* outcompeted native vallisneria (*Vallisneria americana*) for light (Roberts et al. 1999) […]."

"In New Zealand, there was an infestation of *E. densa* in the Wikato River that clogged the water intake pipes resulting in the shut-down of an electrical plant (Washington State Department of Ecology 2013)."

"*Egeria densa* can inhibit recreational activities as a nuisance for navigation, fishing, swimming, and water skiing (Washington State Department of Ecology 2013). The removal of *E. densa* is costly; Washington local and state governments spend thousands of dollars each year to control the species. *Egeria densa* may pose a risk to human safety. In 2006, police reports indicate that

E. densa may have contributed to the death of a physician in San Joaquin County, who drowned after becoming entangled in the "tentacle-like Delta weeds trap" in attempts to save his nephew (Breitler 2006, Victorian DPI 2013)."

From CABI (2018):

"Removal of *E. densa* from lakes and reservoirs in the USA costs some states several million dollars per annum."

From GISD (2018):

"Barreto et al. (2000) state that, […]"In southeast Brazil *E. densa*, together with *E. najas*, causes great annual losses to the hydroelectric companies. Interruptions of electricity generation and damage to grids and equipment are common in reservoirs belonging to CESP in São Paulo.[…]""

4 Global Distribution

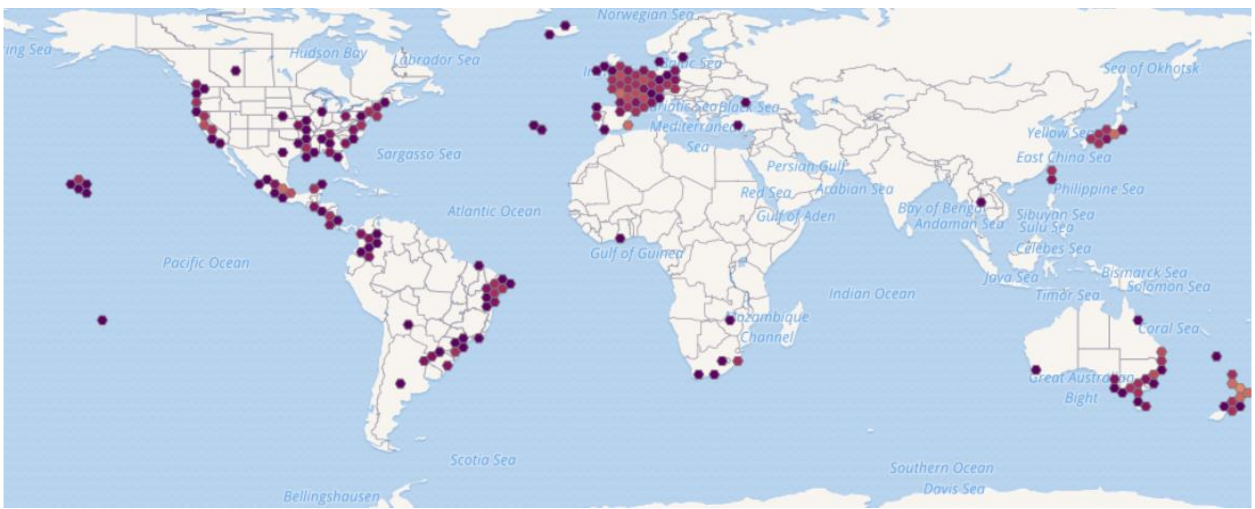

Figure 1. Known global distribution of *Egeria densa*. Map from GBIF Secretariat (2018).

The location in Canada was not used as a source point for the climate match. The record indicates that it is the result of a specimen cultivated in a greenhouse and the location given is the herbarium where the specimen is stored (GBIF Secretariat 2018).

The location in Ghana was not used as a source point for the climate match. The record contained an image of the herbarium specimen which was originally identified as *Lagarosiphon hydrilloides* (GBIF Secretariat 2018) which is a species native to Africa.

The location in Thailand was not used as a source point for the climate match. The basis of the record is unknown (GBIF Secretariat 2018) and no other sources indicate the presence of *Egeria densa* in Thailand.

The location in northern Taiwan was not used as a source point for the climate match. The location of the record is given as the herbarium where the specimen in housed and not where it was collected (GBIF Secretariat 2018).

