Water Lettuce (*Pistia stratiotes*)

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, January 2015
Revised, May 2018, June 2018
Web Version, 8/30/2018

Photo: Forest and Kim Starr. Licensed under Creative Commons BY 3.0. Available: https://www.biolib.cz/en/image/id56873/.

1 Native Range and Status in the United States

Native Range

From Thayer et al. (2018):

"The species is pantropical, occurring on all continents except Antarctica (Adebayo et al. 2011). The center of origin for *P. stratiotes* is unknown. Fossil records for this species can be found around the globe (Stoddard 1989). Ancient Egyptian hieroglyphics depict the plant and Greek botanists Dioscorides and Theophrastus described the plant floating on the Nile River more than

2,000 years ago, indicating African origin (Stoddard 1989). *Pistia stratiotes* in Brazil and Argentina host a large number of co-evolved specialist insect herbivores suggesting a South American origin (Center et al. 2002). In North America, both John and William Bartram described *P. stratiotes* as early as 1765 and 1773, respectively, along the St. Johns River in Florida, up to 300 river km upstream of the ocean inlet where any ballast material would likely have been deposited from trans-oceanic ships (Bartram and Harper 1942; Bartram and Harper 1943). Since plants were found so far upstream from known seaports, a rationale for Florida nativity has been suggested (Evans 2013). Late Pleistocene/early Holocene fossil records for this species in Florida lend support for this contention (Stoddard 1989; Evans 2013)."

From CABI (2018):

"In South and Central America, Africa and South-East Asia it is considered an endogenous species."

CABI (2018) lists *Pistia stratiotes* as native in Brazil, Chile, and the Solomon Islands.

Status in the United States

From Thayer et al. (2018):

"In North America, both John and William Bartram described *P. stratiotes* as early as 1765 and 1773, respectively, along the St. Johns River in Florida, up to 300 river km upstream of the ocean inlet where any ballast material would likely have been deposited from trans-oceanic ships (Bartram and Harper 1942; Bartram and Harper 1943). Since plants were found so far upstream from known seaports, a rationale for Florida nativity has been suggested (Evans 2013). Late Pleistocene/early Holocene fossil records for this species in Florida lend support for this contention (Stoddard 1989; Evans 2013)."

"Established in southern states (Alabama, Arizona, California, Florida, Louisiana, Mississippi, Texas) where plants may overwinter and also germinate from seed (Dray and Center 1989). Plants north of the Gulf states (Colorado, Connecticut, Delaware, Illinois, Kansas, Maryland, Michigan, Minnesota, Missouri, New York, North Carolina, Ohio, Rhode Island, South Carolina, and Wisconsin) likely do not overwinter, and are either extirpated, eradicated, or survive by seed production; the exception being Idaho where populations have established in a hot spring-fed river (Tom Woolf, ID Dept. of Ag., pers.comm.)."

Thayer et al. (2018) list *Pistia stratiotes* as present in Alabama since 2002, Arkansas since 2008, California since 1895, Colorado since 2001, Delaware since 1993, Florida since 1765, Georgia since 1981, Hawaii since 1938, Idaho since 2007, Illinois since 2000, Indiana since 2016, Kansas since 1999, Louisiana since 1958, Maryland since 2003, Michigan since 2011, Minnesota since 2009, Mississippi since 1992, Missouri since 1939, New Jersey since 2010, New York since 2000, North Carolina since 2003, Ohio since 2000, Pennsylvania since 2016, Puerto Rico since 1885, Rhode Island since 2001, South Carolina since 1991, Texas since 1927, U.S. Virgin Islands since 1879, and Wisconsin since 2005.

CABI (2018) lists *Pistia stratiotes* as:

- Present but without an indication of native or introduced status in Arizona, California, Colorado, Delaware, Kansas, Louisiana, Maryland, Mississippi, New Jersey, New York, North Carolina, Ohio, South Carolina, Texas, and the U.S. Virgin Islands
- Introduced and invasive in Alabama and Guam
- Present and invasive but without an indication of native or introduced status in Florida and Puerto Rico
- Introduced in the Northern Mariana Islands

GISD (2017) lists *P. stratiotes* as:

- Alien, established, and invasive in Hawaii and Puerto Rico
- Alien, established, and invasiveness unspecified in Guam
- Cryptogenic, established, and invasiveness unspecified in Northern Mariana Islands
- Established and invasive but status unspecified in Arizona, California, Delaware, Florida, Georgia, Louisiana, Maryland, Mississippi, New Jersey, New York, North Carolina, South Carolina, Texas, and the U.S. Virgin Islands.

USDA, NRCS (2018) lists *P. stratiotes* as native in the contiguous United States, Puerto Rico, and U.S. Virgin Islands and as introduced in Hawaii.

According to USDA, NRCS (2018), *P. stratiotes* is a Class C noxious weed in Alabama, a B list noxious weed in California, a potentially invasive, banned species in Connecticut, a prohibited aquatic plant, Class 2 in Florida, an invasive aquatic plant and plant pest in South Carolina, and a noxious plant in Texas.

From Evans (2013):

"Three arguments about *Pistia* [*stratiotes*] biogeography have been advanced in this paper: 1) existing historic, ecological, and paleo-botanical evidence indicates an apparently ancient, cross-continental distribution for *Pistia* in neo-tropical America, northern Africa, and southern Asia; 2) claims advanced in support of the hypothesis that *Pistia* is non-native to the Florida peninsula are historically, ecologically, and/or logically insufficient for scientific acceptance; and 3) paleo-botanical, historical, and ecological literature provide a compelling basis of support for the hypothesis that *Pistia* meets the consensual definition of a native Florida species."

Means of Introductions in the United States

From Thayer et al. (2018):

"The origin of *Pistia stratiotes* is contentious. Some argue the species is native to North America due to fossil evidence (Evans 2013), while others agree it was dispersed by transcontinental bird migrations (Stoddard 1989) or by dry ballast during early European colonization of North America (Stuckey and Les 1984; Schmitz et al. 1993; Dray and Center 2002)."

