

Floating Watermoss (*Salvinia natans*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, May 2021

Revised, June 2021

Web Version, 7/23/2021

Organism Type: Plant

Overall Risk Assessment Category: Uncertain



Photo: Le.Loup.Gris. Licensed under Creative Commons Attribution-Share Alike 3.0 Unported. Available: [https://commons.wikimedia.org/wiki/File:Salvinia_natans_\(habitus\)_1.jpg](https://commons.wikimedia.org/wiki/File:Salvinia_natans_(habitus)_1.jpg) (May 2021).

1 Native Range and Status in the United States

Native Range

From Allen (2011):

“This is an Eurasiatic (palaeotemperate) species, essentially occurring in central and eastern Europe and in Asia, from the Caucasus to China, northern parts of India and into southeast Asia, and Japan. In Europe, it is scattered from the Rhine valley (Germany) to Russia, and southwards, from northern Italy, to the Danube basin towards the Black Sea, and to northern Greece.”

“Algeria; Armenia; Azerbaijan; Bangladesh; Belarus; Bosnia and Herzegovina; Bulgaria; China (Tibet [or Xizang], Henan, Guangxi, Liaoning, Jiangxi, Jiangsu, Shanghai, Ningxia, Nei Mongol, Gansu, Guizhou, Guangdong, Fujian, Hubei, Heilongjiang, Sichuan, Hebei, Hunan, Shandong, Shaanxi, Hainan, Jilin, Qinghai, Shanxi, Beijing); Croatia; Czechia; Georgia; Germany; Greece (Greece (mainland)); Hong Kong; Hungary; India (Jammu-Kashmir, Assam, Manipur); Iran, Islamic Republic of; Iraq; Israel; Italy (Italy (mainland)); Japan; Kazakhstan; Lithuania; Macao; Moldova; Mongolia; North Macedonia; Pakistan; Poland; Romania; Russian Federation (Dagestan, Ingushetiya, East European Russia, Chechnya, South European Russia, Krasnodar, Central European Russia, Karachaevo-Cherkessiya, Kabardino-Balkariya, Stavropol, Amur, Kamchatka, Sakhalin); Serbia; Slovakia; Slovenia; Spain (Spain (mainland)); Syrian Arab Republic; Taiwan, Province of China (Taiwan, Province of China (main island)); Thailand; Turkey (Turkey-in-Asia, Turkey-in-Europe); Ukraine; Viet Nam”

From POWO (2021):

“Afghanistan, Algeria, Altay [Russia], Amur [Russia], Assam [India], Baltic States [Estonia, Latvia, and Lithuania], Bangladesh, Belarus, Bulgaria, China North-Central, China South-Central, China Southeast, Czechoslovakia, East European Russia, Germany, Greece, Hainan [China], Hungary, Inner Mongolia, Iran, Iraq, Italy, Japan, Jawa [Indonesia], Kazakhstan, Khabarovsk [Russia], Korea, Krym [Russia], Lebanon-Syria, Manchuria [China], Nepal, Netherlands, North Caucasus [Russia], Northwest European R [Russia], Pakistan, Palestine, Poland, Primorye [Russia], Qinghai [China], Romania, South China Sea, Spain, Taiwan, Thailand, Tibet, Transcaucasus [Russia], Tunisia, Turkey, Turkey-in-Europe, Ukraine, Vietnam, West Himalaya [northern Pakistan and northern India], West Siberia [Russia], Xinjiang [China], Yugoslavia”

POWO (2021) states that this species is extinct in France. Allen (2011) states this species is extinct in the Netherlands and Switzerland, with the presence uncertain in Belgium and France.

Status in the United States

According to POWO (2021), *Salvinia natans* has been reported as introduced in Massachusetts and New York.

USGS (2021) reports a single occurrence record from Lake Itasca in northwestern Minnesota in 1948; the status is recorded as “extirpated.”

From Butters (1921):

“For some years the various floras of the eastern United States have reported *Salvinia natans* (L.) All. as occurring in the vicinity of Minneapolis. [...] An examination of both living plants and herbarium material has convinced me that it is all *S. auriculata* var. *Olfersiana* Klotzsch ex.”

From Weatherby (1921):

“The earliest report of the species is in Pursh's Flora of North America, where it is said to have been found ‘floating like *Lemna* on the surface of stagnant waters in several of the small lakes in the western part of New York.’ No subsequent botanist has been able to find the plant in this region: we must conclude either that it did not become permanently established, or that it is one of several very dubious records [...] which are now generally believed to be without foundation of fact.”

