

# Hawaii Arrowhead (*Sagittaria sagittifolia*)

## Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, December 2014  
Revised, October 2018  
Web Version, 2/16/2021

Organism Type: Plant  
Overall Risk Assessment Category: High

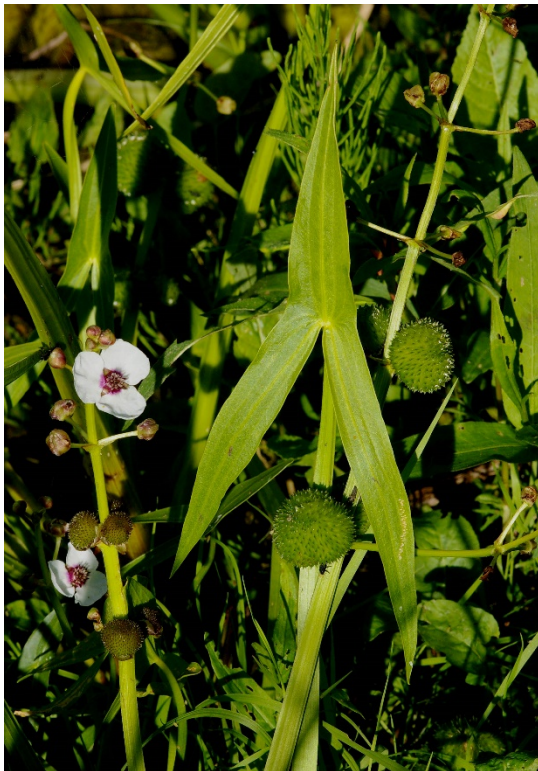


Photo: Christian Fischer. Licensed under Creative Commons BY-SA 3.0 Unported. Available: <https://commons.wikimedia.org/wiki/File:SagittariaSagittifolia.jpg>. (October 17, 2018).

## 1 Native Range and Status in the United States

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### Native Range

From Hroudová et al. (1988):

“*Sagittaria sagittifolia* is a suboceanic species with the centre of its distribution situated between the boreal and meridional zones of Europe and Asia.”

From Lansdown (2014):

“*S. sagittifolia* has a mainly European distribution, extending beyond the region into Siberia, the Caucasus, Turkey and possibly Kazakhstan. It occurs more or less throughout Europe.”

Lehtonen (2003) lists *Sagittaria sagittifolia* as native to Armenia, Azerbaijan, Russian Federation (Ciscaucasia, Eastern Siberia, Western Siberia, European part), China (Zinjiang), Denmark, Finland, Ireland, Norway, Sweden, United Kingdom, Austria, Belgium, Czechoslovakia, Germany, Hungary, Netherlands, Poland, Switzerland, Belarus, Estonia, Latvia, Lithuania, Moldova, Ukraine, Bulgaria, Greece, Italy, Romania, Yugoslavia, France, Portugal, and Spain.

GISD (2017) lists *S. sagittifolia* as native in Albania, Armenia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Bulgaria, China, Croatia, Czech Republic, Denmark, Estonia, Ex-Yugoslavia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Spain, Sweden, Switzerland, United Kingdom, and Vietnam.

## Status in the United States

From Lehtonen (2003):

“*Sagittaria sagittifolia* was listed as a Federal Noxious Weed in 1981. The Federal Register cited as the basis for listing, “impedes flow of irrigation water and interferes with access to water; competes with and reduces yield of rice.” In 1996, Plant Protection and Quarantine (PPQ) personnel realized that the “arrowhead” tubers, approved since 1948 for importation as vegetables under the Fruits and Vegetables Quarantine (7 CFR 319.56), are the same species as the noxious weed prohibited under the noxious weed regulations (7 CFR 360). [...] After reviewing the risk assessment, the APHIS weed team decided to keep *S. sagittifolia* on the Federal noxious weed list, to continue to prohibit importations for propagation, and to issue noxious weed permits for importation and interstate movement of the vegetable for consumption only.”

“Since 1996, PPQ has issued permits for importation and interstate movement of arrowhead tubers into Hawaii, California and New York for human consumption during Chinese New Year. The permits allow movement between the months of November through March. With expanding interest in Chinese cuisine, we anticipate receiving permit applications for movement into additional States.”

“A herbarium survey conducted by Plant Protection and Quarantine in 1992 discovered specimens labeled *S. sagittifolia* collected in Iowa (from 1700), Kentucky (collected in 1893), Virginia (1892), Minnesota (1890), New Hampshire (1940), New York (1829), and Ohio (1881). The identification of these specimens has not been confirmed.”