"*Pistia stratiotes* was sold through aquarium and pond supply dealers, both online and in retail garden centers (Rixon et al. 2005); it is still offered for sale online and in several states (Rebecca Howard, USGS, pers. comm.). New introductions are probably the result of improper disposal of

ornamental pond plants or waters, or when ponds adjacent to local water bodies overflow (Adebayo et al. 2011)."

Remarks
There is significant uncertainty about the native range of this species. This uncertainty is reflected as accurately as possible in the assessment which results in the presentation of contradictory information in some places.

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 Araceae
Genus *Pistia*
Species *Pistia stratiotes* L."

Size, Weight, and Age Range
From Thayer et al. (2018):

"Size: Rosette generally 6 to 30 cm in diameter (Godfrey and Wooten 1981)"

Environment
From CABI (2018):

"Chadwick and Obeid (1966) reported that optimal growth of *Pistia* was obtained in water cultures at a pH of approximately 4. Such a high acidity, however, was never found in heavily infested waterbodies. It was shown by Pieterse et al. (1981) that the plant performs best in water with a pH of 7. *Pistia* showed particularly vigorous growth, although with a relatively small root system, in polluted water in Nigeria (Sharma, 1984)."

From Thayer et al. (2018):

"This species does not tolerate freezing temperatures, although its seeds can survive submerged in water that is 4°C for at least 2 months (Parsons and Cuthbertson 2001). *Pistia stratiotes* has a low saline tolerance; plants cannot survive in waters with more than 2.5 ppt salinity (Sculthorpe 1967; Haller et al. 1974)."

Climate/Range

From Šajna et al. (2007):

"[…] widely distributed in tropical and sub-tropical regions."

From CABI (2018):

"The growth area of *Pistia* seems to be limited by low temperatures (see Small, 1933; Muenscher, 1967; Wiggins, 1980). However, scattered ephemeral populations have been reported in cold climates in the Netherlands, the Erie Canal in upstate New York and in Lake Erie in northern Ohio (Dray and Center, 2002)."

"Though the seeds are able to survive in ice at -5°C for a few weeks, germination does not occur below 20°C."

Distribution Outside the United States

Status Uncertain

From CABI (2018):

"While Blake (1954) and others indicate that it was introduced into Australia some 50 years ago (it was first observed during a survey in 1946/47), Gillet et al. (1988) present evidence for it being indigenous in the Northern Territory. Parsons and Cuthbertson (2001) reference a record in the Northern Territory from 1887, where a complement of organisms naturally regulates its population. Since *P. stratiotes* has not been recorded at nuisance levels in this area, it is highly possible that northern Australia is part of the plant's native range."

CABI (2018) lists *Pistia stratiotes* as:

- Present but without an indication of native or introduced status in Afghanistan, Angola, Antigua and Barbuda, Argentina, Australia, Bangladesh, Belize, Bolivia, Burundi, Cameroon, Canada, Central African Republic, Chad, Colombia, Comoros, Congo Democratic Republic, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Ethiopia, France, French Guiana, Gabon, Gambia, Germany (formerly present), Ghana, Guadeloupe, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Israel, Jamaica, Japan, Lesotho, Liberia, Madagascar, Malawi, Mali, Martinique, Mauritania, Mauritius, Mexico, Montserrat, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Rwanda, Saint Vincent and the Grenadines, Senegal, Sierra Leone, Singapore, Somalia, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Tanzania, Togo, Trinidad and Tobago, Uruguay, Venezuela, Vietnam, Zambia
- Present and invasive but without an indication of native or introduced status in Benin, Burkina Faso, Côte d'Ivoire, Kenya, Malaysia, Philippines, South Africa, Thailand, Uganda, Vanuatu, and Zimbabwe.

GISD (2017) lists *P. stratiotes* as:

- Cryptogenic, established, and invasiveness unspecified in Cambodia, China, Cook Islands, Indonesia, Malaysia, New Caledonia, New Guinea, Philippines, Seychelles, Solomon Islands, Thailand, Vanuatu, and Vietnam
- Established with both status and invasiveness unspecified in Guadeloupe, Martinique

Native

From Thayer et al. (2018):

"The species is pantropical, occurring on all continents except Antarctica (Adebayo et al. 2011). The center of origin for *P. stratiotes* is unknown. Fossil records for this species can be found around the globe (Stoddard 1989). Ancient Egyptian hieroglyphics depict the plant and Greek botanists Dioscorides and Theophrastus described the plant floating on the Nile River more than 2,000 years ago, indicating African origin (Stoddard 1989). *Pistia stratiotes* in Brazil and Argentina host a large number of co-evolved specialist insect herbivores suggesting a South American origin (Center et al. 2002). In North America, both John and William Bartram described *P. stratiotes* as early as 1765 and 1773, respectively, along the St. Johns River in Florida, up to 300 river km upstream of the ocean inlet where any ballast material would likely have been deposited from trans-oceanic ships (Bartram and Harper 1942; Bartram and Harper 1943). Since plants were found so far upstream from known seaports, a rationale for Florida nativity has been suggested (Evans 2013). Late Pleistocene/early Holocene fossil records for this species in Florida lend support for this contention (Stoddard 1989; Evans 2013)."

From CABI (2018):

"In South and Central America, Africa and South-East Asia it is considered an endogenous species."

CABI (2018) lists *Pistia stratiotes* as native in Brazil, Chile, and the Solomon Islands.

Introduced

From Šajna et al. (2007):

"Only 2 years after its first occurrence in 2001 *P. stratiotes* managed to cover most of the water body where the thermal springs cause an elevated temperature (>17°C year round). […] Observations in December revealed viable seed production and seed presence in the sediment."

"Plants have been spotted in water channels in the Netherlands, and there they have represented a regularly recurring problem since 1973, especially in summer (Mennema, 1977; Pieterse et al., 1981; Venema, 2001). Other sites with recent *P. stratiotes* infestation during summer include the French Jalle de Blanquefort near Bordeaux and Cadiz in SW Spain (García Murillo et al., 2005). Records exist also from Central Europe (Pyšek et al., 2002), and surprisingly even in many ponds and rivers in Moscow and its vicinity (Schanzer et al., 2003)."