The locations in Iceland were not used as source points for the climate match. The records are the result of wild populations but according to Wasowivz et al. (2014), *Egeria densa* can only persist in geothermally heated water in Iceland. Those conditions are not reflected in the climate match program therefore the inclusion of these points would produce an erroneous climate match.

5 Distribution Within the United States

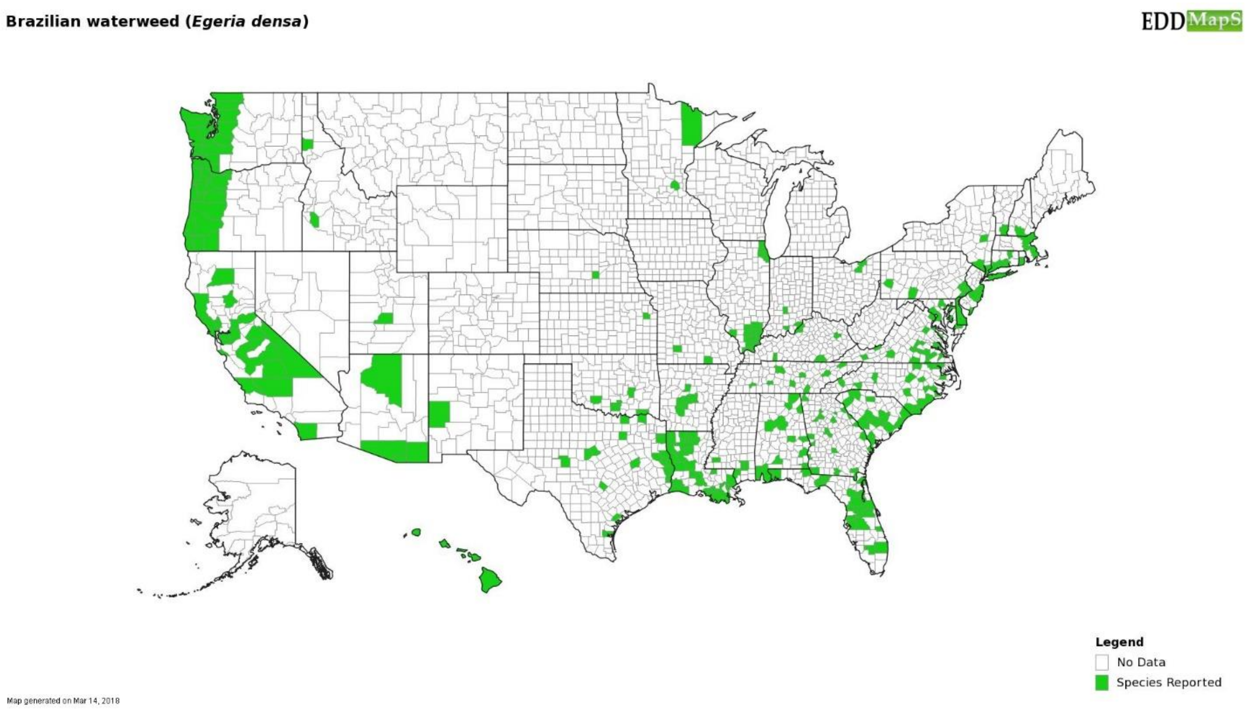

Figure 2. Known distribution of *Egeria densa* by county in the United States. Map from EDDMapS (2018).