“In Gardens of Hawaii, Neal (1965) mentions *S. sagittifolia* as a water garden ornamental that sometimes escapes cultivation. However, the Manual of the Flowering Plants of Hawaii (Wagner, et al, 1990) includes only *S. latifolia* with the notation (*S. sagittifolia* sensu Hawaiian

Botanists, non L.). Clyde Imada of the Bishop Museum indicated *S. sagittifolia* is not known to occur in Hawaii, though it may be possibly grown by some for its edible tubers (Kobayashi, 1996 [State of Hawaii Department of Agriculture, personal communication]).”

“North Carolina regulates *S. sagittifolia* under its Aquatic Weed Control Act of 1991.”

According to USDA, NRCS (2018), *Sagittaria sagittifolia* is listed as a Class A noxious weed in Alabama, North Carolina, and Vermont, a quarantine species in California and Oregon, a prohibited species in Massachusetts, and an invasive aquatic plant and plant pest in South Carolina.

GISD (2017) lists *S. sagittaria* as alien, established, and invasive in Hawaii.

## Means of Introductions in the United States

From Lehtonen (2003):

“*S. sagittifolia* tubers may have arrived in the United States with the first Chinese immigrants. Porterfield (1940) discusses *S. sinense* (a synonym of *S. sagittifolia*) as being available in Chinese food shops in New York. He describes the tubers of this species as germinating readily in submerged pots in a greenhouse and notes that the native species *S. latifolia* does not grow as readily.”

## Remarks

From Lehtonen (2003):

“Determining to what extent *S. sagittifolia* occurs in the United States is difficult because it is often confused with native species, especially *S. latifolia* and *S. cuneata* (Haynes, 1996 [Department of Biological Sciences, The University of Alabama, Tuscaloosa. Personal communication]). *S. sagittifolia* is also confused with *S. montevidensis* Cham. & Schldl. (Aston, 1973; Champion and Clayton, 2001), an introduced species found in 10 States. Sturtevant's Edible Plants of the World includes *S. sagittifolia* as a constituent of North American Indians' diet, based on two reports [...], which were unobtainable. The correspondents probably mistook the species for native *Sagittaria* spp. Haynes (1996 [personal communication]) considers *S. sagittifolia*, *S. cuneata*, and *S. latifolia* to be three distinct and valid species. All three species produce edible tubers.”

From Lansdown (2014):

“*S. sagittifolia* is known to hybridize with *S. natans* but it is unlikely that this will affect the status of populations of the parent.”

## 2 Biology and Ecology

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### 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 Alismataceae

Genus *Sagittaria*

Species *Sagittaria sagittifolia* L.

### Size, Weight, and Age Range

From Lehtonen (2003):

“[...] growing in marshes or on mud, 30-90 cm tall, erect, stoloniferous, with milky juice (Holm et al, 1997).”

### Environment

From Lehtonen (2003):

“*S. sagittifolia* grows emersed in fresh or brackish waters. The preferred habitat of the species is between 0 and 1.1 m of water depth, with flowering and fruiting optimal between 0.1 and 0.8 m. Although it prefers shallow standing water or slow-flowing water of fluctuating depth, the plant can survive in completely dry soil by means of its tubers.”

### Climate

From Lehtonen (2003):

“*S. sagittifolia* grows [...] from the subarctic to the tropics and in a few Pacific Island groups (Haynes, 1989).”

## Distribution Outside the United States

### Native

From Hroudová et al. (1988):

“*Sagittaria sagittifolia* is a suboceanic species with the centre of its distribution situated between the boreal and meridional zones of Europe and Asia.”

From Lansdown (2014):

“*S. sagittifolia* has a mainly European distribution, extending beyond the region into Siberia, the Caucasus, Turkey and possibly Kazakhstan. It occurs more or less throughout Europe.”

Lehtonen (2003) lists *Sagittaria sagittifolia* as native to Armenia, Azerbaijan, Russian Federation (Ciscaucasia, Eastern Siberia, Western Siberia, European part), China (Zinjiang), Denmark, Finland, Ireland, Norway, Sweden, United Kingdom, Austria, Belgium, Czechoslovakia, Germany, Hungary, Netherlands, Poland, Switzerland, Belarus, Estonia, Latvia, Lithuania, Moldova, Ukraine, Bulgaria, Greece, Italy, Romania, Yugoslavia, France, Portugal, and Spain.

