
Pest Risk Assessment for

***Sagittaria sagittifolia* L**

Chinese arrowhead

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Pest Risk Assessment for *Sagittaria sagittifolia* L.

Stage 1: Initiating Pest Risk Assessment (PRA) Process

Step 1. Document the Initiating Event(s) for the PRA

The purpose of this assessment is to assist State departments of agriculture with the decision about whether or not to concur with federal permit issuance for the use of *Sagittaria sagittifolia* tubers as a vegetable. This risk assessment, using the current weed risk assessment template, updates an assessment written in 1996.

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). The first formal risk assessment was written at that time, to determine if *S. sagittifolia* should remain on the Federal noxious weed list. The outcome of the risk assessment was a finding of high risk potential, derived from a medium consequences of introduction score and a high likelihood of introduction score. 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. The weed team decided that permit issuance would be re-evaluated if PPQ detected any new infestations of *S. sagittifolia* in the United States. No infestations have been detected.

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.

Step 2. Identify and Cite Previous Risk Assessments

In 1948, when "arrowhead", or tubers of *Sagittaria*, were first proposed for commercial importation, agriculture officials used a brief type of risk assessment known as "a decision sheet" to document the pest risk for fruits and vegetables. Finding no significant quarantine pests associated with the commodity, plant quarantine officials approved importation of *Sagittaria* tubers for consumption from China, Japan, Mexico, Hong Kong, Taiwan, Bahamas, Dominican Republic, Haiti and Jamaica. The PPQ Permit Unit has issued import permits for arrowhead since 1948. In economic botany references, *S. sagittifolia* is the most commonly mentioned

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edible species in the genus.

S. sagittifolia was listed in the regulations as a Federal noxious weed in 1981. Early listings were based on the recommendations of the Technical Committee to Evaluate Noxious Weeds (TCENW). TCENW was composed of representatives from the Agricultural Research Service, the Animal and Plant Health Inspection Service, the Agricultural Marketing Service and the Weed Science Society of America. This committee recommended for listing serious weeds of other countries if the weeds were either absent from the United States or of limited distribution. The *Geographical Atlas of World Weeds* (Holm et al, 1979) identifies *S. sagittifolia* as a principal weed in four countries and Hawaii. Weed risk assessment in the early 1980's consisted of checking world weed references for the most serious weeds and then determining distribution in the United States. The TCENW considered distribution in three or fewer states to meet the criterion for listing (Gunn and Ritchie, 1982).

As mentioned in the initiating events section of this document, the first formal weed risk assessment for *S. sagittifolia* was written in 1996. The conclusions of that assessment are still valid. This document updates the previous assessment, using the current risk assessment format.

Step 3. Establish Identity of Weed

Scientific Name: Order, Family, Genus, and species:

Alismatales, Alismataceae, *Sagittaria sagittifolia* L.

Synonym(s):

Sagittaria minor Mill. Gard. Dict. ed. 8. 1768.
Sagitta major Scop. Fl. Cam. ed. 2. 2:239.1772.
Sagittaria natans Pallas, Reise 3:77.1778.
Sagittaria monoica Gilib. Fl. Lith. 2:218. 1782.
Sagittaria obtusa Thunb. Fl. Jap. 242. 1784.
Sagittaria sagittata Thunb. Fl. Jap. 242. 1784.
Sagittaria vulgaris Gueldens. Reisen Russ. 2:45.179
Sagittaria alpina Willd. Sp. Pl. 4:410. 1805.
Vallisneria bulbosa Poir. in Lam. Encyc. 7:321.1808.
Sagittaria heterophylla Schreb. in Schweigg. & Korte, Fl. Erl. 2:119. 1811.
Sagittaria sinensis Sims. Bot. Mag. pl. 1631. 1814.
Sagittaria acuminata J.E.Sm. in Rees, Cyc. 31:4. 1814.
Sagittaria aquatica S.F.Gray, Nat. Arr. Br. Pl. 2:216.1821.
Sagittaria aquatica var. *minor* (Mill.) S.F.Gray, Nat. Arr. Br. Pl. 2:216.1821.
Sagittaria hastata Don, Prodr. Fl. Nep. 22. 1825.
Sagittaria doniana Sweet, Hort. Brit. 375. 1826.
Sagittaria sagittifolia var. *tenuior* Wahl. Fl. Succ. 2:621.1826.
Sagittaria hirsutifolia Blume, Enum.Pl. Jav. 34. 1827.
Sagittaria hermaphrodita Ham. in Wall. Cat. 175. 1832. Nomen nudum.
Sagittaria macrophylla Bunge, Mem. Sav. Etr. 2:147. 1833.
Sagittaria edulis Schlecht. Linnaea 18:432. 1844.