CABI (2018) lists *Pistia stratiotes* as:

- Introduced and invasive in Botswana, Brunei Darussalam, Cambodia, Canary Islands, China, Cook Islands, Cuba, French Polynesia, Indonesia, Laos, New Caledonia, New Zealand, Palau, Réunion, Slovenia, and Taiwan
- Introduced in India, Kazakhstan, Portugal, Romania, Russian Federation, Seychelles, Saint Lucia, and Ukraine
- Introduced but not established in Belgium and Czech Republic

GISD (2017) lists *P. stratiotes* as:

- Alien, invasive, and established in Australia, Burkina Faso, Reunion, and Swaziland
- Alien, established and invasiveness unspecified in Bermuda, French Polynesia, Papua New Guinea, and Saint Lucia
- Alien and eradicated in New Zealand

NOBANIS (2018) lists *P. stratiotes* as locally established in Austria, invasiveness not known.

Pallewatta et al. (2003) list *P. stratiotes* as introduced in Bangladesh and Pakistan.

From NIES (2018):

"First introduction was in 1920s in Okinawa and Ogasawara [Japan]. Infested on mainland since 1990s"

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

Means of Introduction Outside the United States

From Šajna et al. (2007):

"The introduction into Europe most likely occurred as an accidental release from aquaria (Pilipenko, 1993) or from horticulture, since it is cultivated widely as an ornamental plant (Venema, 2001; Schanzer et al., 2003)."

From GISD (2017):

"*P. stratiotes* can spread from broken-off pieces or whole plants being moved on boats or fishing equipment from an infested to a clean body of water (Rivers, 2002).According to Ramey (2001), *P. Stratiotes* continues to be sold through aquarium supply dealers and through the internet. Rivers (2002) cites that dumping of aquarium or ornamental pond plants is often the means of spread for *P. stratiotes*."

"*Pistia stratiotes* was deliberately imported by the aquarium trade as an ornamental plant. It was also deliberately planted at two known 'wild' locations but these were successfully and completely eradicated by a successful programme begun in 1979."

Short Description

From Thayer et al. (2018):

"Stem/Roots: *Pistia stratiotes* is a free-floating, herbaceous monocot with a rosette of gray-green leaves, resembling a head of lettuce (thus the common name), occurring as a single plant or connected to others by stolons (Dressler et al. 1987; Langeland and Burks 1998). Roots numerous and feathery."

"Leaves: Leaves are ovate to obovate, up to 15 cm in length, without a leaf stalk, spongy near the leaf base, densely pubescent, with deeply furrowed parallel veins and wavy leaf margins (Godfrey and Wooten 1981; Dressler et al. 1987; Langeland and Burks 1998)."

"Flowers: Flowers inconspicuous, perfect, clustered in leaf axils with a single female flower and multiple male flowers (Langeland and Burks 1998)."

"Fruit/Seeds: Produces abundant seeds with high percentage of seed viability (Dray and Center 1989a, 1989b)."

From CABI (2018):

"The morphology of *Pistia* varies largely owing to the influence of environmental factors. In a survey of two populations in ponds of distinct hydrochemical characteristics, two biotypes were identified that propagate true. The biotypes were distinct regarding biomass, productivity allocation, pH of the cell saps, chlorophyll, nucleic acids, total free amino acid content of the leaves and total nitrogen, crude protein and phosphorus in whole plants (Rao and Reddy, 1984). The leaves rise into the air, but under conditions less favourable for optimal growth they may lie flat on the water."

Biology

From Thayer et al. (2018):

"*Pistia stratiotes* is a free-floating, fast growing, obligate aquatic that can form vast, dense floating mats, covering the entire water surface of lakes and slow moving rivers (Langeland and

Burks 1998). It is the sole species of this genus. In tropical and subtopical climates it is a perennial. In temperate regions the plant behaves as an annual, returning after the winter months from submersed seeds."

"*Pistia stratiotes* reproduces rapidly by vegetative fragmentation from offshoots on short, brittle stolons. Seed production is also considered a major method of reproduction and dispersal (Dray and Center 1989a, 1989b). Plants can be solitary rosettes, or may have more than a dozen stolon-connected ramets or daughter plants. Standing crop may be as high as 2 kg/m2 at the peak of the growing season (Dray and Center 1992). Although vegetative reproduction is thought to be the primary means of propagation, seed crop has been reported to be in excess of 700 seeds/m2 in a stand at a south Florida location, with greater than 80% seed viability (Dray and Center 1989a, 1989b)."

Human Uses

From Thayer et al. (2018):

"*Pistia stratiotes* has the fiber content, carbohydrate, and crude protein levels that are comparable with quality forages (Parsons and Cuthbertson 2001). Research has been conducted to utilize this species for biofuels and water remediation (Mishima et al. 2008; Lu et al. 2010)."

From CABI (2018):

"The widespread distribution in most countries with a tropical climate may be the result of its ancient use as medicine for humans, as well as its use as fodder for cattle and pigs (Sculthorpe, 1971)."

Diseases

No information on parasites or pathogens of *Pistia stratiotes* was found.

Threat to Humans

From Thayer et al. (2018):

"Larvae and pupae of the mosquito genera *Culex* and *Mansonia*, found in the southeastern U.S., attach themselves to the root system of *P. stratiotes* (Lounibos and Escher 1985; Center et al. 2002). These mosquitoes are important vectors of St. Louis Encephalitis (Lounibos and Escher 1985; Petr 2000)."

3 Impacts of Introductions

From Šajna et al. (2007):

"In Slovenia, as early as 3 years after the first observation of *P. stratiotes*, native freshwater plants (*Ceratophyllum demersum* L., *Myriophyllum spicatum* L., *Najas marina* L. and *Trapa natans* L.) in this species-rich wetland habitat were on decline, because the whole water surface was covered with a dense mat that remained closed even during the winter (2004). Dissolved

oxygen values declined by more than 50% when measured under the *P. stratiotes* cover, reaching only 2.5 mg L^{-1}, a critical value for fish survival (measured by the Fisheries Research Institute, Ljubljana 2003)."