GISD (2017) lists *S. sagittifolia* as native in Albania, Armenia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Bulgaria, China, Croatia, Czech Republic, Denmark, Estonia, Ex-Yugoslavia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Spain, Sweden, Switzerland, United Kingdom, and Vietnam.

### Introduced

From Lehtonen (2003):

“In the New World, *S. sagittifolia* has been found in Mexico, Cuba and Argentina (Hayes, 1989).”

“Holm et al (1979) include Hawaii, Taiwan, Iran, Philippines, and Portugal within its weedy range. *S. sagittaria* has been reported in Australia and New Zealand, but the reports are probably based on misidentifications of *S. montevidensis* (Aston, 1973; Champion and Clayton, 2001).”

“According to Caton et al (2004), *S. sagittifolia* occurs in Bangladesh, Cambodia, Indonesia, India, Laos, Malaysia, Myanmar (Burma), Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam”

“*S. sagittaria* is a prohibited plant in New Zealand, [...]”

GISD (2017) lists *S. sagittaria* as alien, established, and invasive in Argentina, Australia, Cuba, Mexico, and New Zealand.

*S. sagittaria* is listed as an invasive aquatic species in Bangladesh (Pallewatta et al. 2003).

## Means of Introduction Outside the United States

From Lehtonen (2003):

“The most likely pathway is intentional introduction by people who value *S. sagittifolia* for its many uses.”

## Short Description

From GISD (2017):

“The leaves are borne on triangular stalks that vary in length with the depth of the water in which the plant is growing. They do not lie on the water but stand boldly above it. They are large and arrow-shaped and very glossy. [...] The flower-stem rises directly from the root and bears several rings of buds and blossoms, three in each ring or whorl, and each flower composed of three outer sepals and three large, pure white petals, with a purple blotch at their base. The upper flowers are stamen bearing; the lower ones generally contain the seed vessels only.”

From Hroudová et al. (1988):

“The species produces a leaf-rosette arising from the base, together with one or several scapes bearing usually several tri-petalous flowers of a white colour with purple bases of the petals. The flowers are unisexual. The bottom whorls of inflorescence consist mostly of female flowers, the upper whorls of male flowers, but there is considerable variability in the sexual composition of the two bottom whorls (SIDORSKIJ et al. 1984, 1986). Characteristic of *S. sagittifolia* are several leaf forms occurring in accordance with the ontogenetic stage of the plant and environmental conditions. The first leaves forming a rosette at the stem base are ribbon-shaped; the next, of a transitory form, are spatulate; further leaves have heart-shaped bases and, finally, arrow-shaped leaves are formed. Plants that remain submerged either permanently or for a prolonged period and possess only ribbon-shaped leaves, have been distinguished as f. *stratiotoides* BOLLE; these leaves are often greatly elongated in deep and flowing water (forma *vallisneriifolia* Coss. et GERM.). The plant producing floating leaves differentiated into a petiole and a blade have been designed as f. *natans* (KLINGE) BUCHENAIU, which displays considerable variation in both shape and size [...]. The ovate leaves with a concurrent blade base gradually give way to the arrow-shaped leaf form with a heart-shaped base, almost identical in shape with that of emerged leaves. The most developed leaves that occur during the ontogenesis of the plant are erect arrow-shaped leaves (f. *typica* KLINGE). These leaves are produced by both terrestrial and aquatic forms (emerged leaves) [...]. Sometimes the blade is greatly reduced (f. *bollei* ASCHERS. et GRAEBN.). The leaves of this form have a very narrow blade lining the central vascular bundles of the leaf axis and of the two lobes. This form provides evidence of the variability of the species, but no explanation has been given concerning the conditions promoting the development of this form.”

“Stolonis emerging from the leaf axils are curved downwards. They produce underground tubers which serve as both reproductive and reserve organs; [...].”

“The roots of *S. sagittifolia* are only poorly [*sic*] branched; they appear in dense bundles, and grow to depths of up to 0.15 to 0.3 m according to the character of the soil profile. The surface of

some roots is wrinkled and is thus similar to that of contractile roots in other water-plant species.”

“The fruits - achenes - rest on a receptacle and produce typical spherical syncarps.”

## Biology

From Hroudová et al. (1988):

“*Sagittaria sagittifolia* plays an important role in communities of water- and wetland plants because of its considerable morphological variability and adaptability to changing environmental conditions. This accounts for its considerably wide amplitude of occurrence. Terrestrial forms of the plant occur in the limosal and the terrestrial ecophases; on the other hand, *S. sagittifolia* has been found also in communities of an open water surface, but its occurrence is limited here by the water depth and duration of the hydrophase (terms of ecophases are used according to HEJNÝ 1960).”