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Sagittaria alpina var. *emersa* Turcz. Bull. Soc. Imp. Nat. Mosc. 27(3):58. 1854.
Sagittaria alpina var. *submersa* Turcz. Bull. Soc. Imp. Nat. Mosc. 27(3):58. 1854.
Sagittaria sagittifolia var. *longiloba* Turcz. Bull. Soc. Imp. Nat. Mosc. 27(3):58. 1854.
Sagittaria sagittifolia var. *vallisneriifolia* Coss. & Godr. Fl. Fr. 3:167.1855.
Sagittaria sagittifolia var. *stratiotooides* Bolle, Verh. Bot. Ver. Mark. Brand 3:164. 1861.
Sagittaria sagittifolia var. *breviloba* Reg. Mem. Acad. St.-Petersb. 7(4):154. 1862.
Sagittaria sagittifolia var. *minor* (Mill.) Reg. Mem. Acad. St.-Petersb. 7(4):154. 1862.
Sagittaria sagittifolia var. *subaequilonga* Reg. Mem. Acad. St.-Petersb. 7(4):154. 1862.
Sagittaria sagittifolia var. *edulis* (Schlecht.)Sieb. ex Miq. Ann. Mus. Lugd. Bot. 2:138. 1865.
Sagittaria sagittifolia var. *aequiloba* Schur., Enum. Pl. Transsil. 630. 1866.
Sagittaria sagittifolia var. *heterophylla* (Schreb.) Schur., Enum. Pl. Transsil. 630. 1866.
Sagittaria sagittifolia var. *divaricata* Schur., Enum. Pl. Transsil. 630. 1866.
Sagittaria sagittifolia var. *leucopetala* Miq. Ill. FL. Arch. Ind. 49. 1870.
Sagittaria tenuior (Wahl.) Gandoger, Fl. Lyonn. 226. 1875.
Sagittaria sagittifolia var. *diversifolia* Micheli in DC. Monogr. Phan. 3:66. 1881.
Sagittaria aquatica (S.F.Gray) St. Lager in Cariot Etudes Fl. ed. 8. 2:819. 1899.
Sagittaria palustris Bub. Fl. Pyren. 4:4. 1891.
Sagittaria aginashi Makino, Bot. Mag. Tok. 15:104. 1901.
Sagittaria hyperborea Laest. ex Lindb. Medd. Soc. Faun. Fl. Fenn. 27:66.1901. Nomen nudum.
Sagittaria septentrionalis Laest. ex Lindb. Medd. Soc. Faun. Fl. Fenn. 27:66.1901. Nomen nudum
Sagittaria leucopetala (Miq.)Bergm. Vasti Pl. Rot. 479. 1924.
Sagittaria triflora Auct. non L.

Common names: arrowhead, giant arrowhead, Old World arrowhead, Chinese arrowhead, swamp-potato, swan potato, omodaka zoku or Kuwai (Japan), Chee-koo (China), Gauai-gauai (Philippines), flèche d'eau, Pfeilkraut, espadana, sagitária , flecha de agua, saeta de agua (Rehm, 1994).

Description, general morphology:

S. sagittifolia L. is an herbaceous perennial or rarely annual aquatic herb. Monoecious, or sometimes dioecious, it may be anchored beneath the water, growing in marshes or on mud, 30-90 cm tall, erect, stoloniferous, with milky juice (Holm et al, 1997). Rhizomes measure up to 2.5 cm long, to 2.5 cm in diameter, stolons to 18 cm long to 0.3 cm in diameter, often terminated by tubers, which are elongate, 5-7 cm long (Haynes, 1989).

