Giant Salvinia (*Salvinia molesta*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, January 2023
Revised, May 2023
Web Version, 4/30/2025

Organism Type: Fern
Overall Risk Assessment Category: High

Photo: Ian Pfingsten. Public domain. Available: https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=298 (January 2023).

1 Native Range and Status in the United States

Native Range

According to Lal (2016), *S. molesta* is native to southeast Brazil, Uruguay, Paraguay, and northeast Argentina.

Status in the United States

From Thayer et al. (2023):

"Populations established in the southeast and southwest U.S., including Guam, Hawaii, and Puerto Rico. Extirpated from colder climate states (Connecticut, District of Columbia, Kansas, Missouri, Virginia) and eradicated from Northern Alabama and California, and parts of the Carolinas, Florida, and Texas. More than 99% of the Pascagoula River population was killed by storm surge salinity or by being deposited on land during Hurricane Katrina in 2005, thus leaving about 2 hectares of *S. molesta* distributed over ~20 sites (Fuller et al. 2010)."

According to Thayer et al. (2023), *Salvinia molesta* has been reported as introduced and established in Alabama, Arizona, Arkansas, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, North Carolina, Puerto Rico, South Carolina, Texas, U.S. Virgin Islands, and Virginia. It has been reported as introduced but extirpated in Washington and as introduced but the status is unknown in Missouri.

From McFarland et al. (2004):

"In the United States, severe infestations have occurred in the Swinney Marsh Complex, Texas, in the Lower Colorado River, Arizona/California, and in Lake Wilson and Enchanted Lake, Hawaii (Jacono and Pitman 2001; TenBruggencate 2003)."

Salvinia molesta may be in the aquarium trade in the United States (e.g., Aquarium Roots 2023, GardenAquaria 2023, ebay 2023).

Regulations

From Westbrooks (2010):

"USDA APHIS first listed Giant salvinia as a Federal Noxious Weed in 1981. As a listed Federal Noxious Weed, Giant salvinia cannot be imported into the United States or transported across State lines without a Federal permit from APHIS. Under the U.S. Plant Protection Act of 2000, USDA APHIS can also cooperate with State and local agencies to eradicate infestations of listed Federal Noxious Weeds such as Giant salvinia."

"Giant salvinia is also listed as a regulated State Noxious Weed in a number of U.S. states and territories. These include Alabama, Arkansas, Arizona, California, Colorado, Connecticut, Florida, Idaho, Louisiana, Massachusetts, Maryland, Michigan, Mississippi, Nevada, North Carolina, Oklahoma, Oregon, Puerto Rico, South Carolina, Tennessee, Texas, Vermont, and West Virginia."

"In Louisiana, Giant salvinia is listed as an Invasive Noxious Aquatic Plant under Louisiana Revised Statutes Title 76, Section 1101. In Texas, Giant salvinia is listed as a Noxious and Invasive Plant under Texas Administrative Code – Title 4 – Agriculture - Rule 19.300."

Salvinia molesta is also regulated in Hawaii (S.B. No 1505 2003), Illinois (Illinois DNR 2015), Indiana (Indiana DNR 2022), Minnesota (Minnesota DNR 2022), New Hampshire (NHDES

2022), New Mexico (NMDA 2020), Virginia (VDACS 2022), and Wisconsin (Wisconsin DNR 2022). Please refer back to state agency regulatory documents for details on the regulations, including restrictions on activities involving this species. While effort was made to find all applicable regulations, this list may not be comprehensive. Notably, it does not include regulations that do not explicitly name this species or its genus or family, for example, when omitted from a list of authorized species with blanket regulation for all unnamed species.

Means of Introductions within the United States

From McFarland et al. (2004):

"The attraction of *S. molesta* as an ornamental plant has led to its inter-continental transport via aquarium and landscaping trades. Its introduction to North America, […] has been linked to cultivation activities of botanical gardens and commercial horticulture sites (Harley and Mitchell 1981; Nelson 1984; Thomas and Room 1986a; Oliver 1993; Jacono 2003a). Plants initially introduced to the United States probably arrived in Florida from Sri Lanka, as cargo for direct sale or as a contaminant in an aquatic plant shipment (Nelson 1984; Oliver 1993; Jacono 2003a). A long-standing assumption has been that naturalized populations of exotic plants occur by these plants being dumped into nearby waterways or being "seeded" deliberately in the wild for future marketing."

