Water Spangles (*Salvinia minima*)

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, December 2014
Revised, April 2018
Web Version, 8/19/2019

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1 Native Range and Status in the United States

Native Range

GISD (2018) lists *Salvinia minima* as native to Argentina, Belize, Bolivia, Brazil, Colombia, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Uruguay, and Venezuela.

From Howard Morgan (2018):

"Native Range: Central and South America; common and wide-ranging from southern Mexico to northern Argentina and Brazil (Mickel a[n]d Beitel 1988, [Stoltze] 1983). De la Sota (1976)

remarked that, in Argentina, the natural range of *Salvinia minima* could not be precisely determined due to its frequency in the watergarden and aquarium trade."

Status in the United States

GISD (2018) lists *Salvinia minima* as alien, invasive and established in Alabama, Florida, Louisiana, Minnesota, New York, and Texas.

Howard Morgan (2018) list *Salvinia minima* as present in the wild in Alabama (first report in 1982), Arkansas (first report in 1998), California (first report in 2008), Florida (first report in 1930), Georgia (first report in 1936), Idaho (first report in 2004), Louisiana (first report in 1980), Maryland (first report in 1984), Massachusetts (first report in 1992), Mississippi (first report in 1999), New Mexico (first report in 1999), New York (first report in 1990), Ohio (first report in 2017), Oklahoma (first report in 1989), Puerto Rico (first report in 1998), South Carolina (first report in 1997), and Texas (first report in 1992).

From Howard Morgan (2018):

"Although it continues to infest new regions, it is not included on the Federal Noxious Weed List and is prohibited only in the states of Texas and Louisiana."

From Tewari and Johnson (2011):

"Common salvinia is native to South America and was probably introduced to North America during the late 1920s and early 1930s (Jacono et al. 2001). As of April 2005, common salvinia has been recorded in more than 690 locations in 89 freshwater drainage basins of Florida, Georgia, Louisiana, Alabama, Texas, South Carolina, Mississippi, and Arkansas (USGS 2005a)."

Means of Introductions in the United States

From GISD (2018):

"Most likely the discharge of spore contaminated ship ballast from international ship traffic in the St. Johns River at Jacksonville was responsible for introducing *Salvinia minima* into Florida (Schmitz et al. 1988)."

From Howard Morgan (2018):

"Cultivated in greenhouses and gardens in the United States since the late 1880s (Weatherby 1921, 1937; Fernald 1950). Early plants in Florida likely entered natural areas from flooding of cultivated pools or through intentional release (Jacono et al. 2001). *Salvinia minima* is still widely available in the water garden trade, either as a sale item or a contaminant."

From Parys and Johnson (2013):

"Infestation by *S. minima* has spread across the southeastern U.S. from an initial introduction in the St. Johns river in Florida during the late 1920's (Small 1931; Jacono et al. 2001). Established

populations of *S. minima* are currently recorded from 14 states, and infestations are considered problematic in both Texas and Louisiana (Jacono et al. 2001; USDA & NRCS 2011). *Salvinia minima* has a history of being sold in the nursery trade, and is still widely available on the internet in spite of its invasive nature (Forno et al. 1983; Kay & Hoyle 2001)."

"Like other aquatic weeds, *S. minima* can easily spread between water bodies if boats and vehicles are not properly cleaned (Johnstone et al. 1985; Miller & Wilson 1989; Jacono 2003). Weather can also contribute to the spread of *Salvinia* spp., as mats fragment when flooding occurs (Harley & Mitchell 1981; Room 1983, 1990)."

Remarks
No additional remarks.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing
From ITIS (2018):

"Kingdom Plantae
Subkingdom Viridiplantae
Infrakingdom Streptophyta
Superdivision Embryophyta
Division Tracheophyta
Subdivision Polypodiophytina
Class Polypodiopsida
Subclass Polypodiidae
Order Salviniales
Family Salviniaceae
Genus *Salvinia*
Species *Salvinia minima* Baker"

"Taxonomic Status:
Current Standing: accepted"

Size, Weight, and Age Range
From GISD (2018):

"*Salvinia minima* is a free floating, rootless aquatic fern 1 to 4cm long. […] Leaf lengths range from 0.4 to 2.0cm."