S. sagittifolia forms three types of leaves: submerged (ribbon-like), floating (transitional in shape) and aerial (long-stemmed arrowhead-shaped) (Hroudova, 1980).

The inflorescence is an erect and simple or rarely paniculate scape of 2-10 whorls of 3 flowers. Flowers are imperfect, the upper flowers are staminate and the lower are carpellate. The petals are white with purple to red claws; carpels numerous, distributed evenly over the receptacle (Haynes, 1989).

The round fruiting head is a mass of flat achenes (Neal, 1965). Achenes are 2 mm by 1 mm, enclosed in a wide winged membranous sheath, 6 mm by 4 mm; seeds are brown, obovate with a

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thick rim (Reed, 1977).

Preferred habitat and climatic tolerance:

S. sagittifolia grows in Europe and Asia in a variety of aquatic habitats from the subarctic to the tropics and in a few Pacific Island groups (Haynes, 1989). *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. *S. sagittifolia* may be found in standing water, shallow river banks and reservoirs, quiet river bays, canals, old oxbows. *S. sagittifolia* grows mostly in finely granular, muddy or loamy soils, occasionally in very nutrient-poor peaty or sandy soil (Hroudova, 1980; Hroudova et al, 1988).

Native distribution:

(From USDA, ARS, GRIN, 2004)

ASIA-TEMPERATE

Caucasus: Armenia; Azerbaijan; Russian Federation - Ciscaucasia

Siberia: Russian Federation - Eastern Siberia, Western Siberia

China: China - Xinjiang

EUROPE

Northern Europe: Denmark; Finland; Ireland; Norway; Sweden; United Kingdom

Middle Europe: Austria; Belgium; Czechoslovakia; Germany; Hungary; Netherlands; Poland; Switzerland

East Europe: Belarus; Estonia; Latvia; Lithuania; Moldova; Russian Federation - European part; Ukraine

Southeastern Europe: Bulgaria; Greece; Italy; Romania; Yugoslavia

Southwestern Europe: France; Portugal; Spain

Current world distribution beyond native distribution:

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

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Stage 2: Assessing pest risk

Step 4. Verify Quarantine Pest Status

Federal noxious weeds are prohibited entry into the United States, and thus should meet the International Plant Protection Convention (IPPC) definition of a quarantine pest, i.e., one having “potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled” (FAO, 1995).

Geographic Criterion: 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). *S. sagittifolia* is also confused with *S. montevidensis* Cham. & Schltdl. (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 reports¹, which were unobtainable. The correspondents probably mistook the species for native *Sagittaria* spp. Haynes (1996) considers *S. sagittifolia*, *S. cuneata*, and *S. latifolia* to be three distinct and valid species. All three species produce edible tubers.

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.

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).

The most recent U.S. flora, Flora of North America, does not include *S. sagittifolia* as a native of North America or as an introduced species (Haynes and Hellquist, 2000). The PLANTS database lacks distribution records of this species in the United States (USDA, NRCS, 2004).

¹Kalm, P. *Trav. No. Amer.* 1:386. 1772., and Torrey, J. *Pacific R.R. Rpt.* 6:91. 1857.

Regulatory criterion: North Carolina regulates *S. sagittifolia* under its Aquatic Weed Control Act of 1991. The Federal listing of *S. sagittifolia* in 1981 established an official control program for the species by requiring a federal permit for importation and interstate movement.

Accepting the treatment in Flora of North America, *S. sagittifolia* meets the geographic and regulatory criteria for “quarantine pest” because it is of limited distribution and officially controlled.

Step 5. Assess Economic and Environmental Importance: Consequences of Introduction

After each of the four risk elements (A-D) in step 5, we discuss the rationale for the rating and the level of certainty.

A. Establishment potential or habitat suitability in the protected area.

Estimate the potential range in the United States, considering suitable climate conditions.

Assign rating as follows:

Rating	Numerical Score	Explanation: A suitable climate and habitats would permit the weed to survive and establish:
High ✓	3 ✓	In most or all of the United States (generally, in more than four plant hardiness zones).
Medium	2	In approximately one-third to two thirds of the United States (generally, in three or four plant hardiness zones).
Low	1	In less than one third of the United States.
Negligible	0	No potential to survive and become established in the PRA area.