“*Sagittaria sagittifolia* is reproduced by seeds as well as vegetatively.”

“Stolons and tubers are formed soon after formation of the aboveground parts of the plant. It was pointed out by GLÜCK (1905) that water deficiency accelerates the formation of the tubers in terrestrial forms. This property becomes evident on a drying-out emerged fishpond bottom: the more rapid its dessication [*sic*], the earlier the formation of underground tubers, to the disadvantage of the development of aboveground plant parts. Thus, there occurs a change in the proportions of aboveground and underground plant parts, which conform to the moisture gradient in the soil; the plant can survive in completely dry soil by means of its tubers [...]”

“Toward the end of the growing season, the parent plant dies, the tubers over-winter. [...] In the spring, the terminal tip starts to elongate and forms a swelling from which both the roots and the leaves of the new plant develop [...]”

“Immediate germination seldom occurs in fresh mature achenes. In nature, they germinate mostly in spring of the subsequent year; seedlings appear in large numbers mainly on emerged fishpond bottoms. Evidently, germination requires a disturbance of the pericarp by physical, chemical and microbial processes in the muddy sediment.”

From GISD (2017):

“North American region: *S. sagittifolia* flowers in mid-summer, and the seeds ripen through the fall. The flowers are monoecious (individual flowers are either male or female, but both sexes can be found on the same plant) and are pollinated by insects (Plants for a Future, 2000).”

## Human Uses

From Hroudová et al. (1988):

“For the ornamental appearance of *S. sagittifolia*, numerous authors (SCHUSTER et SOMMER 1984, DOBREV et KOČEV 1985, etc.) have suggested its cultivation in garden pools. Its

cultivation in aquaria has not been recommended for its considerable size and its requirements for a dormancy period (RATAJ et HEJNÝ 1968, RATAJ 1977). Wildlife (water rodents, wild pigs, etc.) feed on the underground tubers of the Arrow-head; SMIRENSKIJ (1952) recommended its use as feed for farm animals.”

From Lehtonen (2003):

“*Sagittaria* tubers, a good source of carbohydrates, are eaten by many populations especially in China, Japan, Southeast Asia, and Russia (Juzepczuk 1934, Mühlberg 1982). *S. sagittifolia* is used medicinally for indigestion and as an anti-rheumatic (Neumann et al. 1989). Tubers comprise a food source for wildlife. In some countries, tubers are fed to cattle and pigs. The species is used in the aquarium trade and in aquatic gardens (Holm et al. 1977).”

From GISD (2017):

“Plants for a Future (2000) offers a variety of uses both edible and medicinal for *S. sagittifolia*. The leaves and roots of *S. sagittifolia* are edible. The root can be cooked and is apparently excellent when roasted and likened to potatoes. The tubers are starchy with a distinct flavour, but should not be eaten raw. The leaves and young stems can also be cooked but are apparently somewhat acrid. The plant also has medicinal properties as an antiscorbutic; diuretic, and galactofuge but may induce premature birth.”

## Diseases

No information on diseases of *Sagittaria sagittifolia* was found.

## Threat to Humans

From GISD (2017):

“The plant also has medicinal properties as an antiscorbutic; diuretic, and galactofuge but may induce premature birth.”

## 3 Impacts of Introductions

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From Lehtonen (2003):

“According to Haynes (1996 [personal communication]), *S. sagittifolia* is known to grow in rice paddies, but not to the extent that it becomes a noxious weed. Holm et al (1997), however, describe the species as a principal weed of rice in India, Italy and Taiwan.”

“*S. sagittifolia* may rapidly overgrow fish ponds and influence the oxygen regime and environmental conditions in reservoirs (Hroudá et al, 1988). The species can create meadows of green underwater vegetation to interfere with water flow (Holm et al, 1977). On the positive side, tubers comprise a food source for some wildlife (water rodents, wild pigs, birds etc.) and the foliage provides shade, shelter and spawning areas for fish (Holm et al, 1977).”



“High growth rate and high biomass production under optimum conditions may lead to impediments to navigation and recreation (Hroudova et al, 1988). In British canals, *S. sagittifolia* often covers canal margins (with *Nuphar lutea*), but is invariably absent from the center of the channel, probably because propeller action breaks up laminae and petioles. Murphy and Eaton (1983) report *S. sagittifolia* is probably not a notable hindrance to navigation because heavy boat traffic suppresses aquatic macrophyte growth. On the other hand, canals with no or very low boat traffic suffer growth from macrophytes sufficient to impair navigation, angling, and water flow.”