From Thayer et al. (2018):

"Dense populations of *P. stratiotes* can clog waterways and make fishing, swimming and boating difficult (Howard and Harley 1998). Thick colonies of water-lettuce block the air-water interface which reduces the amount of dissolved oxygen in the water making it less suitable habitat for fish species (Attionu 1976, Šajna et al. 2007, Sridhar and Sharma 1986). These dense mats can also block animal access to the water and may crowd or shade out native plants upon which other organisms depend for food or shelter (Sculthorpe 1967)."

"Larvae and pupae of the mosquito genera *Culex* and *Mansonia*, found in the southeastern U.S., attach themselves to the root system of *P. stratiotes* (Lounibos and Escher 1985; Center et al. 2002). These mosquitoes are important vectors of St. Louis Encephalitis (Lounibos and Escher 1985; Petr 2000)."

From CABI (2018):

"*P. stratiotes* can seriously interfere with paddy crops (Holm et al., 1977; Waterhouse, 1993). Although no accurate measurement is available of the loss of water needed for agriculture through transpiration from beds of *P. stratiotes*, losses are believed to be considerable (Holm et al., 1977)."

"*P. stratiotes* is one of the major aquatic weeds in tropical and sub-tropical regions. It rapidly forms dense mats which may completely cover the surface of the water. Consequently, such dense stands of *Pistia* may have serious negative effects on the multifunctional human use of waterbodies. These harmful effects include impediment of the transport of irrigation and drainage water, interference with hydro-electric schemes from artificial lakes, hindering navigation and fishing and the creation of habitats favourable for the transmittance of water-borne diseases (Mbati and Neuenschwander, 2005)."

"Cai (2006) reports that growth of *P. stratiotes* causes increases in transparency, nitrate, ammonium, total nitrogen, total phosphorus and total bacteria, as well as a decrease in pH, DO, permanganate index, total plankton and plankton species diversity. The plant also influenced the size structure of planktonic communities, causing a miniaturization of plankton volume. Dray and Center (2002) review additional ecological impacts of *P. stratiotes* and note that they include increased rates of siltation, slowing of water velocities, degradation of fish nesting sites, increased nutrient loading, thermal stratification, increase in alkalinity and fish and macroinvertebrate mortality."

4 Global Distribution

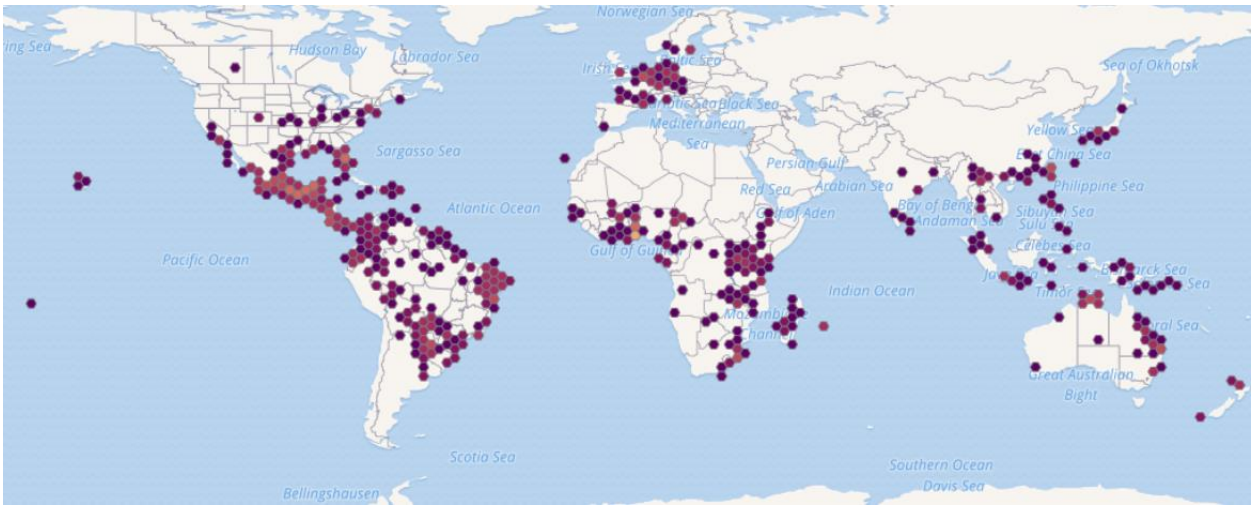

Figure 1. Known global distribution of *Pistia stratiotes*. Map from GBIF Secretariat (2018).

The location in Alberta, Canada was not used as a source point for the climate match. It is the result of a herbarium specimen that was cultivated in a university greenhouse (GBIF Secretariat 2018) and is not representative of an established population.