Rationale for the rating and the level of certainty:

The center of *S. sagittifolia*’s distribution is between the boreal and meridional zones of Europe and Asia. The species is morphologically variable and adaptable to changing environmental conditions. Since it occurs in a variety of aquatic habitats from the subarctic to the tropics and in a few Pacific Island groups (Haynes, 1989), *S. sagittifolia* can be expected to thrive in four or more hardiness zones within the United States.

Level of certainty = uncertain. The conservative prediction is based on climate preference and documented distribution in other parts of the world.

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B. Spread potential after establishment, Dispersal Potential

Check each of the following that apply:

- Consistent and prolific seed production
- Rapid growth to reproductive maturity
- High germination rate under a wide range of conditions
- Ability to suppress the growth of other plants by releasing a chemical inhibitor
- Ability to persist as dormant long-lived propagules or underground parts, such as rhizomes, tubers✓, turions or stolons
- Seed dormancy ✓
- Stress tolerance ✓, including ability to resist herbicides
- Ability to colonize a wide variety of habitats
- Lack of natural control agents
- Well-developed storage tissue (for example, tap root)
- Dispersal by wind, water ✓, machinery, animals ✓, and/or humans ✓.

Assign rating as follows:

Rating	Numerical score	Explanation
High	3	Weed has potential for rapid natural spread throughout its potential range in the PRA area (<i>e.g.</i> , high reproductive potential AND highly mobile propagules).
Medium ✓	2 ✓	Weed has potential for natural spread throughout a physiographic region of the PRA within a year (<i>e.g.</i> , it has either high reproductive potential OR highly mobile propagules).
Low	1	Weed has potential for natural spread locally in the PRA area within a year (some reproductive potential and/or some mobility of propagules).
Negligible	0	Weed has no potential for natural spread in the PRA area.

Rationale for the rating and the level of certainty:

New plants grow by division, seeds, and tubers (Hroudova et al, 1988). Seed production, while influenced by habitat conditions, is generally high under favorable conditions. Seeds can float for prolonged periods, or be spread by waterfowl and easily germinate after a period of dormancy. Seeds tolerate desiccation (Guppy, 1897). Some seeds survive ten years in storage

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(Ewart, 1908).

Germination occurs mostly in spring of the subsequent year and requires a disturbance of the pericarp by physical, chemical and microbial processes in muddy sediment. Seedlings can develop only on emerged muddy sediments and seldom find favorable conditions for development (Hroudova et al, 1988).

The terrestrial ecophase has an unfavorable effect on the fruiting capacity of the plants, and their populations maintain themselves vegetatively (Hroudova, 1980). Tubers are produced at the ends of long stolons arising from the leaf axils. Water deficiency accelerates tuber formation, and plants can survive in completely dry soil by means of its tubers. However, tubers can only be dispersed in water, and are deeply seated which partly prevents their emergence to the water surface to be spread by spring floods, etc. At the end of a growing season, the parent plant dies, the tubers overwinter. Eight to nine tubers may be produced by one plant during one growing season (Chung and Ripperton, 1929; Hroudova et al, 1988).

S. sagittifolia frequently grows in nutrient-poor, acid and often peaty soils. It tolerates lime and fertilizer, but is curtailed by high salt content (Hroudova et al, 1988).

Arrowhead may be spread by humans who value them as a food source, ornamental, or medicinal plant.

Level of certainty = uncertain. This is a high medium. Clearly, the propagules are mobile, being spread by water, animals, water fowl, and humans. The reproductive potential is less high, with seed and tuber production less than prolific, and their survival dependant on favorable conditions.

C. Economic Impact

Discuss the potential economic importance of the species in the PRA area. Consider three primary types of damage:

1. Reduced crop yield (*e.g.*, by parasitism, competition, or by harboring other pests).
2. Lower commodity value (*e.g.*, by increasing costs of production, lowering market price, or a combination); or if not an agricultural weed, by increasing costs of control.
3. Loss of markets (foreign or domestic) due to presence of a new quarantine pest.