From GISD (2017):

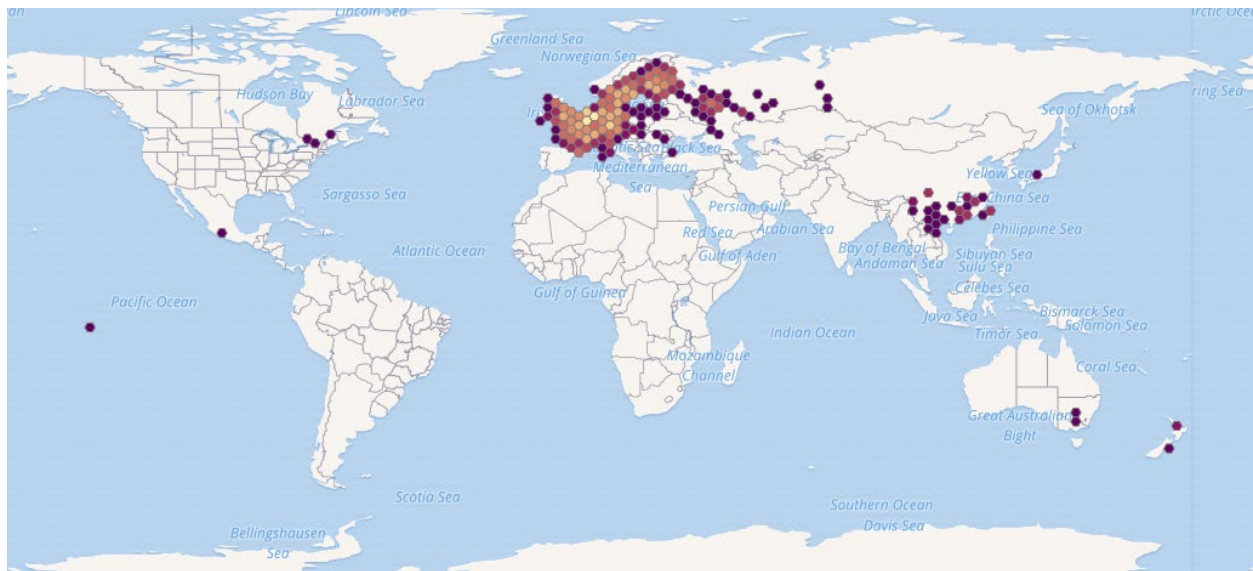
“The Nature Conservancy (2005) explains that *S. sagittifolia* is a general nuisance in the crops' irrigation systems, drains and waterways of more than 50 countries. This invasive potential stems from its remarkable ability to adapt, both in form and physiology to a variety of habitats.”

## 4 History of Invasiveness

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*S. sagittifolia* has invaded Mexico, Cuba, Bangladesh, Cambodia, Indonesia, India, Laos, Malaysia, Myanmar (Burma), Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam, Taiwan, Iran, Portugal and Argentina and New Zealand, although all or some of the Australian and New Zealand introductions may be misidentifications. The plant is prohibited by law in New Zealand. *S. sagittifolia* tubers may have arrived in the United States with the first Chinese immigrants, at least as far back as the 1930s. Various impacts are reported including impacts to crop production, water chemistry and flow, and may impact recreation and navigation. The history of invasiveness is High.

## 5 Global Distribution



**Figure 1.** Known global distribution of *Sagittaria sagittifolia*. Map from GBIF Secretariat (2018). The locations in Canada were not used to select source points for the climate match. The observations are all from 1925 or earlier and in the attached images the herbarium specimens are identified as *Sagittaria latifolia* which is a separate valid species (GBIF Secretariat 2018). The location in the middle of the Pacific Ocean is on an island in French Polynesia; however, it was not used to select source points in the climate match due to the absence of climate stations on those islands (Sanders et al. 2018).