Environment
From GISD (2018):

"[…] inhabiting water bodies with salinity levels as high as 4-7ppt."

Climate/Range

From Howard Morgan (2018):

"[…] *S. minima* was impacted by flooding and freezing and *Spirodela punctata* became the most abundant species (Dickinson and Miller 1998)."

Distribution Outside the United States

Native

GISD (2018) lists *Salvinia minima* as native to Argentina, Belize, Bolivia, Brazil, Colombia, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Uruguay, and Venezuela.

From Howard Morgan (2018):

"Native Range: Central and South America; common and wide-ranging from southern Mexico to northern Argentina and Brazil (Mickel a[n]d Beitel 1988, [Stoltze] 1983). De la Sota (1976) remarked that, in Argentina, the natural range of *Salvinia minima* could not be precisely determined due to its frequency in the watergarden and aquarium trade."

Introduced

GISD (2018) lists *Salvinia minima* as alien, invasive and established in Spain.

From Tipping and Center (2005):

"It is adventive [introduced] in Bermuda (Weatherby 1937), […], and Spain (Lawalree 1964)."

Means of Introduction Outside the United States

From GISD (2018):

"S. minima is still widely available in the water garden trade, either as a sale item or a contaminant (Jacono 2003)."

Short Description

From GISD (2018):

"*Salvinia minima* is a free floating, rootless aquatic fern 1 to 4cm long. It has horizontal branching rhizomes that float just below the water surface and produce, at each node, two floating leaves (fronds), and a third, submersed leaf that is dissected into filaments. The leaves are distributed in whorls of 3. Floating leaves are orbicular to oval in shape, with heart shaped bases and rounded to notched tips. Leaf lengths range from 0.4 to 2.0cm. Smaller, orbicular leaves lie flat on the water surface while larger leaves become elongated and fold upright on the midrib. Shade grown leaves remain broadly orbicular, and emerald green. Leaves grown in full sun become larger and elongated and often change from emerald green to rusty brown with maturity and senescence. The upper surfaces of floating leaves are uniformly covered with rows

of white, bristly hairs. The stalks of each hair divide into four thin branches that are spreading and free at the tips. The branching hairs create a water repellent shield. Long chestnut coloured hair coats the underside of floating leaves, the submersed filaments, buds and the rhizome (Aquatic Plant Information System, 2002; Jacono, 2003)."

Biology

From GISD (2018):

"The continuous branching and fragmentation of rhizomes turns out large volumes of vegetative daughter plants throughout the growing season. Lateral buds deeply imbedded in the rhizome, may lie dormant during periods of reduced moisture and cold temperature. Small rhizome fragments, commonly sheltered in associating vegetation, provide material for reintroduction on the return of favourable growing conditions (Jacono 2003)."

"*Salvinia minima* reproduce by vegetative fragments (Aquatic Plant Information System, 2002). *S. minima* is believed to be a sterile species. It is not known to produce fertile spores and is postulated to be of hybrid origin. Regardless, sporocarps are common among the submersed leaves of large plants. Sporocarps are sacs, which enclose smaller sacs (sporangia) that are formed to hold microscopic spores. Shaped like small lemons (~1mm wide) sporocarps are attached in spirals along the main axis of the submersed filaments (Jacono, 2003)."

"*Salvinia minima* grow in still waters of ponds, small lakes, canals, and slow streams. It can also be found in shallow backwaters of bayous, oxbows, ditches, cypress swamps and marshes […]"

From Tewari and Johnson (2011):

"The plants have 3 growth stages that are morphologically dissimilar and distinct. The initial growth stage, or primary stage, is characterized by isolated plants with leaves that lie flat on the water surface and is associated with initial colonization of a water body. The secondary stage is reached when plants have been growing for some time, and the edges of leaves start to curl upward. The tertiary or final stage is marked by crowding of plants, and the leaves curl to assume an almost vertical position. At this stage the infestation may resemble a "mat" covering the water surface."