Assign ratings as follows:

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Rating	Numerical score	Explanation
High	3	Weed causes all three of the above impacts, or causes any two impacts over a wide range (over 5 types) of economic plants, plant products, or animals.
Medium ✓	2 ✓	Weed causes any two of the above impacts, or causes any one impact to a wide range (over 5 types) of economic plants, plant products, or animals.
Low	1	Weed causes any one of the above impacts.
Negligible	0	Weed causes none of the above impacts.

Rationale for the rating and the level of certainty:

1. Reducing crop yield: According to Haynes (1996), *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.

2. Costs of Control/Lowering commodity value: *S. sagittifolia* may infest irrigation systems (Holm et al, 1997).

3. Loss of markets: No. *S. sagittaria* is a prohibited plant in New Zealand, but would not likely be a contaminant in any US export to New Zealand (Excerpt, 2004).

Level of certainty = reasonably certain. Both potential economic impacts, to rice yield and to irrigation systems, are highly speculative. Caton, BP, AM Mortimer and JE Hill, 2004 (*in press*) corroborate this rating in *A Practical Field Guide to Weeds of Rice in Asia* by classifying *S. sagittifolia* as "low to moderate" in competitiveness.

D. Environmental Impact

Check each of the following that apply. Consider whether or not the weed, if introduced, could:

- Cause impacts on ecosystem processes (alteration of hydrology, sedimentation rates, a fire regime, nutrient regimes, changes in productivity, growth, yield, vigor, etc.).
- Cause impacts on natural community composition (*e.g.*, reduce biodiversity, affect native populations, affect endangered or threatened species, impact keystone species, impact native fauna, pollinators, or microorganisms, etc.).
- Cause impacts on community structure (*e.g.*, change density of a layer, cover the canopy, eliminate or create a layer, impact wildlife habitats, etc.).
- Have impacts on human health such as allergies or changes in air or water quality.
- Have sociological impacts on recreation patterns and aesthetic or property values.

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- Stimulate control programs including toxic chemical pesticides or introduction of a nonindigenous biological control agent.

Assign ratings as follows:

Rating	Numerical Score	Explanation
High	3	Three or more of the above. (Potential to cause major damage to the environment with significant losses to plant ecosystems and subsequent physical environmental degradation.)
Medium ✓	2 ✓	Two of the above. (Potential to cause moderate impact on the environment with obvious change in the ecological balance, affecting several attributes of the ecosystem, as well as moderate recreation or aesthetic impacts.)
Low	1	One of the above, unless the factor is potential to reduce populations of endangered or threatened species, which rates High. (Limited potential impact on environment.)
Negligible	0	None of the above. (No potential to degrade the environment or otherwise affect ecosystems.)

Rationale for the rating and the level of certainty:

1. Ecosystem processes: Yes. *S. sagittifolia* may rapidly overgrow fish ponds and influence the oxygen regime and environmental conditions in reservoirs (Hrouda 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).

2. Impacts on natural community composition: No. *S. sagittifolia* frequently occurs in mixed stands with other species, and is not reported to replace other species (Murphy and Eaton, 1983; L.L. Smith, 1978).

3. Impacts on community structure: No evidence found to support.

4. Have impacts on human health: No evidence found to support negative impacts. Researchers in Russia (Sidorskii et al, 1992) established that peculiarities of the sexual structure of the inflorescence correlate with the degree of pollution in the water, indicating the species has potential as a bioindicator of ecological condition and a means of monitoring the ecological conditions.

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5. Sociological impacts on recreation patterns and aesthetic or property values: Yes. 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.

6. Stimulate control programs using toxic pesticides or nonindigenous agents: Little evidence found to support. The United States flora includes many closely related native species, which suggests the presence of natural enemies.

Level of uncertainty = reasonably certain.