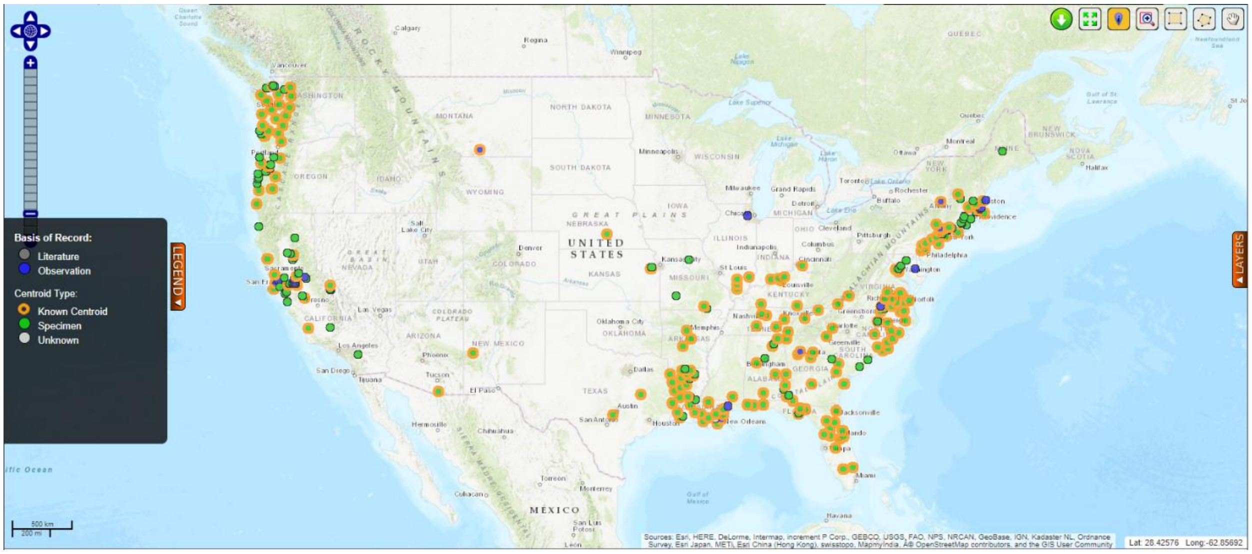

Figure 3. Known distribution of *Egeria densa* in the contiguous United States. Map from BISON (2018).

The location in Montana was used as a source point for the climate match. The record from the National Park Service (accessed through BISON 2018) indicated that it was the first record for *Egeria densa* in Montana.

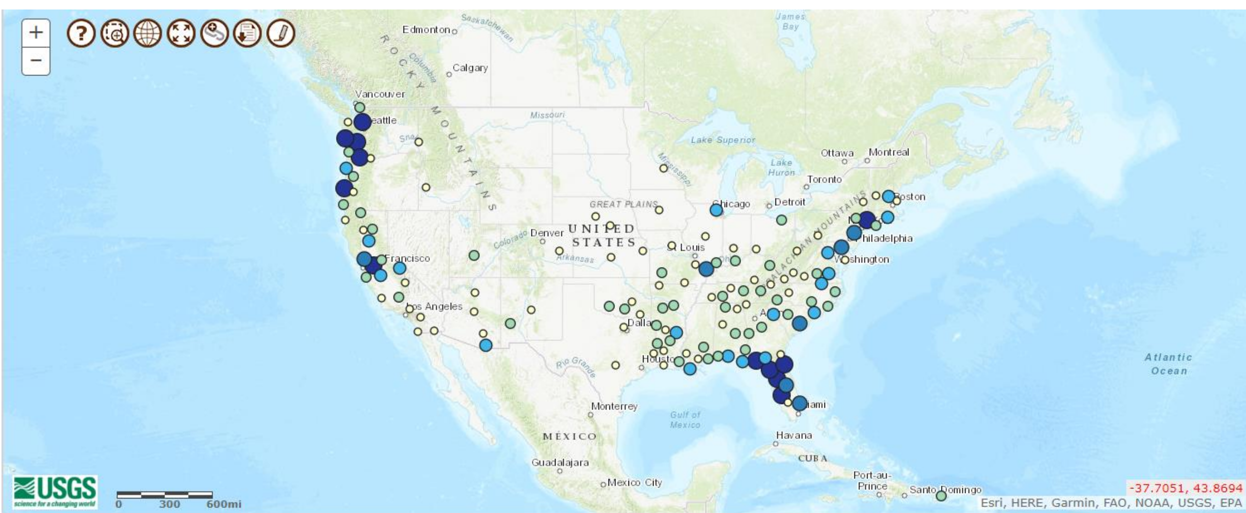

Figure 4. Additional known distribution of *Egeria densa* in the contiguous United States. Map from Pfingsten et al. (2018).