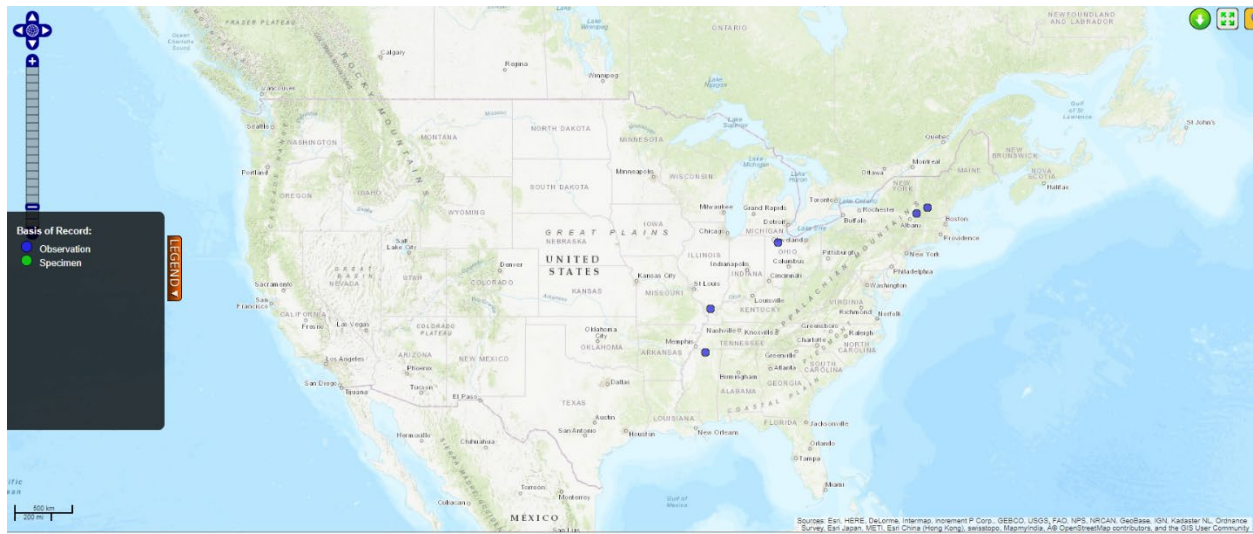


**Figure 2.** Known distribution of *Sagittaria sagittifolia* in India. Map from India Biodiversity Portal (no date).

Additional georeferenced observations in Europe are provided in Keener (2005).

*Sagittaria sagittifolia* was reported as present in Albania, Argentina, Armenia, Azerbaijan, Bangladesh, Bulgaria, Cuba, Indonesia, Iran, Malaysia, Moldova, Nepal, Pakistan, Philippines, Portugal, Sri Lanka, Thailand, and Ukraine, but no georeferenced observations were available for these areas.