ECONOMIC and ENVIRONMENTAL IMPORTANCE SUMMARY: Consequences of Introduction: Cumulative Risk Element Score

Add together the numerical estimates for the four risk elements to produce an overall estimate of the Consequences of Introduction Risk Rating for the weed. The overall risk rating is used to assign a Consequences of Introduction Risk Score as follows:

Risk: Consequences of Introduction (Sum Risk Elements #1-4) (3+2+2+2 = 9)		
Cumulative Risk Element Score	Risk Rating	Risk Score
0 – 2	Negligible	0
3 – 6	Low	1
7 - 10 ✓	Medium ✓	2
11 – 12	High	3

The Consequences of Introduction Risk Rating, an indicator of the potential of the weed to become established and spread, and its potential to cause economic and environmental impacts, is medium for *S. sagittifolia*.

Step 6. Assess Likelihood of Introduction

Discuss entry potential and establishment potential. What is the likelihood that the species will enter the United States, survive the shipment and find a suitable habitat for establishment?

Assign ratings as follows:

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Rating	Numerical Score	Explanation: Introduction is
High ✓	3 ✓	Very likely or certain
Medium	2	Likely
Low	1	Low, but clearly possible
Negligible	0	Extremely unlikely

Rationale for rating and the level of certainty:

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

Likely pathways into the United States are aquarium and ornamental plant shipments, and intentional importation in baggage and cargo for planting as a source of vegetable or medicine. None of these pathways is subject to treatment prior to shipping, and the propagules would be likely to survive the shipment and be introduced intentionally and repeatedly into the environment. In the absence of regulation, *S.sagittifolia* would almost certainly be introduced beyond its present limited range.

Level of certainty = reasonably certain

Step 7. Conclusion: Pest Risk Potential of Weed

Produce an estimate of the pest risk potential by considering the Consequences of Introduction and the Likelihood of Introduction using the following table as a guide. The pest risk potential will be obtained from the combination of the scores for likelihood of introduction and consequences of introduction, and will be assigned as follows:

Consequences of Introduction (Rating and Score)	Likelihood of Introduction (Rating and Score)	Overall Pest Risk Potential
Negligible (0)	Negligible (0)	Negligible
Negligible (0)	Low (1)	Negligible
Negligible (0)	Medium (2)	Negligible
Negligible (0)	High (3)	Negligible
Low (1)	Negligible (0)	Negligible

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Consequences of Introduction (Rating and Score)	Likelihood of Introduction (Rating and Score)	Overall Pest Risk Potential
Low (1)	Low (1)	Low
Low (1)	Medium (2)	Low
Low (1)	High (3)	Low
Medium (2)	Negligible (0)	Negligible
Medium (2)	Low (1)	Low
Medium (2)	Medium (2)	Medium
Medium (2) ✓	High (3) ✓	Medium- High ✓
High (3)	Negligible (0)	Negligible
High (3)	Low (1)	Low
High (3)	Medium (2)	Medium-High
High (3)	High (3)	High

Summary and Recommendations:

S. sagittifolia earns a medium-high pest risk potential rating. According to APHIS weed policy, plants earning a high or medium-high risk potential rating are eligible for listing. *S. sagittifolia* should remain on the noxious weed list.

Since 1948, USDA has issued permits for importation of arrowhead as a vegetable commodity. In 1999, PPQ added interstate movement provisions to the noxious weed regulations (7CFR 360). Since 1999, the regulations require noxious weed permits for importation and interstate movement of all Federal noxious weed propagules. As of January 2004, PPQ has issued several noxious weed permits for human consumption of arrowhead during Chinese New Year (November through March) into California, Hawaii, and New York. Each permit is issued with State concurrence.

Permit issuance for use of arrowhead as a vegetable should be continued. The risk-related considerations include:

- *Sagittaria* tubers have been imported for consumption since 1948 without the species becoming established as a weed.
- If tubers for consumption are not available through existing channels, people who enjoy the vegetable will be more likely to cultivate the species illegally, increasing the risk of establishment.

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- Closely related species of *Sagittaria* are native to the United States, which suggests the presence of natural enemies.

Weed Team Recommendations:

1. Do not propose delisting *S. sagittifolia* L. from the Federal noxious weed list.
2. Continue to prohibit importations for propagation, except for research in containment under permit.
3. Continue to issue noxious weed permits for consumption only during Chinese New Year (March-November), if the State of destination concurs.
4. Re-evaluate permit issuance if PPQ discovers any new infestations of *S. sagittifolia* in the United States.

Step 8. References

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