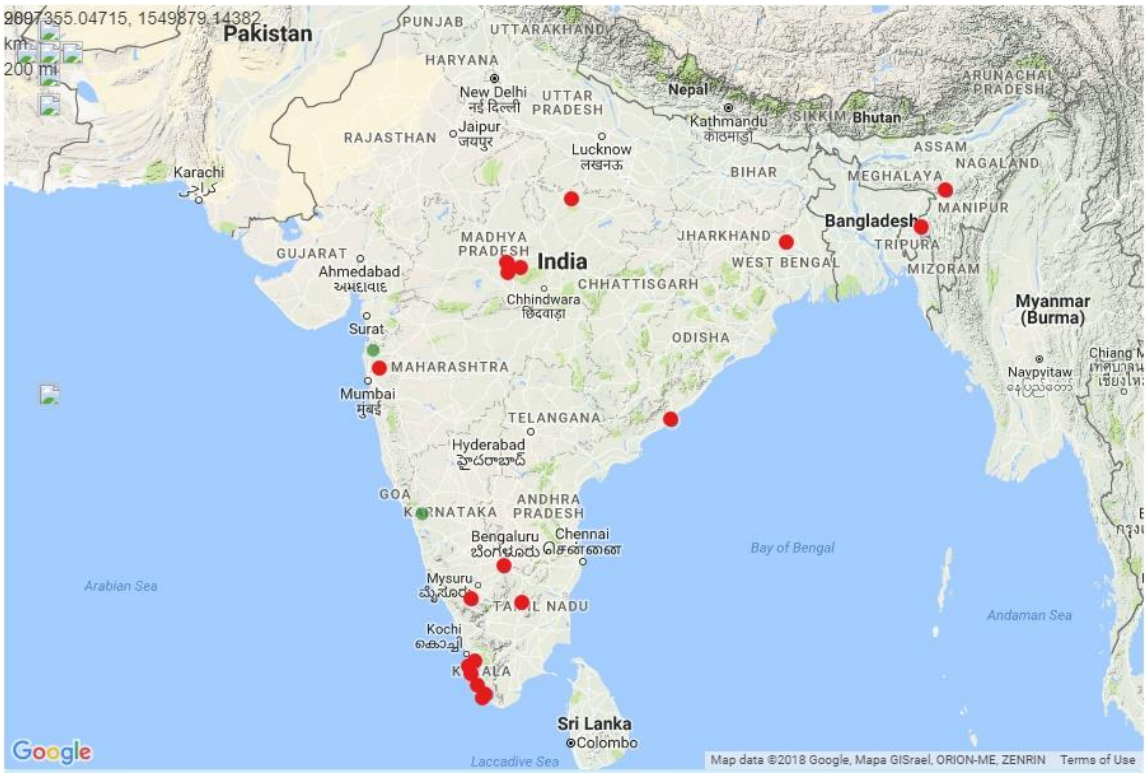

Figure 2. Additional known distribution of *Pistia stratiotes* in India. Map adapted from India Biodiversity Portal (No date).

5 Distribution Within the United States

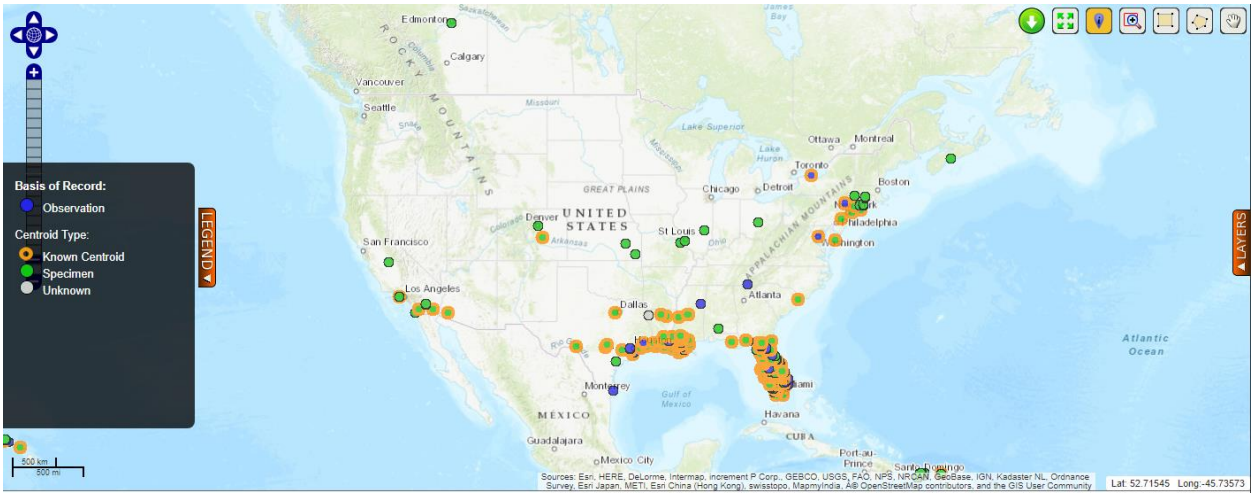

Figure 3. Known distribution of *Pistia stratiotes* in the contiguous United States. Map from BISON (2018).

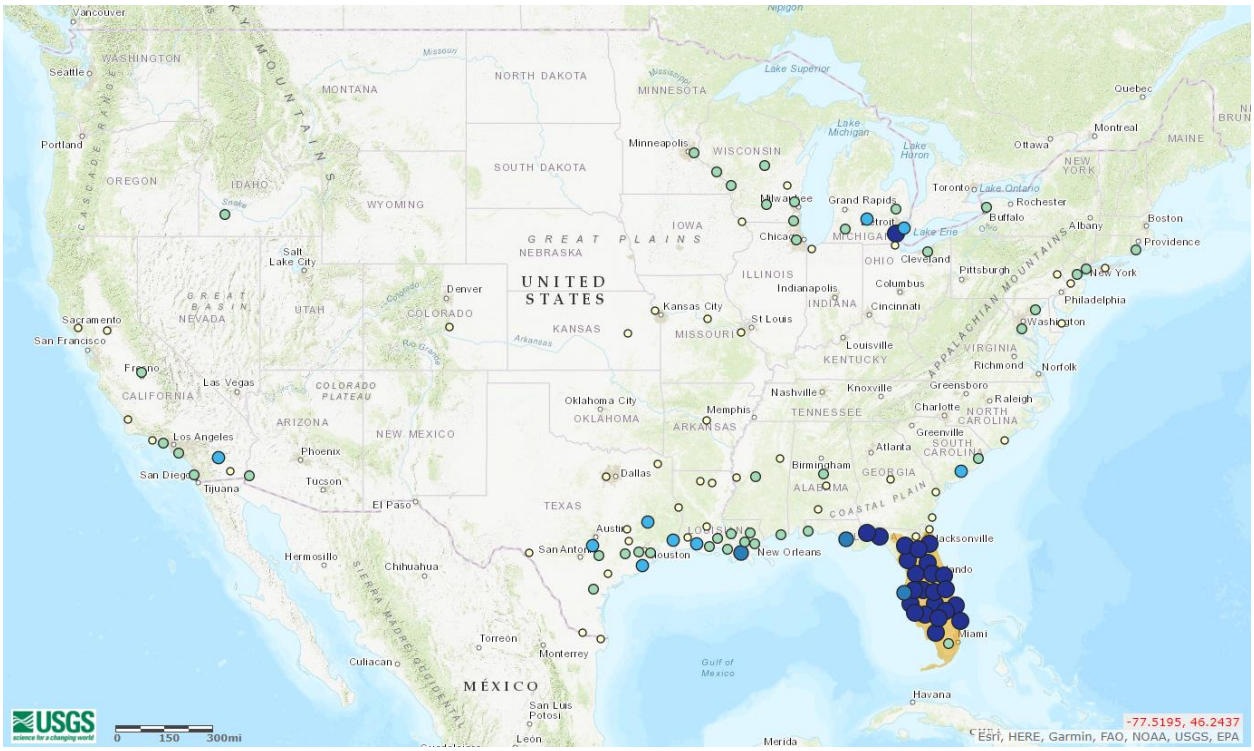

Figure 4. Aditional known distribution of *Pistia stratiotes* in the contiguous United States. Map from Thayer et al. (2018).