Human Uses

From GISD (2018):

"*S. minima* is still widely available in the water garden trade, […]"

Diseases

No records of diseases of *Salvinia minima* were found.

Threat to Humans

From Parys and Johnson (2013):

"Persistence of these mats also raises human health issues, as *Salvinia* spp. provides ideal habitat for *Mansonia* spp. (Diptera: Culicidae) which have been identified as vectors in the spread of West Nile Virus, St. Louis Encephalitis and Venezuelan Equine Encephalitis (Chow et al. 1955; Ramachandran 1960; Lounibos et al. 1990). Several species of biting midges (Diptera: Ceratopogonidae) have also associated with *Salvinia* infestations (Buckingham & Balciunas 1994; Borkent & Craig 2001)."

3 Impacts of Introductions

From Wersal and Madsen (2010):

"Waterhyacinth (*Eichhornia crassipes* [Mart.] Solms) and common salvinia (*Salvinia minima* Baker) are two floating aquatic plants that can cause wide-spread problems in the southern United States. These species can cause reductions in ecosystem function as well as the abundance of native plant species."

"In Louisiana, common salvinia biomass reached 1.02 kg m-2 and caused reductions in native plant abundance (Walley 2007)."

From Parys and Johnson (2013):

"Uncontrolled *S. minima* forms dense mats of plant material that decrease aesthetic value and limit use of aquatic areas (Montz 1989). Infestations obstruct waterways, decrease light availability, reduce available dissolved oxygen, and alter pH levels (Hatch 1995; Flores & Carlson 2006). […] Utilization of freshwater resources for activities like fishing, migratory bird hunting, and alligator harvests contributed a total positive economic effect of over US$ 1.2 billion to the state of Louisiana in 2006, making them an important asset to protect (Southwick Associates 2008)."

From Dickinson and Miller (1998):

"In the summer competition experiment, *Salvinia minima* grew rapidly and had negative effects on the relative change in cover of both *Azolla caroliniana* and *Spirodela punctata*. Relative change in cover of *Salvinia minima* increased when it was grown with *Spirodela punctata*, but only when *A. caroliniana* was not present. A negative correlation in the swamp between cover of *Salvinia minima* and *Spirodela punctata*, the two most abundant species during the summer, was consistent with the strong competitive effects of *Salvinia minima* in the summer competition experiment. During the autumn competition experiment, *S. minima* had a negative effect on the relative increase in *A. caroliniana* cover. This effect, however, was not competitive and was caused by a herbivore of *S. minima* that switched to *A. caroliniana* as the growth of *S. minima* slowed in the autumn."

From Howard Morgan (2018):

"In Texas and Louisiana, *S. minima* typically occurs in dense, expansive populations and is known as a very troublesome weed. At Lacassine Bayou, southwestern Louisiana, plants completely blanket a waterway measuring 19.3 km long and 110 m wide (Jacono et al. 2001). Mats in Louisiana have been measured as thick as 20 - 25 cm (Montz 1989)."

"An eight-year study at Jean Lafitte National Historic Park, Louisiana, found complete displacement of native *Lemna* species by *Salvinia minima*. (T. Doyle, LA, pers. comm.). The Lemnaceae (duckweeds) contain high protein content and are important food sources for waterfowl."

From Tewari and Johnson (2011):

"Thick mats of common salvinia prevent sunlight from reaching submerged plants, whereas floating plant species such as antler fern (*Ceratopteris pteridoides* [Hooker]) and duckweed (*Lemna* spp.) are also displaced (USGS 2005b). Common salvinia can lower the dissolved oxygen of infested water and provide safe haven to pest species such as mosquitoes (USGS 2005b). Motor crafts used for recreational activities such as boating and fishing get tangled in thick floating mats of common salvinia, making it extremely difficult to navigate, and these infestations may hinder the ability of law enforcement agencies to carry out their duties effectively (USGS 2005b). Commercial activities such as rice and crawfish farming, water drainage, and electrical power generation can also be negatively impacted by common salvinia (Charles Dugas, Louisiana Department of Wildlife and Fisheries, retired, pers. comm.)."