“A second New York locality is on Staten Island. [...] specimens of it, which I have had the privilege of examining at the New York Botanical Garden and at the Gray Herbarium, prove to be, like the Minnesota material, *S. auriculata*, var. *Olfersiana*.”

“[One specimen from Missouri] is preserved at Cambridge and is true *Salvinia natans*. Mr. B. F. Bush and Mr. E. J. Palmer, who have collected very extensively in Missouri in recent years, state that they have never met with the plant.”

“The claim of *Salvinia natans* to a place in our [U.S.] flora rests, then, on one ancient and very doubtful report, two mis-identifications, and a single authentic collection, never repeated, at a station which has not been re-discovered in 35 years.”

Salvinia natans is found for sale in the aquarium trade in the United States. Buce Plant (2021) lists this species for sale for \$4.99.

All species in the genus *Salvinia* are listed as prohibited species in Texas: “No person may possess or place them into water of this state except as authorized by the department” (Texas Parks and Wildlife 2021).

Means of Introductions in the United States

From Weatherby (1921):

“[...] I made the following notes in my journal: ‘Sunday, April 3, 1899. I planted *Salvinia natans* in Ketchum's Mill Pond, as I did last spring. I have not been able to find that any planted last year lived over winter.’ ‘September 23, 1899 (Saturday). In the spring I planted some *Salvinia natans* in Ketchum's Mill Pond and now there are countless numbers of fine plants.’”

From USDA (2021):

“Potential Pathway: released aquarium”

Remarks

From Allen (2011):

“The species appears to be declining throughout much of its European range with some local extinction, however the cause of the decline is not known.”

“This species is listed on Annex II of the European Habitats Directive.”

“The species is classed as Extinct in the Netherlands and Switzerland, Critically Endangered in Germany, Endangered in Czech Republic, and Near Threatened in Croatia and Belarus; it is protected but not classed as threatened in Hungary and protected throughout France and in Greece. It is included in the Red Data Book of Ukraine and included in some protected areas. In Russia it is categorized as Near Threatened (I. Illarionova pers. comm. 2010).”

According to WFO (2021), *Marsilea natans* is a synonym for *Salvinia natans*. Both scientific names were used in searching for information for this report.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

According to WFO (2021), *Salvinia natans* (L.) All. is the current accepted scientific name for this species.

From ITIS (2021):

Kingdom Plantae
Subkingdom Viridiplantae
Infrakingdom Streptophyta
Superdivision Embryophyta
Division Tracheophyta
Subdivision Polypodiophytina
Class Polypodiopsida
Subclass Polypodiidae
Order Salviniiales
Family Salviniaceae
Genus *Salvinia*
Species *Salvinia natans* (L.) All.

Size, Weight, and Age Range

From Missouri Botanical Garden (2021):

“Height: 0.25 to 0.25 feet
Spread: 0.25 to 1.00 feet”

From Szmeja and Gałka (2013):

“*S. natans* is an annual plant [...]”

Environment

From Allen (2011):

“The species is a free-floating fern, growing in large populations at the surface of still waters or in weak currents: ditches, canals, ponds, oxbows.”

From Missouri Botanical Garden (2021):

“Grow on still water in full sun to part shade.”

From Zutshi and Vass (1971):

“Under laboratory conditions, water of a pH between 4.6–6.0, sodium chloride concentrations higher than 1% and continuous submergence under water are harmful to the growth of the weed. Partial shady situations seem to be quite beneficial for the growth.”

From Szmeja et al. (2016):

“Macrospores germinate at water temperature of $12.4 \pm 0.2^\circ\text{C}$ or higher; at 20°C they develop more effectively than at 15°C .”

Climate

From Szmeja and Gałka (2013):

“[...] temperate, subtropical and tropical climate (Rothmaler et al. 1986) [...]”

“Observations under the microscope show that freezing air temperatures kills young gametophytes.”

From Szmeja et al. (2016):

“The expansion of *Salvinia natans* in the Vistula Delta is most likely due to climate warming, and primarily to the rise of March and April mean temperature combined with the narrowing of its variation in these months.”

Distribution Outside the United States

Native

From Allen (2011):

“This is an Eurasiatic (palaeotemperate) species, essentially occurring in central and eastern Europe and in Asia, from the Caucasus to China, northern parts of India and into southeast Asia, and Japan. In Europe, it is scattered from the Rhine valley (Germany) to Russia, and southwards, from northern Italy, to the Danube basin towards the Black Sea, and to northern Greece.”