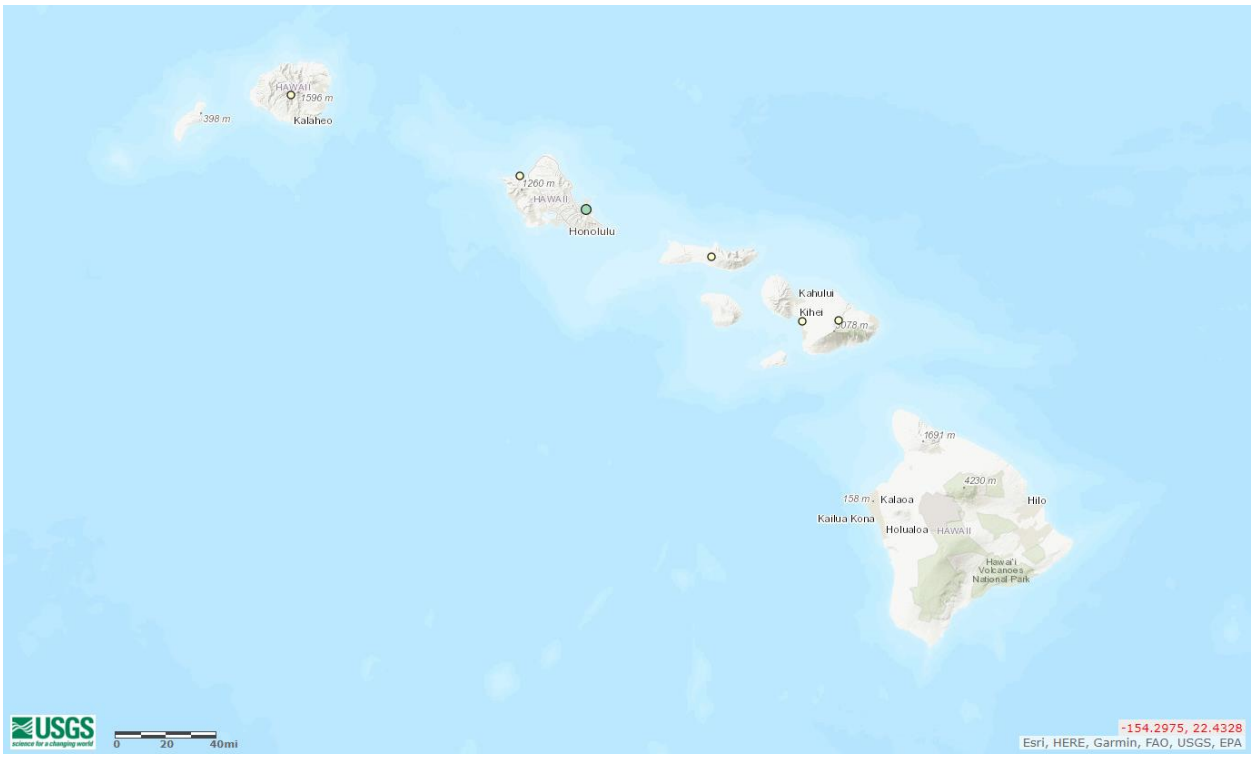

Figure 5. Known distribution of *Pistia stratiotes* in Hawaii. Map from Thayer et al. (2018).

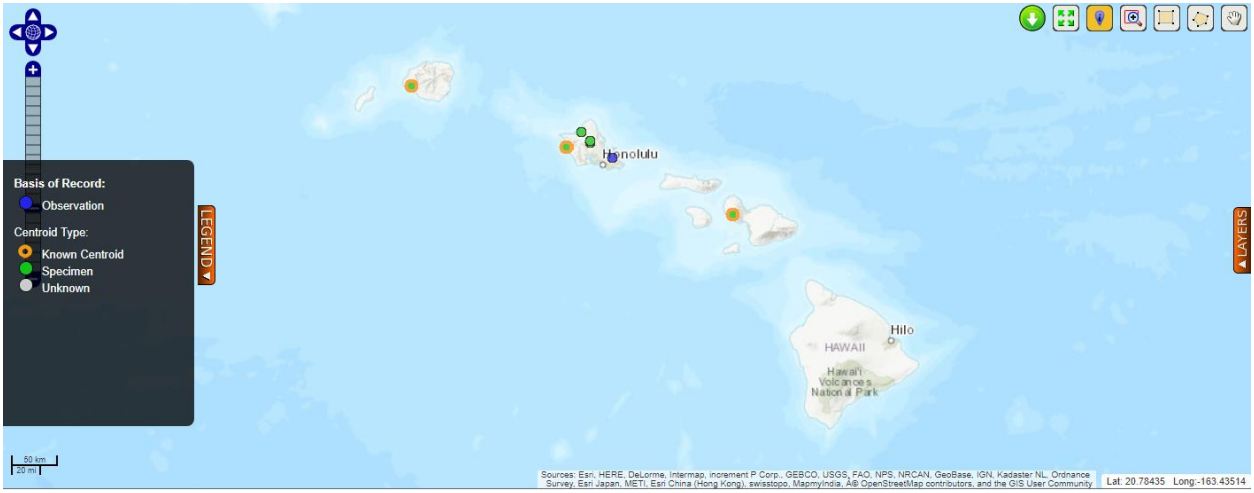

Figure 6. Additional known distribution of *Pistia stratiotes* in Hawaii. Map from BISON (2018).