"The cost of controlling common salvinia using herbicides by state and contract workers may range from $198 to $297/ha, depending on herbicide used, and the cost to private land owners is much higher (Charles Dugas, Louisiana Department of Wildlife and Fisheries, retired, pers. comm.)."

4 Global Distribution

Figure 1. Known global distribution of *Salvinia minima*. Map from GBIF Secretariat (2018). The location in Minnesota does not have enough data to conclude it was captured in the wild and it was not mentioned in other literature therefore the location was not used to select source points for the climate match.

5 Distribution Within the United States

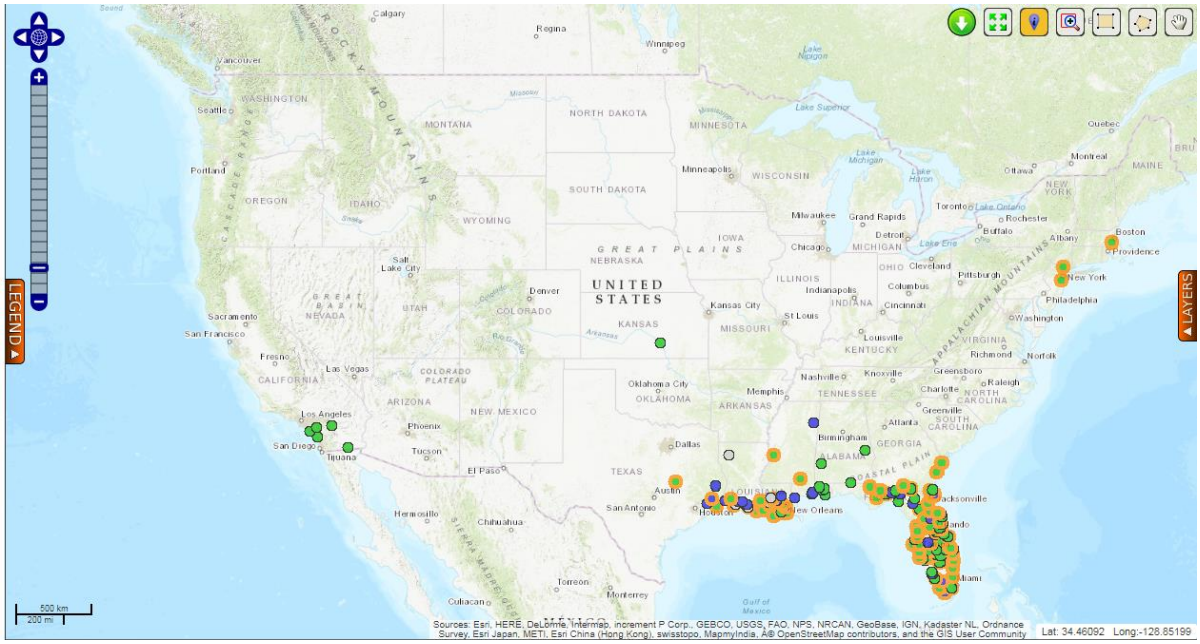

Figure 2. Known distribution of *Salvinia minima* in the United States. Map from BISON (2018). The location in Kansas represents a specimen grown in a greenhouse and was not used to select source points for the climate match.