“Algeria; Armenia; Azerbaijan; Bangladesh; Belarus; Bosnia and Herzegovina; Bulgaria; China (Tibet [or Xizang], Henan, Guangxi, Liaoning, Jiangxi, Jiangsu, Shanghai, Ningxia, Nei Mongol, Gansu, Guizhou, Guangdong, Fujian, Hubei, Heilongjiang, Sichuan, Hebei, Hunan, Shandong, Shaanxi, Hainan, Jilin, Qinghai, Shanxi, Beijing); Croatia; Czechia; Georgia; Germany; Greece (Greece (mainland)); Hong Kong; Hungary; India (Jammu-Kashmir, Assam, Manipur); Iran, Islamic Republic of; Iraq; Israel; Italy (Italy (mainland)); Japan; Kazakhstan; Lithuania; Macao; Moldova; Mongolia; North Macedonia; Pakistan; Poland; Romania; Russian Federation (Dagestan, Ingushetiya, East European Russia, Chechnya, South European Russia, Krasnodar, Central European Russia, Karachaevo-Cherkessiya, Kabardino-Balkariya, Stavropol, Amur, Kamchatka, Sakhalin); Serbia; Slovakia; Slovenia; Spain (Spain (mainland)); Syrian Arab Republic; Taiwan, Province of China (Taiwan, Province of China (main island)); Thailand; Turkey (Turkey-in-Asia, Turkey-in-Europe); Ukraine; Viet Nam”

From POWO (2021):

“Afghanistan, Algeria, Altay [Russia], Amur [Russia], Assam [India], Baltic States [Estonia, Latvia, and Lithuania], Bangladesh, Belarus, Bulgaria, China North-Central, China South-Central, China Southeast, Czechoslovakia, East European Russia, Germany, Greece, Hainan [China], Hungary, Inner Mongolia, Iran, Iraq, Italy, Japan, Jawa [Indonesia], Kazakhstan, Khabarovsk [Russia], Korea, Krym [Russia], Lebanon-Syria, Manchuria [China], Nepal, Netherlands, North Caucasus [Russia], Northwest European R [Russia], Pakistan, Palestine, Poland, Primorye [Russia], Qinghai [China], Romania, South China Sea, Spain, Taiwan, Thailand, Tibet, Transcaucasus [Russia], Tunisia, Turkey, Turkey-in-Europe, Ukraine, Vietnam, West Himalaya [northern Pakistan and northern India], West Siberia [Russia], Xinjiang [China], Yugoslavia”

POWO (2021) states that this species is extinct in France. Allen (2011) states this species is extinct in the Netherlands and Switzerland, with the presence uncertain in Belgium and France.

Introduced

According to both Allen (2011) and POWO (2021), *S. natans* has been introduced and is established in Cuba and Jamaica.

Zutshi and Vass (1971) propose that *S. natans* has been introduced and become established in the Kashmir region. However, both Allen (2011) and POWO (2021) include Kashmir or northern India in the native range of the species. No definitive information was found to confirm the species status as native or introduced.

From Zutshi and Vass (1971):

“There is no authentic record of the first appearance of *Salvinia* in Kashmir waters. MUKEERJEE (1920, 1925), who for the first time gave some details about the lake vegetation of Kashmir, has made no mention of this plant in his account. The first report regarding the presence of the fern in Dal lake, Srinagar is by BISWAS & CALDER (1936). [...] So far, there has been no publication on the weedy nature of *S. natans*. It is therefore, justifiable, to regard the introduction of the weed in the inland waters of Kashmir as fairly recent. If it be so, the spread of the species in the valley has evidently been quite rapid.”

Means of Introduction Outside the United States

No information is available on means of introduction outside the United States.

Short Description

From Zutshi and Vass (1971):

“*S. natans* is an annual aquatic free-floating fern belonging to the family Salviniaceae. The sporophyte has a delicate horizontal rhizome growing up to 20 cm long. The leaves are opposite, oblong and ovate with a number of minute bristles on the upper surface. They are 1.5-1.8 cm long and 1.0-1.2 cm broad, and are usually between 25-30 cm on a single mature rhizome. A tuft of shining leafy roots, 11-13 per node and each 10-12 cm long, are produced on the under surface of leaves and rhizome.”