## 6 Distribution Within the United States



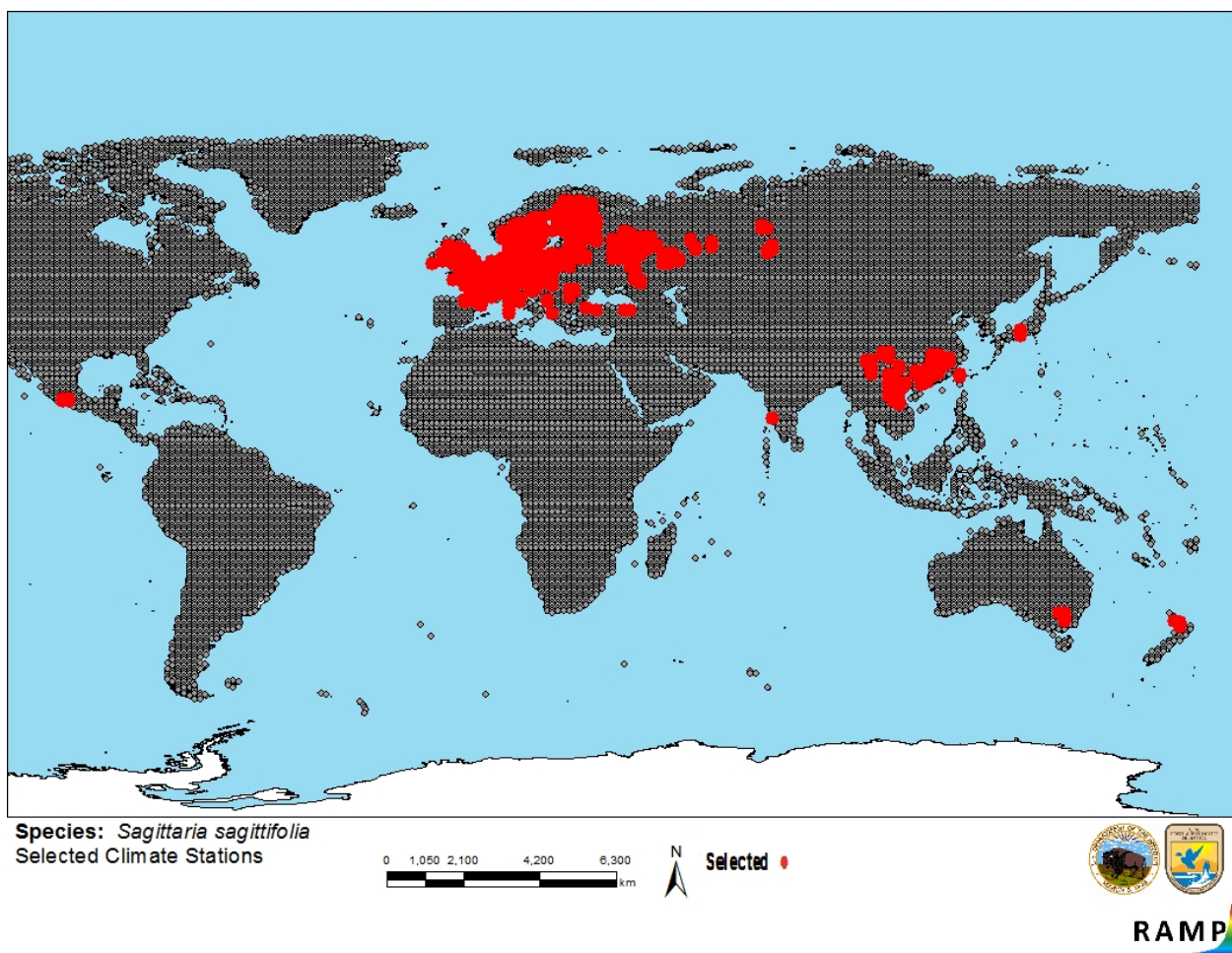
**Figure 3.** Known records of *Sagittaria sagittifolia* in the United States. Map from BISON (2018). The locations outside of Mississippi are the result of a global citizen science biodiversity project and the presence of this species in those locations was not corroborated in the literature. The location in Mississippi was not used to select source points in the climate match. There is no evidence that this single record represents an established population.