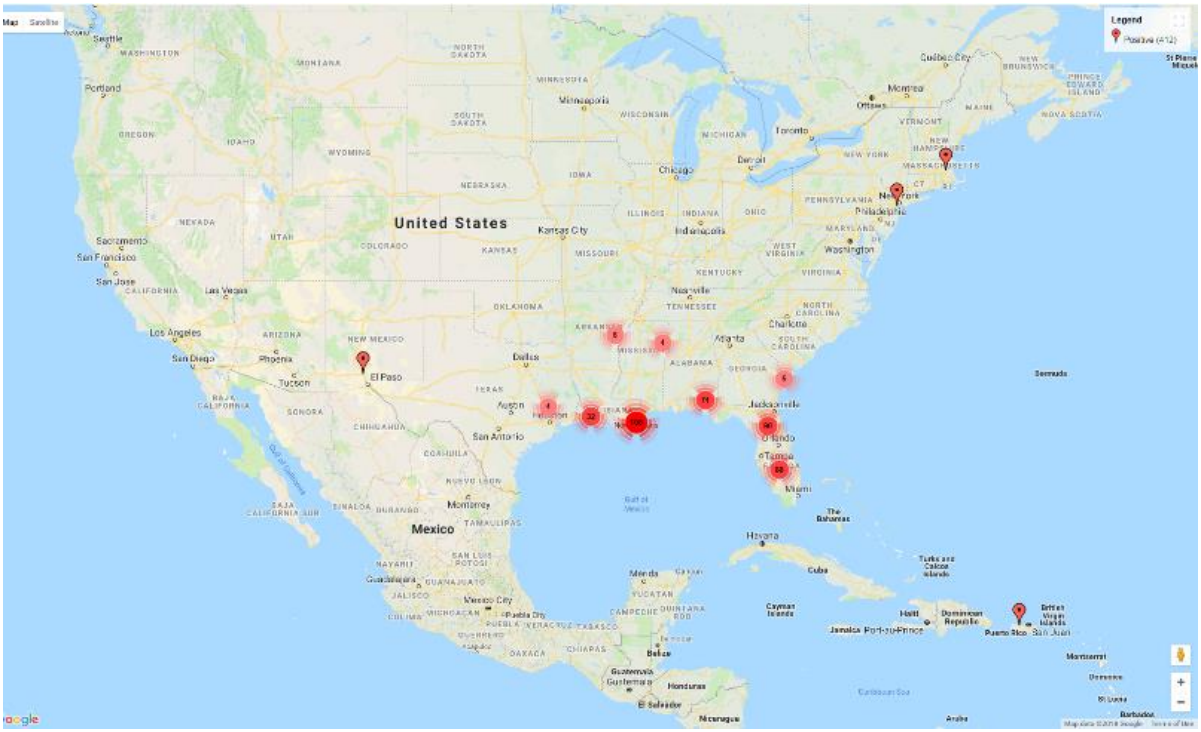

Figure 3. Known distribution of *Salvinia minima* in the United States. Map from EDDMapS (2018). The location in New Mexico does not have enough data to conclude it was captured in the wild; it was not used to select source points for the climate match.

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Salvinia minima* was high in the eastern United States as well as the southwest. The northern Pacific Coast, upper Midwest, and much of the Great Plains low to medium match. There are already established populations of *S. minima* in much of the southeastern part of the United States. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous United States was 0.533, high (scores 0.103 and greater are classified as high). Most States had high individual Climate 6 scores except for Colorado, Oregon, and Utah, which had medium scores, and Idaho, Minnesota, Montana, Nebraska, North Dakota, South Dakota, and Wyoming, which had low scores.