From eFloras (2008):

“Floating fronds sessile or with stipe to ca. 1 mm; lamina *Robinia*-shaped, 0.8-1.4 × 0.5-0.8 cm, base rounded or subcordate, margin entire, apex obtuse; lateral veins 15-20 on each side of costa, each one with 5-8 low dome-shaped papillae, each with a terminal bunch of ca. 4 white setae; lamina deep green on upper surface, densely brown villous on lower surface; submersed fronds finely dissected into linear segments, covered with hairs, and acting as roots. Sporocarps 4-8, clustered at bases of submersed fronds, with sparse bunches of hairs; microsporocarps yellowish, megasporocarps brownish.”

Biology

From Allen (2011):

“The species is a free-floating fern, growing in large populations at the surface of still waters or in weak currents: ditches, canals, ponds, oxbows. It is often associated with *Lemnaceae* [sic] and other floating plants.”

From Szmeja and Gałka (2013):

“*Salvinia natans* is an annual clonal plant; however, its architecture makes it more similar to perennials than to other annual plants. *S. natans* reproduces by sexual and asexual means, which

is an intrinsic feature of the perennial life strategy (Grime and Mackey 2002; de Kroon et al. 2005), not the annual one. Low mortality of mature individuals (2.4–4.4%) and vegetative offspring (ramets) is another *S. natans* characteristic typical of clonal perennials. [...] On the other hand, high seasonal variation of population size is a feature that makes *S. natans* different from clonal perennials and similar to annuals.”

From Zutshi and Vass (1971):

“The sporophyte of *S. natans* is extremely delicate and breaks readily. The fragments thus formed develop into new plants within two to three weeks and thereby add to the population. Ten to twelve axillary branches also develop on the rhizome imparting it a stellate appearance. [...] Sporocarps are produced by all plants at maturity, including those stranded on mud by the receding water level.”

“Higher temperature and better light during August-September support maximum biomass production of *S. natans*. Plants growing under partial shade are better producers of dry matter than those growing under deep shady situations.”

“The most common associates of *Salvinia* are *Hydrocharis dubia* and *Ceratophyllum demersum*.”

Human Uses

From eFloras (2008):

“The whole plant is used medicinally; it is boiled and eaten for ‘consumptive disease’ and eczema and externally used for inflammatory diseases affecting the skin.”

From Allen (2011):

“The species is used as ornamental plant in basins but is found in trade less frequently than other *Salvinia* species.”

Salvinia natans is found for sale in the aquarium trade in the United States. Buce Plant (2021) lists this species for sale for \$4.99.

Diseases

From Missouri Botanical Garden (2021):

“No serious insect or disease problems.”

Threat to Humans

From Szmeja and Gałka (2013):

“Studies by Markowski et al. (2004) and Szmeja et al. (2012) indicate that from the mid-19th century to the end of the 20th the plant was rare in the [Vistula River] delta [in northern Poland]

but that after 2005 it grew in every watercourse and formed very numerous populations. The population increase was so rapid that it completely clogged the delta's vast hydrological regulation system, construction of which began in the Middle Ages and was gradually expanded over the next centuries.”

3 Impacts of Introductions

Zutshi and Vass (1971) propose that *S. natans* has been introduced and become established in the Kashmir region. However, both Allen (2011) and POWO (2021) include Kashmir or northern India in the native range of the species. No definitive information was found to confirm the species status as native or introduced, so it is unknown whether the impacts described below are truly impacts resulting from introduction or whether they are impacts of a native species that has increased substantially in abundance.

From Zutshi and Vass (1971):

“Abnormal growth of *S. natans* in the side channels of Dal and Anchar lakes result [sic] in a thick vegetation mat. Once this floating mat is established it controls the sequence of submerged vegetation underneath by changing the environmental conditions, particularly light penetration. [...] The establishment of *Salvinia* during May-June when the light conditions become slightly unfavourable, brings a shift for the under water vegetation and results in the replacement of the *P. crispum* association by the *Ceratophyllum demersum* association which seems to prefer low light intensity. [...] During summer the floating association of *Spirodelo-Lemnetum gibbae* is also offered great competition by the expanding *Salvinia natantis* [sic] association. Besides the lake channels, *Salvinia* [...] may also invade an open association of *Typhetum angustatae*.”