One source lists *S. sagittifolia* as established in Hawaii (GISD 2017) but this is not corroborated elsewhere and no georeferenced points were available.

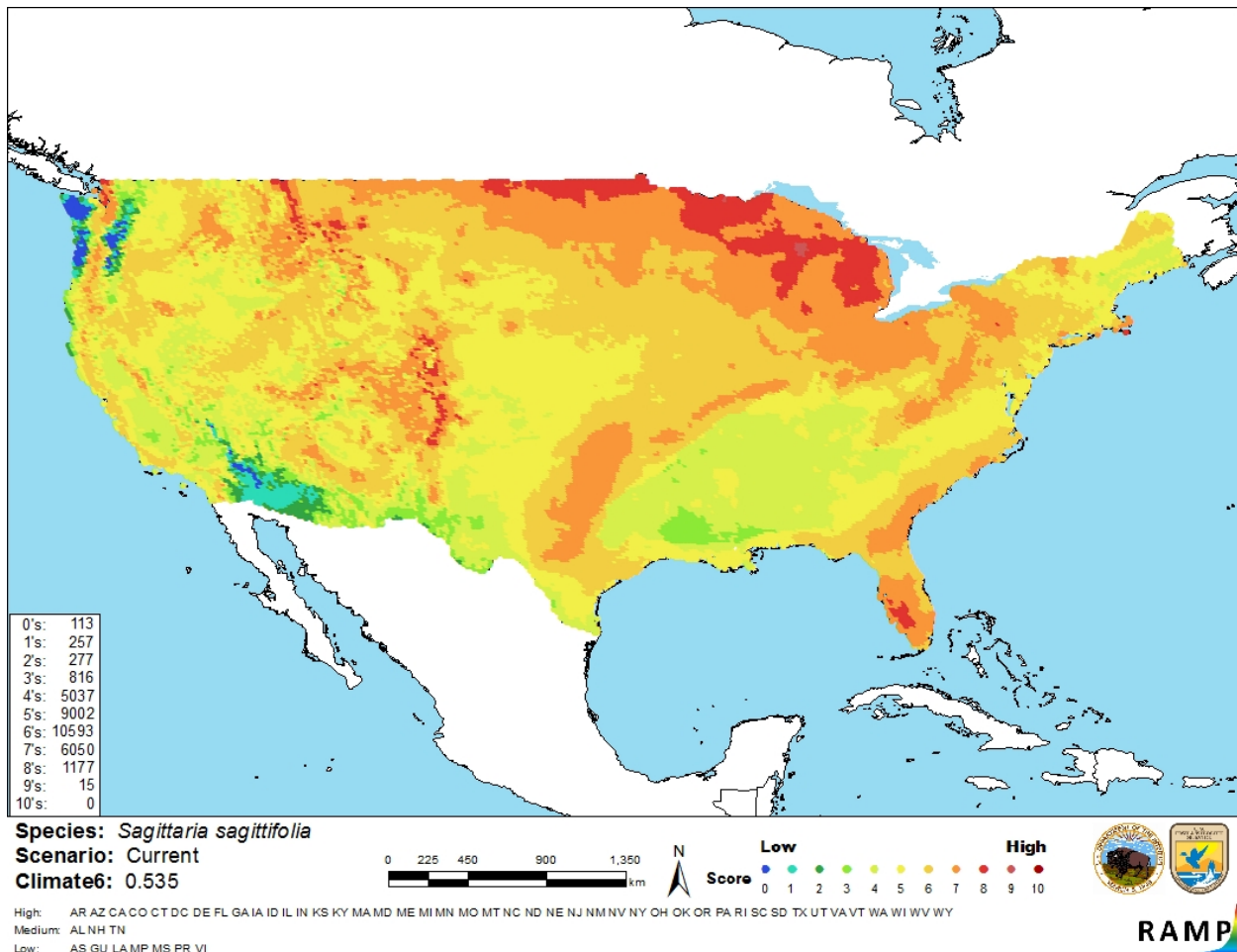
## 7 Climate Matching

### Summary of Climate Matching Analysis

The climate match for *Sagittaria sagittifolia* was medium for much of the contiguous United States. There were areas of low match in New England, inland areas of the south, along the Mexican border and desert areas of Arizona, and the Pacific Northwest. Areas of high climate match included southern Florida and the southern Atlantic Coast, much of the Great Lakes basin, upper Midwest, and small patches in the Great Plains and Pacific Northwest. The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for contiguous United States was 0.535, high (scores 0.103 and greater are classified as high). All States had high individual climate scores, except for Alabama, New Hampshire, and Tennessee, which had medium scores and Louisiana and Mississippi, which had low scores.



**Figure 4.** RAMP (Sanders et al. 2018) source map showing weather stations in Mexico, Eurasia, southern Asia, Japan, Australia, and New Zealand selected as source locations (red) and non-source locations (gray) for *Sagittaria sagittifolia* climate matching. Source locations from GBIF Secretariat (2018) and India Biodiversity Portal (no date). 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. 2018) climate matches for *Sagittaria sagittifolia* in the contiguous United States based on source locations reported by GBIF Secretariat (2018) and India Biodiversity Portal (no date). 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
$\geq 0.103$	High

## 8 Certainty of Assessment

Information on the biology, invasion history, and impacts of this species is available, but is mostly available from gray literature. Enough impact information was available to assess a high history of invasiveness. Large areas of the species' range may not be represented in the source

points of the climate match due to the lack of georeferenced observations in those areas. Certainty of this assessment is medium.

## 9 Risk Assessment

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### Summary of Risk to the Contiguous United States

Hawaii Arrowhead (*Sagittaria sagittifolia*) is a wetland plant native to Eurasia. This plant can grow in water up to 4 ft as well as in muddy conditions. It reproduces both by seed and vegetatively. *S. sagittifolia* has been used as a food source and for medicinal properties. The history of invasiveness is High. The plant has been introduced into other countries including Australia, New Zealand and Mexico and established populations there. This species is currently listed as a Federal Noxious Weed, and is banned from several States but some trade in the tubers as a food source has been allowed. There is information regarding impacts from *S. sagittifolia* invasion including impacts on crop production and water chemistry. Climate matching indicated the contiguous United States has a high climate match. Areas of high match were spread across the contiguous United States. However, there may be much of the species' range that is not represented in the source points used for the climate match due to a lack of available data. The certainty of assessment is medium, mostly due to the gap in distribution data for the climate match. The overall risk assessment category is High.

### Assessment Elements

- **History of Invasiveness (Sec. 4): High**
- **Overall Climate Match Category (Sec. 7): High**
- **Certainty of Assessment (Sec. 8): Medium**
- **Remarks/Important additional information:** *Sagittaria sagittifolia* is on the Federal Noxious Weed list.
- **Overall Risk Assessment Category: High**

## 10 Literature Cited

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**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

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**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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