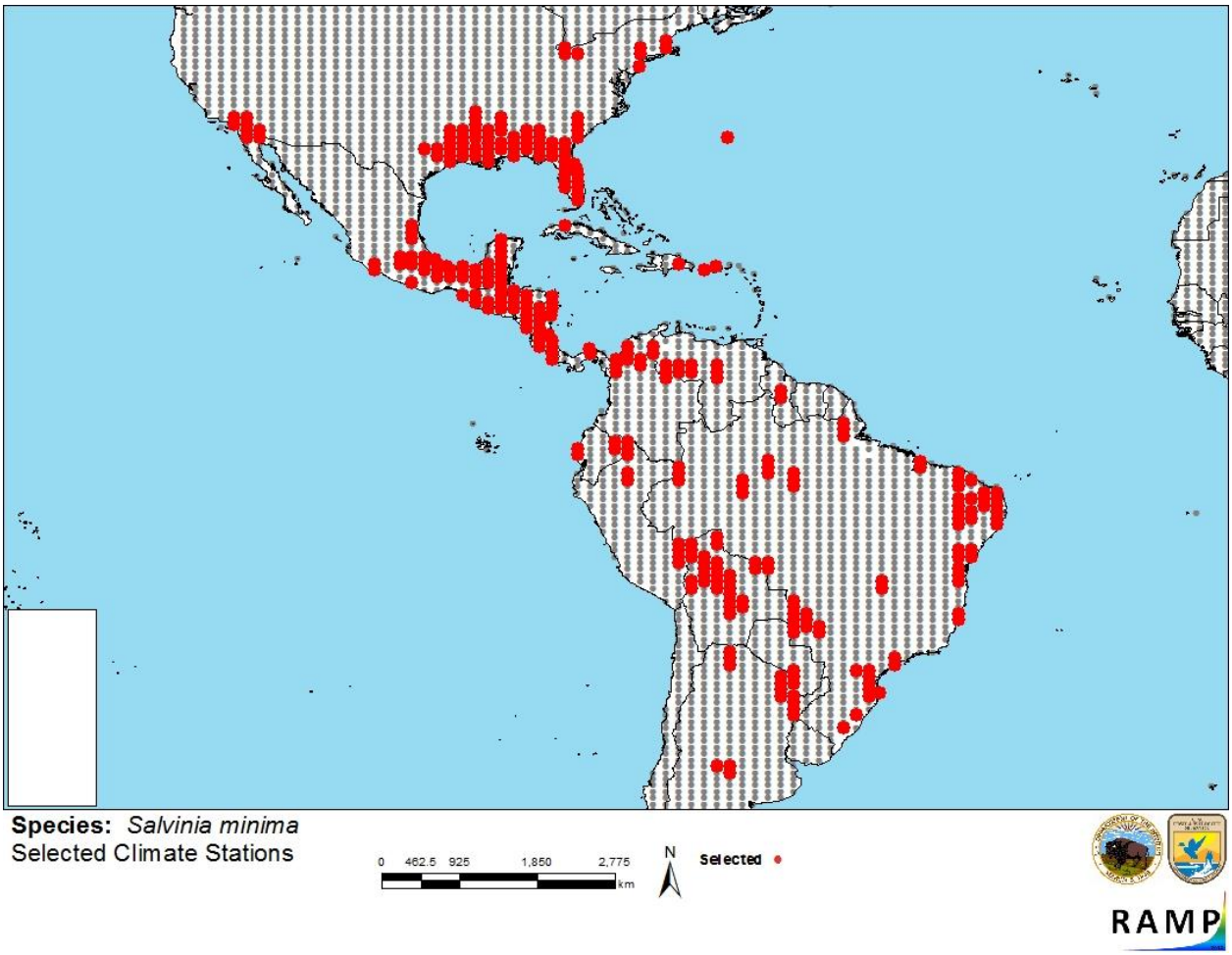

Figure 4. RAMP (Sanders et al. 2014) source map showing weather stations in North and South America selected as source locations (red) and non-source locations (gray) for *Salvinia minima* climate matching. Source locations from BISON (2018), EDDMapS (2018), and GBIF Secretariat (2018). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