“A well established mat of *S. natans* has a characteristic effect on the water, vegetation and substrate beneath it. The thermal stratification of channel water covered with the plant is quite different from open water. A thick carpet of this species acts as a screen against the solar radiation, with the result that the water beneath is much cooler. [...] Reduction of oxygen tension under *Salvinia* cover has important ecological implications. At sites covered densely with the weed, the oxygen content of the water is reduced from 4.5 mg/l to 0.7 mg/l. These oxygen poor layers are detrimental to the development of juvenile fish and insect life.”

“In conclusion, it may be said that the increased growth of *S. natans* in the lakes of Kashmir has already started posing many problems, the most serious being its effect on fish life and on the growth of paddy.”

All species in the genus *Salvinia* are listed as prohibited in Texas (Texas Parks and Wildlife 2021).

4 History of Invasiveness

The history of invasiveness is Data Deficient. *Salvinia natans* has been documented as introduced and established in the Caribbean, outside of its native range; no information was found on any impacts of these introductions. Negative impacts on water quality and native species have been documented in the central Asian region of Kashmir, but it is unclear whether

S. natans is native or introduced in this region. Because the history of invasiveness is scored based exclusively on impacts outside the native range, further clarity is required on the native range of this species in Central Asia.

5 Global Distribution

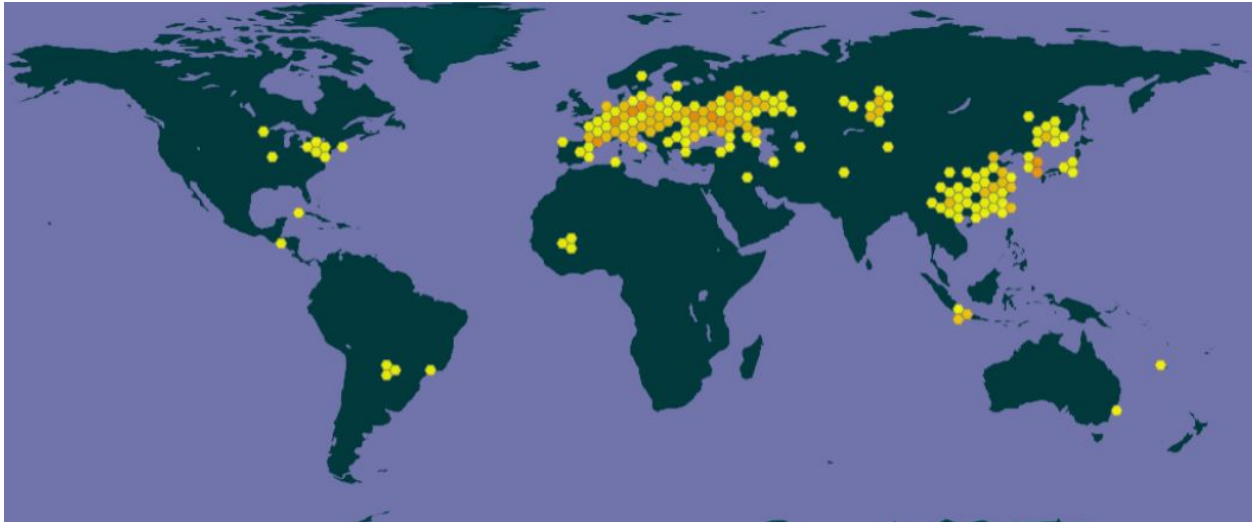


Figure 1. Known global distribution of *Salvinia natans*. Observations are reported throughout Europe, and Asia, with scattered locations in North America, South America, Africa, Indonesia, Australia, and New Caledonia. Map from GBIF Secretariat (2021). Locations in Canada, the United States, Honduras, Brazil, Paraguay, Mali, France, Belgium, the Netherlands, Switzerland, Sweden, Finland, Australia, and New Caledonia will not be included in the climate match as no source provided information to indicate these locations represent populations that are currently established in the wild.

No georeferenced occurrences were available for parts of the species established range in Afghanistan, Bangladesh, Greece, Israel, Jamaica, Lithuania, Mongolia, Nepal, North Macedonia, Pakistan, Syria, Thailand, or Tunisia.