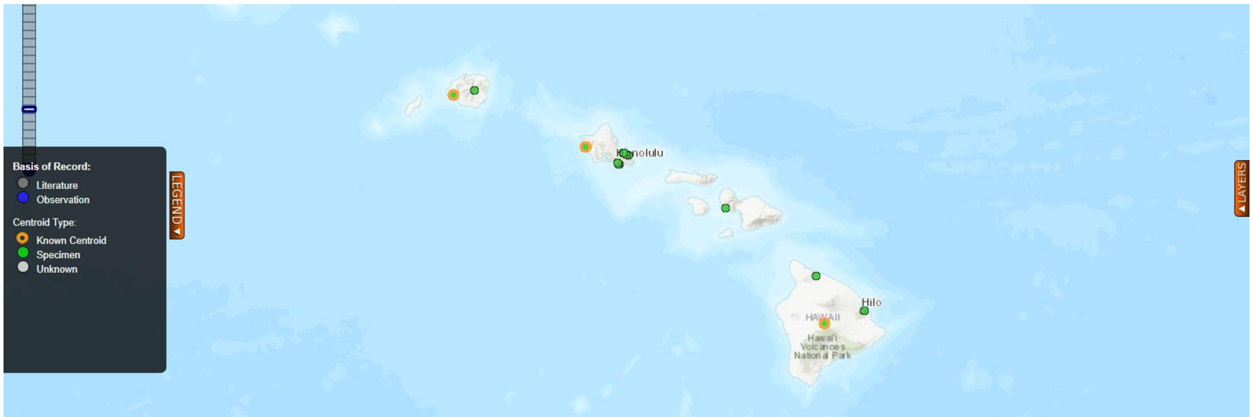

Figure 5. Known distribution of *Egeria densa* in Hawaii. Map from BISON (2018).

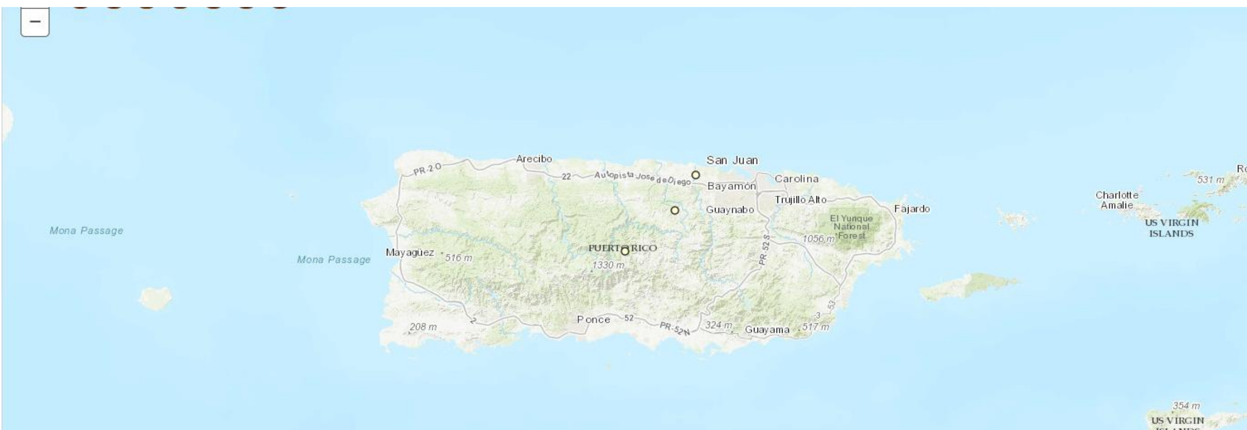

Figure 6. Known distribution of *Egeria densa* in Puerto Rico. Map from Pfingsten et al. (2018).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Egeria densa* was high across most of the contiguous United States. There were small pockets of medium and low match in the Great Plains, southern Texas, and along the Canadian border in the Midwest. Established populations of *E. densa* already occur in many states. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous United States was 0.962, high. All states had individually high climate scores.