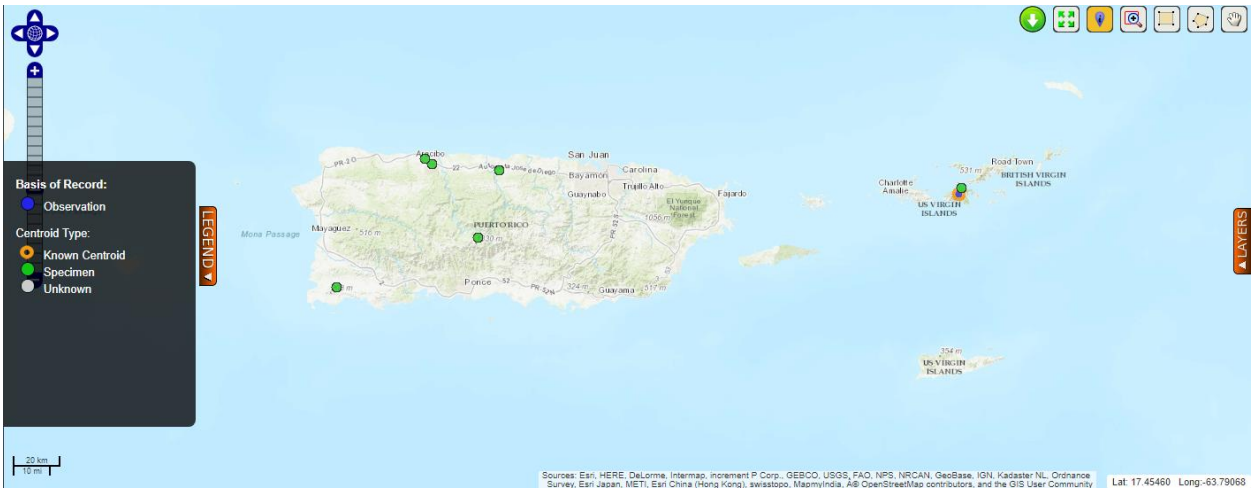

Figure 7. Known distribution of *Pistia stratiotes* in Puerto Rico and the U.S. Virgin Islands. Map from BISON (2018).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Pistia stratiotes* was low in the Pacific Northwest and small pockets in the Great Plains. The match was low in northern New England, the upper Mid-west, most of the Great Plains, and parts of the Pacific Coast; everywhere else had a high match. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous United States was 0.933, high. All states in the contiguous United States had high individual climate scores.

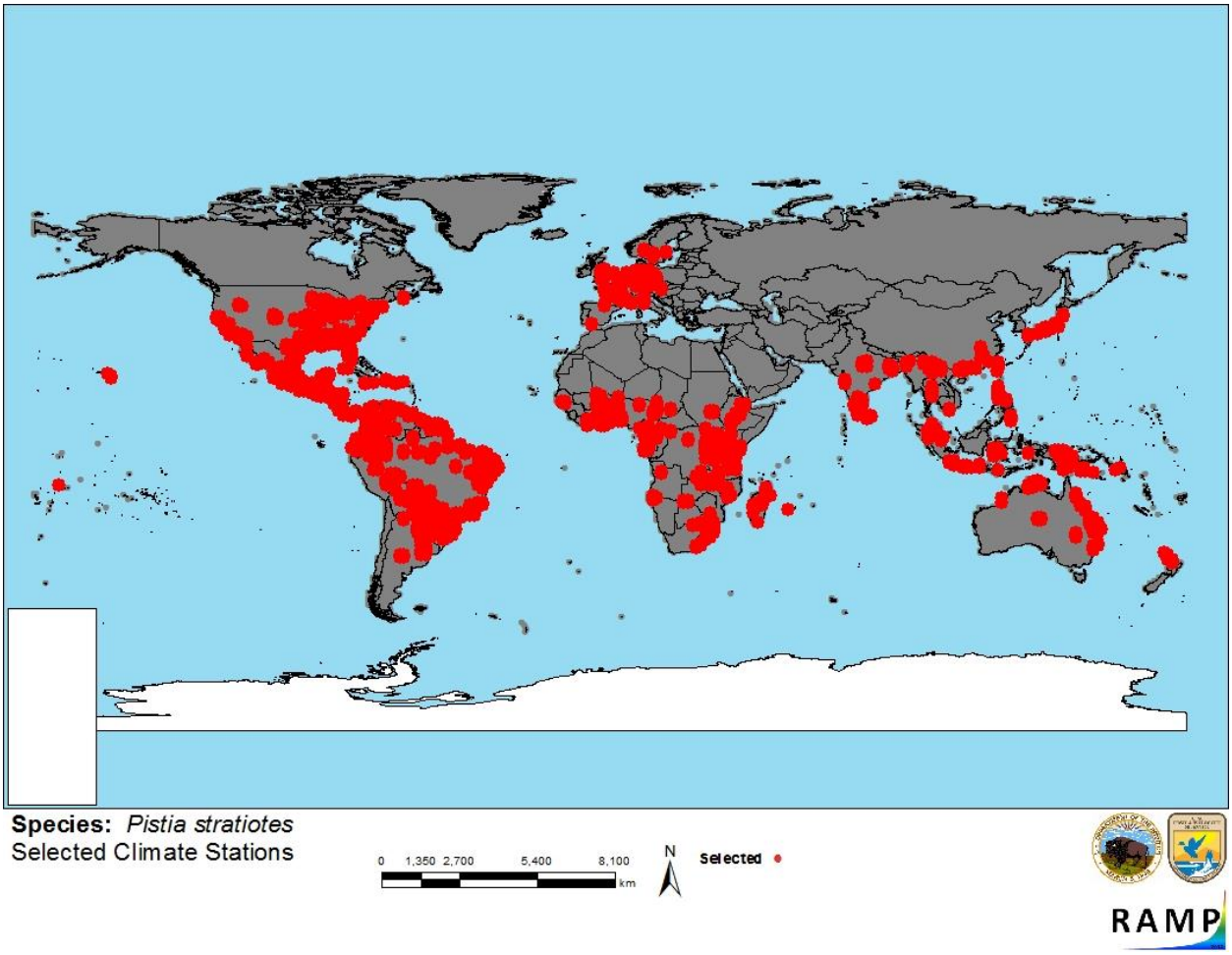

Figure 8. RAMP (Sanders et al. 2014) source map showing global weather stations selected as source locations (red) and non-source locations (gray) for *Pistia stratiotes* climate matching. Source locations from BISON (2018), GBIF Secretariat (2018), Thayer et al. (2018), and India Biodiversity Portal (no date).