6 Distribution Within the United States

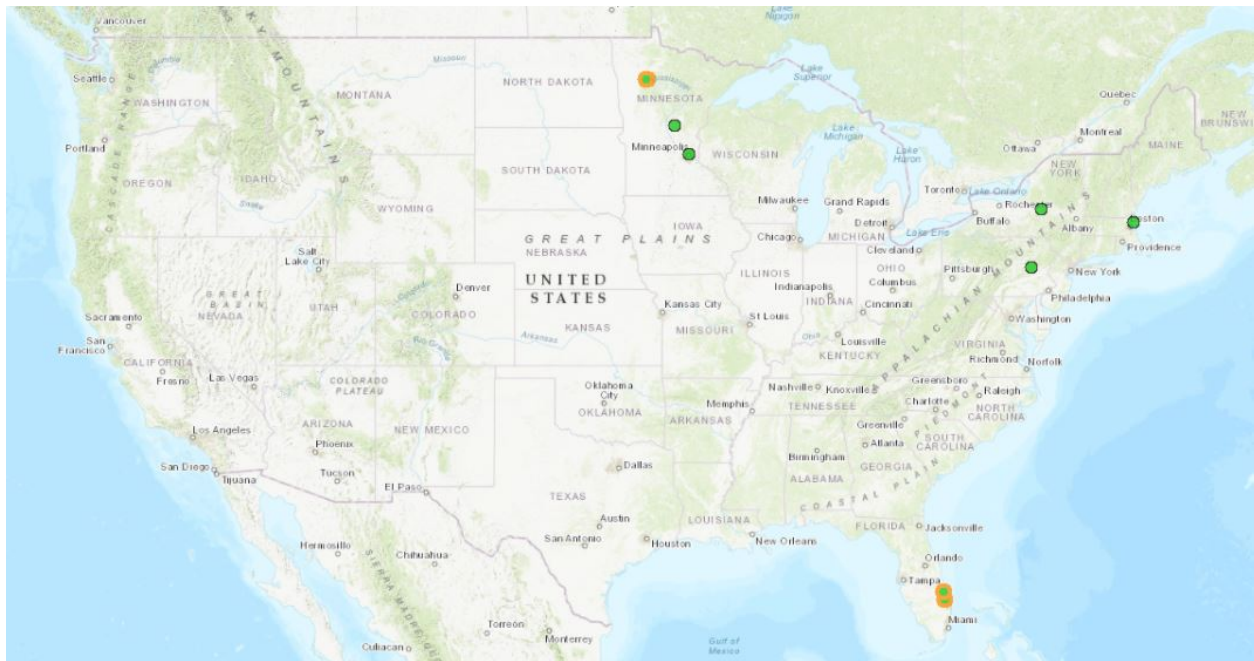


Figure 2. Known distribution of *Salvinia natans* in the United States. Map from BISON (2021). No locations will be used in the climate match as no established populations have been documented in the United States.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for the contiguous United States was generally high. High match was found throughout a majority of the country including in western, central, mid-Atlantic, and southeastern States. The areas of highest match were found in the Great Lakes and north-central regions. Small patches of low to medium-low match were found in the Pacific Northwest, along the United States and Mexico border, inland in the Southeast, and in the Northeast. The overall Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for the contiguous United States was 0.731, high (scores of 0.103 and greater are classified as high). Nearly all States had high individual Climate 6 scores; only Alabama and Mississippi had medium individual Climate 6 scores, while Louisiana received the only low individual Climate 6 score.