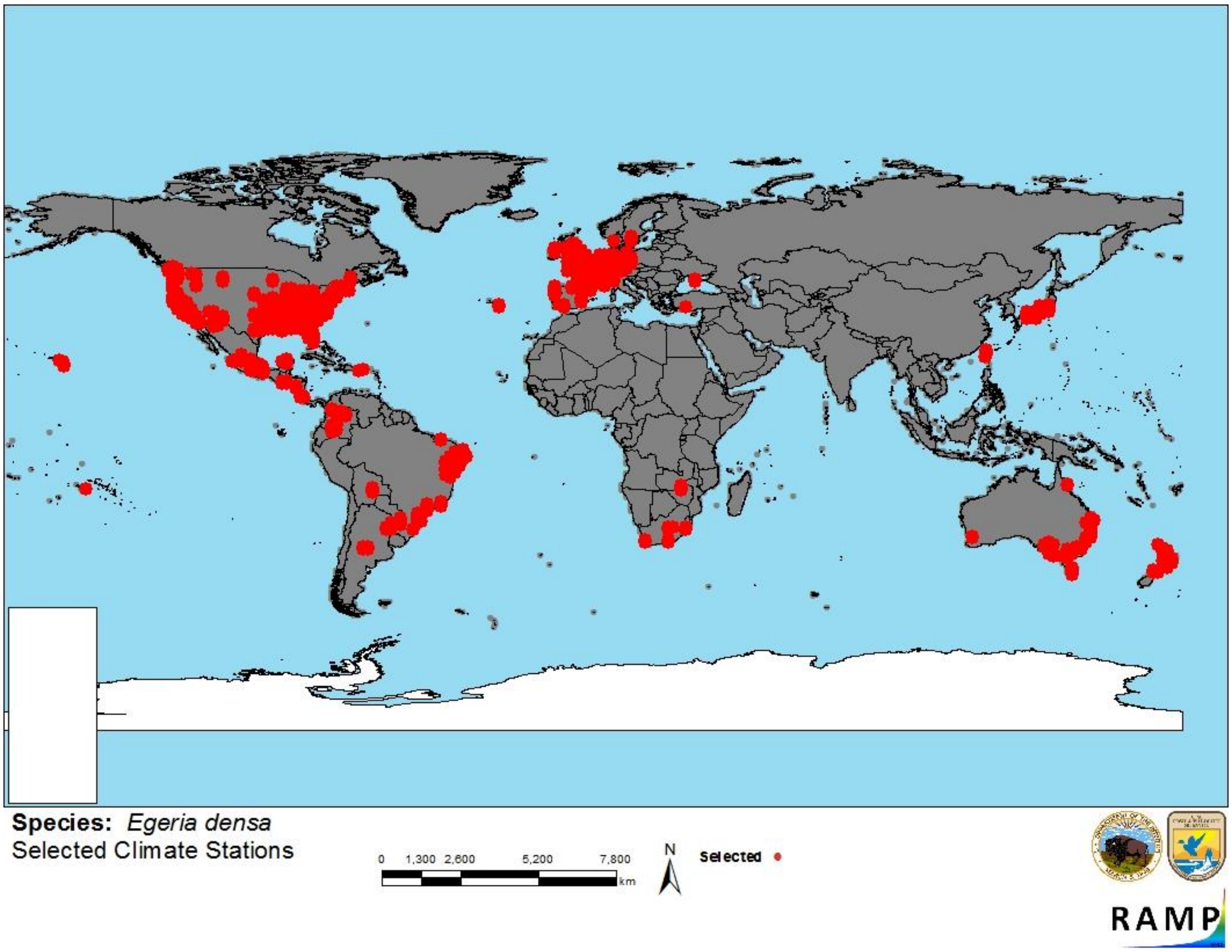

Figure 7. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Egeria densa* climate matching. Source locations from Wasowivz et al. (2014), BISON (2018), EDDMapS (2018), GBIF Secretariat (2018), and Pfingsten et al. (2018).