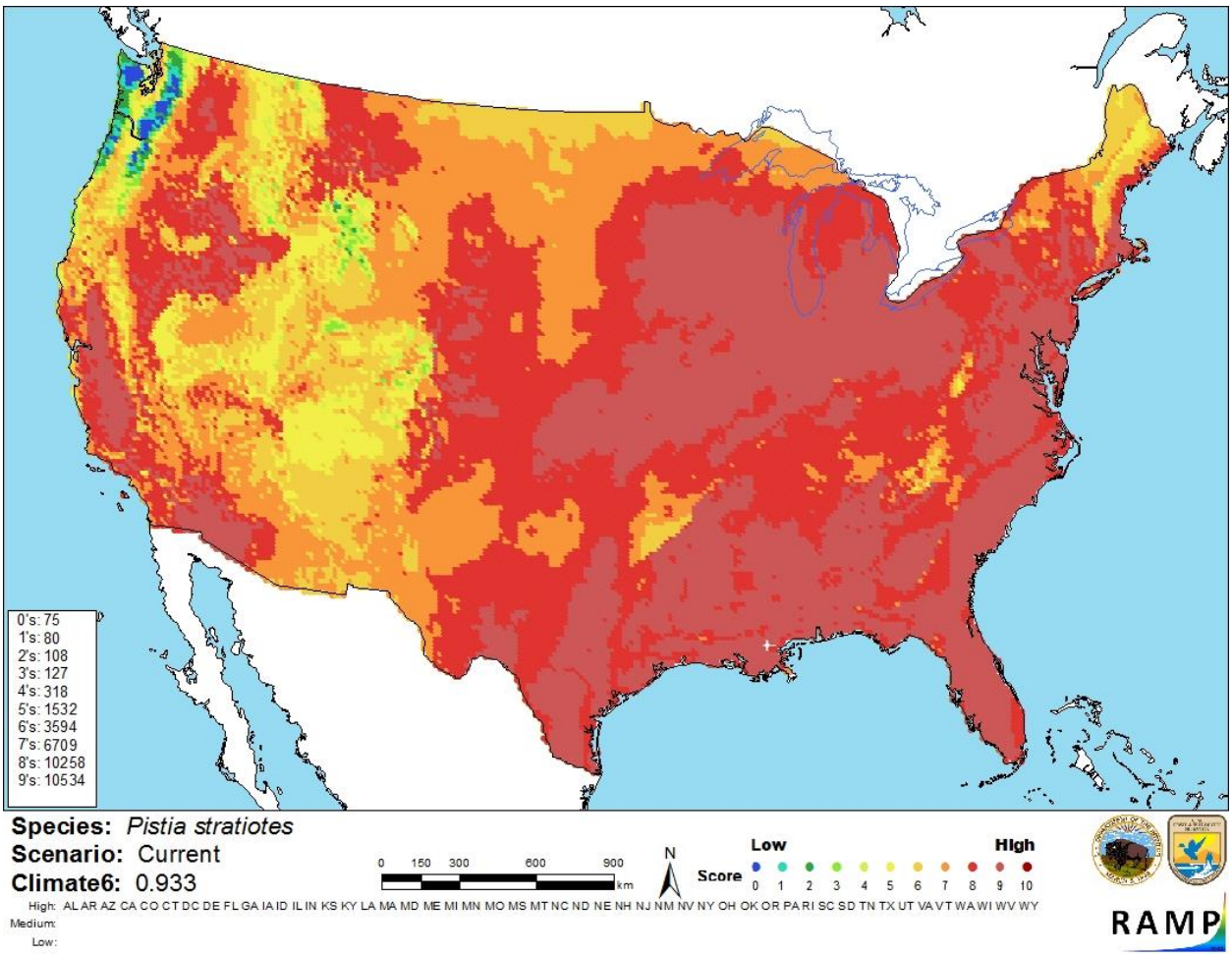

Figure 9. Map of RAMP (Sanders et al. 2014) climate matches for *Pistia stratiotes* in the contiguous United States based on source locations reported by BISON (2018), GBIF Secretariat (2018), Thayer et al. (2018), and India Biodiversity Portal (no date). 0 = Lowest match, 10 = Highest match. Counts 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

Certainty of this assessment is medium. Information on the invasion history and impacts of this species is available, with some peer-reviewed literature.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Pistia stratiotes is an aquatic plant with a world-wide distribution. Its native range is not well described. The history of invasiveness is high. There are records of known introductions and negative impacts to both biodiversity and human health where this species establishes large colonies. Established populations of *P. stratiotes* reduce native plant species, lower the dissolved oxygen under mats to below critical levels, and inhibit recreation uses such as boating and swimming. The mosquito carriers for St. Louis Encephalitis use the roots of this plant during reproduction. Climate matching indicated the contiguous United States has a high climate match with established *P. stratiotes* populations. The certainty of assessment is medium. 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): Medium**
- **Remarks/Important additional information:** No additional remarks.
- **Overall Risk Assessment Category: High**

9 References

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

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

CABI. 2018. *Pistia stratiotes* (water lettuce) [original text by J. Rojas-Sandoval, P. Acevedo-Rodríguez, and A. Mikulyuk]. *In* Invasive Species Compendium. CAB International, Wallingford, U.K. Available: https://www.cabi.org/isc/datasheet/41496. (October 2017).

Evans, J. M. 2013. *Pistia stratiotes* L. in the Florida Peninsula: Biogeographic evidence and conservation implications of native tenure for an 'invasive' aquatic plant. Conservation and Society 11:233-246.

GBIF Secretariat. 2018. GBIF backbone taxonomy: *Pistia stratiotes* L. Global Biodiversity Information Facility, Copenhagen. Available: https://www.gbif.org/species/2870583. (May 2018).

GISD (Global Invasive Species Database). 2017. Species profile: *Pistia stratiotes.* Invasive Species Specialist Group, Gland, Switzerland. Available: http://www.iucngisd.org/gisd/speciesname/Pistia+stratiotes. (May 2018).

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