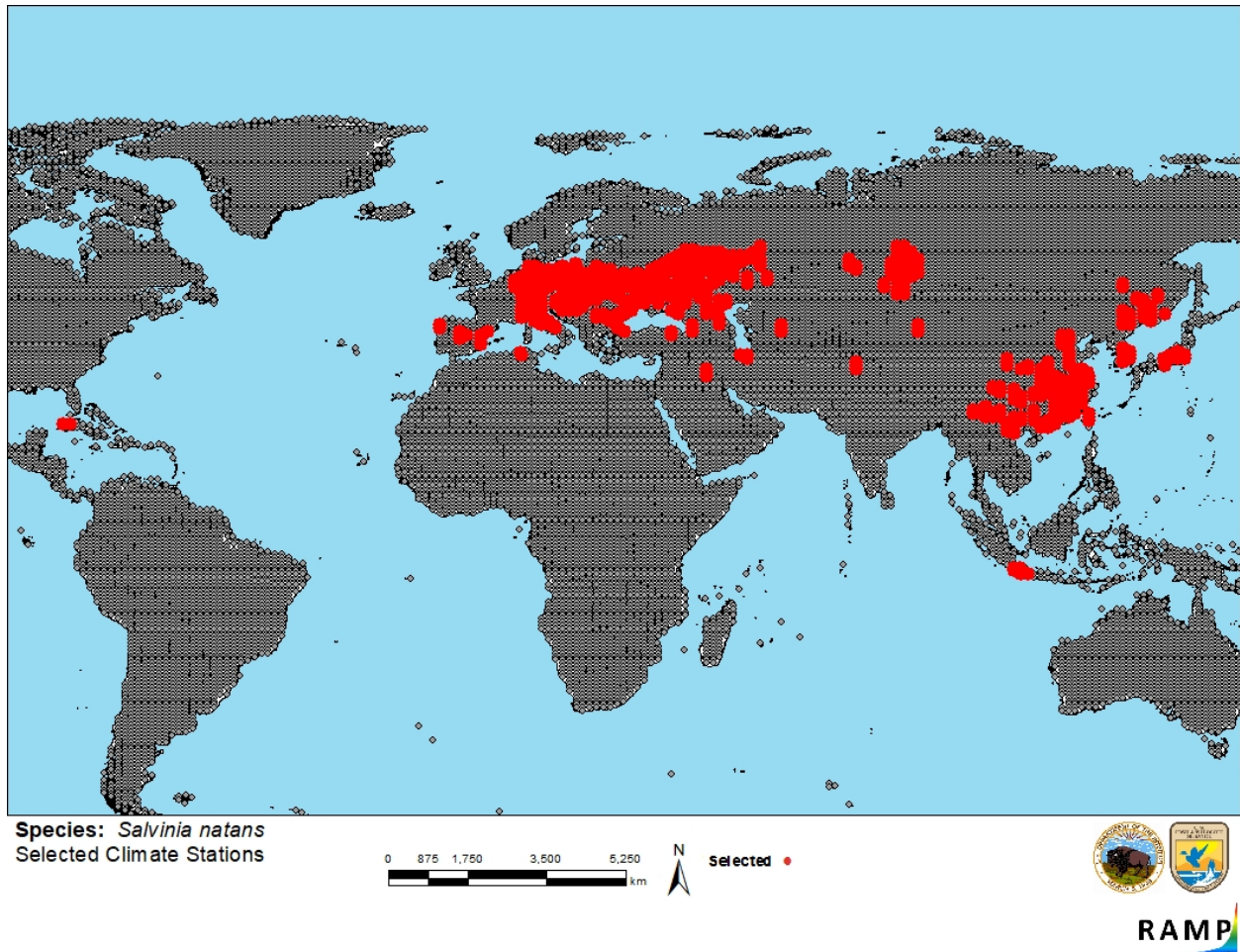


Figure 3. RAMP (Sanders et al. 2018) source map showing weather stations selected as source locations (red; Portugal, Spain, Italy, Austria, Germany, Czech Republic, Poland, Slovakia, Hungary, Slovenia, Croatia, Serbia, Romania, Bulgaria, Moldova, Belarus, Ukraine, Turkey, Georgia, Algeria, Iraq, Iran, Russia, Turkmenistan, Uzbekistan, Kazakhstan, India, China, Vietnam, Myanmar, South Korea, Taiwan, Japan, Indonesia, and Cuba) and non-source locations (gray) for *Salvinia natans* climate matching. Source locations from GBIF Secretariat (2021). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