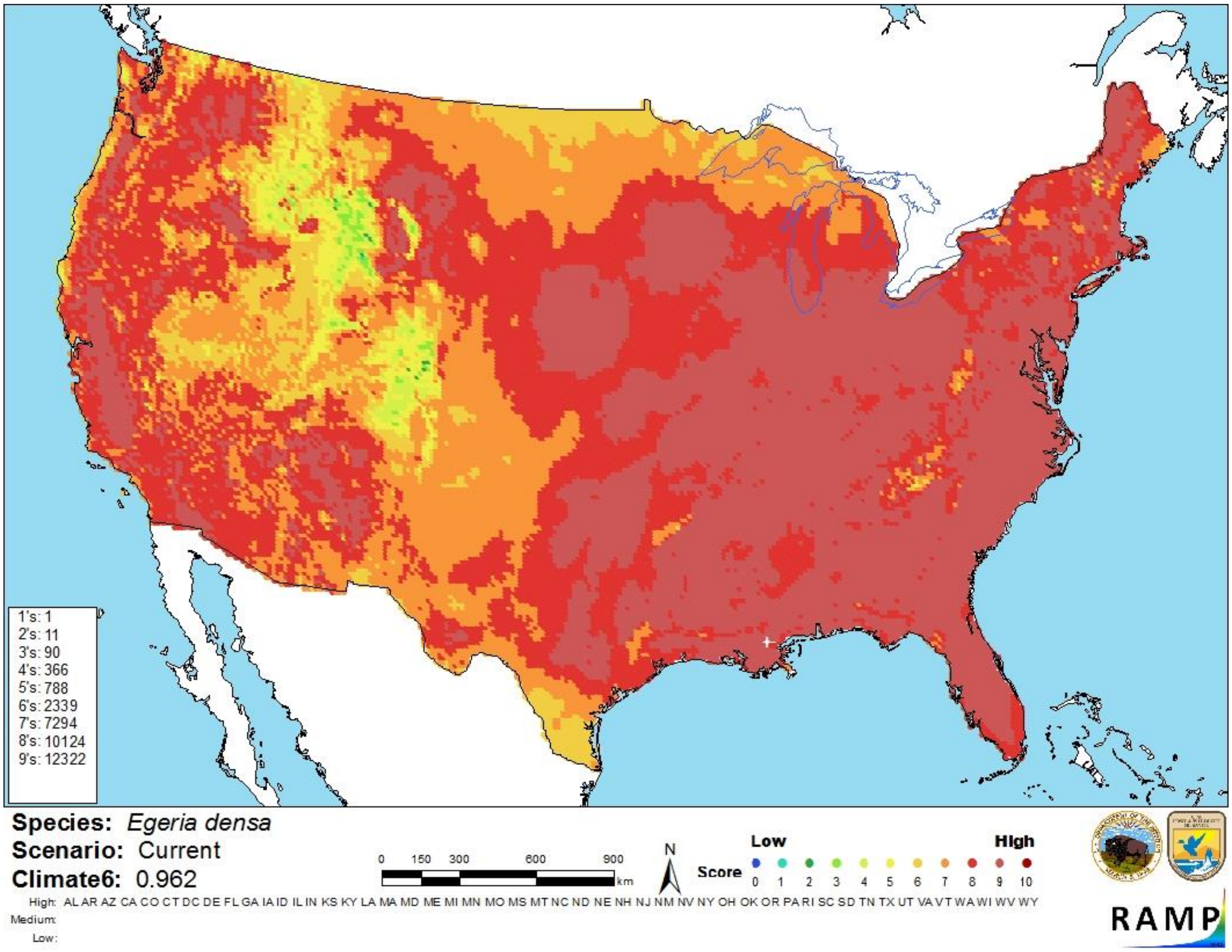

Figure 8. Map of RAMP (Sanders et al. 2014) climate matches for *Egeria densa* in the contiguous United States based on source locations reported by Wasowivz et al. (2014), BISON (2018), EDDMapS (2018), GBIF Secretariat (2018), and Pfingsten et al. (2018). 0 = Lowest match, 10 = Highest match. Counts of climate match scores are tabulated on the left.

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

The certainty of assessment for *Egeria densa* is high. Information on the biology, invasion history, and impacts of this species is available from scientific databases and peer reviewed literature. There is enough information available to describe the risks posed by this species. There are no concerns with the distribution of the species used for the climate match.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Egeria densa is an aquatic macrophyte that has spread from its native range in Brazil, Argentina and Uruguay through the aquarium trade. Like other invasive plants, this species is prolific with broad physiological tolerances. A number of U.S. states have restricted the species as a noxious weed. The history of invasiveness is high. It is now established in countries around the world. Invasive populations have had negative impacts on biodiversity, hydro energy infrastructure, and have even been implicated as contributing to a human death. Climate matching indicated the contiguous United States has a high climate match. There are established *E. densa* populations across most of the country but primarily concentrated along the coasts. The certainty of 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 in many states.
- **Overall Risk Assessment Category: High**

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