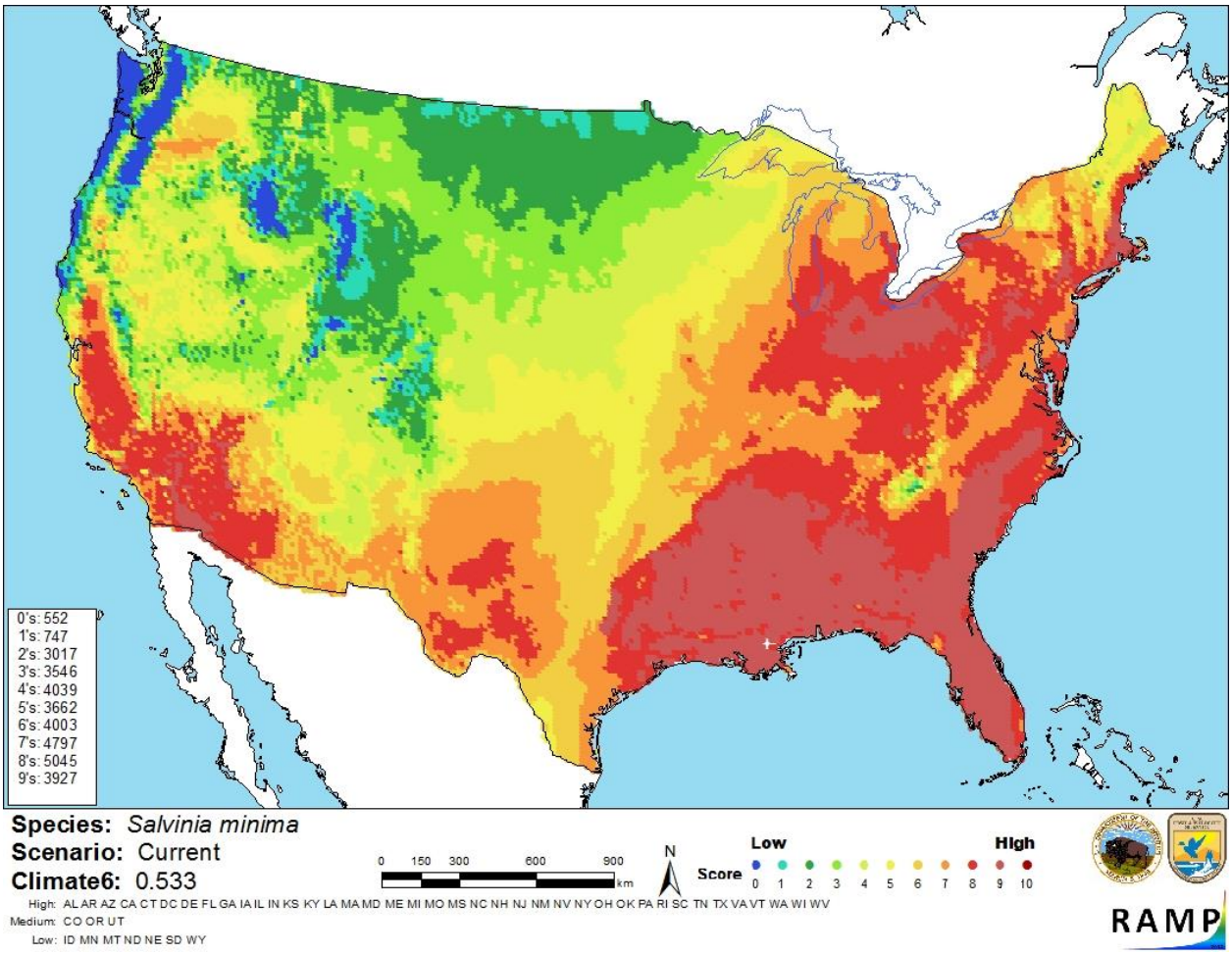

Figure 5. Map of RAMP (Sanders et al. 2014) climate matches for *Salvinia minima* in the contiguous United States based on source locations reported by BISON (2018), EDDMapS (2018), and GBIF Secretariat (2018). Counts of climate match scores are tabulated on the left. 0 = Lowest match, 10 = Highest match.

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

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

7 Certainty of Assessment

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

8 Risk Assessment

Summary of Risk to the Contiguous United States

Water spangles (*Salvinia minima*) is an aquatic freshwater plant native to South America. The species has spread via the aquatic plant industry to the United States, and is now established in several states. The history of invasiveness is high. *S. minima* can outcompete native plants, reduce plant biodiversity, clog waterways, and reduce access for recreational activities. Climate matching indicated the contiguous United States has a high climate match. There are already established *S. minima* populations in much of the southern United States but not everywhere the climate match indicated there was suitable climate. 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:** 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.

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10 References Quoted But Not Accessed

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

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