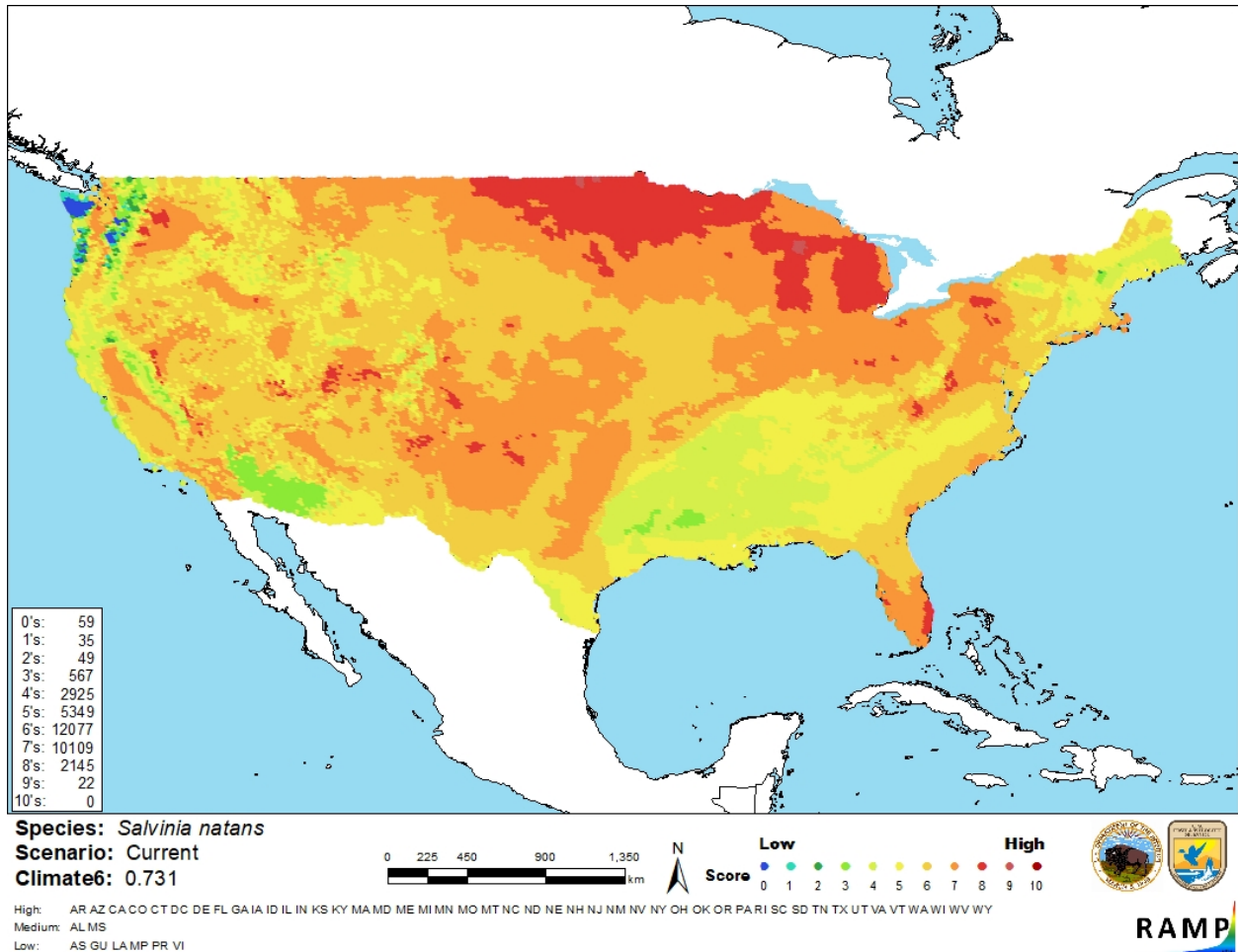


Figure 4. Map of RAMP (Sanders et al. 2018) climate matches for *Salvinia natans* in the contiguous United States based on source locations reported by GBIF Secretariat (2021). Counts of climate match scores are tabulated on the left. 0/Blue = Lowest match, 10/Red = Highest match.

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

Climate 6: (Count of target points with climate scores 6-10)/ (Count of all target points)	Overall Climate Match Category
$0.000 \leq X \leq 0.005$	Low
$0.005 < X < 0.103$	Medium
≥ 0.103	High

8 Certainty of Assessment

The certainty of assessment is Low. Information is available on the biology and ecology of *S. natans*. This species has been introduced outside of its native range in the Caribbean, although there is some uncertainty about native status and established status at the margins of its native range in Europe and Asia. Limited information was found on impacts of introduction.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Floating watermoss, *Salvinia natans*, is an aquatic plant native to Europe, Asia, and northern Africa. This species is found in the aquarium trade in the United States and is listed as a prohibited species in Texas. *S. natans* has been reported as introduced in the United States but no populations are currently established. It has also been reported as introduced and established in Jamaica and Cuba. Impacts have been reported from the Kashmir region of Central Asia, where it grows in thick mats that cause changes in water temperature and reduce dissolved oxygen concentrations, potentially affecting native plant and fish health. However, sources do not agree on the nonnative status of *S. natans* in Kashmir, so the history of invasiveness is Data Deficient. The overall climate match for the contiguous United States is High, with the highest matches occurring in the Great Lakes and north-central regions. The certainty of assessment is Low due to limited information on establishment and impacts of introduction. The overall risk assessment category for *Salvinia natans* is Uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 4): Data Deficient**
- **Overall Climate Match Category (Sec. 7): High**
- **Certainty of Assessment (Sec. 8): Low**
- **Remarks, Important additional information: No additional remarks**
- **Overall Risk Assessment Category: Uncertain**

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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11 Literature Cited in Quoted Material

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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