From Westbrooks (2010):

"Once it infests a waterway, Giant salvinia is spread to new areas by flowing water and by boats, trailers, and other recreational watercraft."

Remarks

This ERSS was previously published in August 2019. Revisions were completed to incorporate new information and conform to updated standards.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2023):

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

Species *Salvinia molesta* (D.S. Mitch.)

According to WFO (2023), *Salvinia molesta* D. Mitch. is the current valid name for this species.

From CABI (2013):

"Originally identified as a form of *S. auriculata*, *S. molesta* was renamed based on its fruiting bodies in 1972 (Mitchell, 1972)"

Size, Weight, and Age Range

From Thayer et al. (2023):

"**Size:** Paired fronds or leaves 2-4 cm long and 1-6 cm wide"

Environment

From CABI (2013):

"*S. molesta* easily colonizes disturbed habitats including rice paddies, flood canals, artificial lakes and hydro-electric facilities (Barrett, 1989). In its native range, *S. molesta* occurs in artificial reservoirs, swamps, drainage channels and along river margins (Forno and Harley, 1979). It occurs most commonly in freshwater lakes, rivers, swamps, streams, ditches and water tanks (Reed, 1977; Westbrooks, 1984). It prefers stagnant or slow moving water, often in small bays and inlets of dissected shorelines and tributaries of small streams, where it is protected from wave action. It will also grow around emergent brush and trees on flooded shorelines where it is also sheltered from wave action. Though it grows as a free-floating hydrophyte, it has been observed to thrive on land in a zone of constant mist near the foot of Victoria Falls in southern Africa (Holm et al., 1977). It can also survive on mudbanks, and will tolerate some drying (Owens et al., 2004). It is quickly killed by sea water (Holm et al., 1977) but can tolerate lower concentrations of salt (Biber, 2009)."

"The growth of *S. molesta* is enhanced by high light intensities, relatively high water temperatures, and plenty of available nutrients (Mitchell and Tur, 1975). Water temperatures rising to 30°C, results in elevated growth rates, as does increasing the concentrations of nutrients, especially nitrogen and phosphorus (Cary and Weerts, 1983). Thus, eutrophic habitats such as nutrient-rich springs and phosphate mine reclamation wetlands and ponds in the United States are particularly suitable for rapid colonization and growth (Oliver, 1993)."

"*S. molesta* has a low tolerance of salinity and only produces new growth at salinity levels less than 5 ppt; levels above 11 ppt are toxic (Biber, 2008). Optimum growth occurs in nutrient-rich situations, pH 6-7.5, with water temperatures between 20 and 30°C, particularly when the nitrogen source is ammonium ions (NH_4^+) rather than nitrate ions (NO_3^-) (Cary and Weerts, 1983). Under these ideal conditions, a doubling of plant dry weight in 2.2 days has been recorded in Queensland, Australia (Parsons and Cuthbertson, 1992)."

From Thayer et al. (2023):

"*Salvinia molesta* […] cannot withstand ice formation on the water surface except when dense mats protect the underlying plants (Whiteman and Room 1991)."

Climate

From McFarland et al. (2004):

"[…] native […] in a subtropical zone (between latitudes 24° 05' S and 32° 05' S), extending inland to an elevation of about 900 m (Forno and Harley 1979; Forno 1983)."

From Thayer et al. (2023):

"*Salvinia molesta* demonstrates tolerance to freezing air temperature […]"

From CABI (2013):

"Infestations of Salvinia can be killed when terminal buds are exposed to temperatures below -3°C, but the leaves can survive freezing air temperatures if they are under the water surface (Whiteman and Room, 1991)."

Distribution Outside the United States

Native

According to Lal (2016), *S. molesta* is native to southeast Brazil, Uruguay, Paraguay, and northeast Argentina.

Introduced

From CABI (2013):

"[*S. molesta*] been spread widely throughout the world during the past 50 years and can be found in Africa, the Indian subcontinent, southeast Asia, Australia, New Zealand, […] and some Pacific islands (Thomas and Room, 1986a)."

From Thayer et al. (2023):

"The first establishment outside of its native range was in Sri Lanka in 1939 (Room 1990), by the Botany Department at the University of Colombo."

From McFarland et al. (2004):

"*S. molesta* is presently established in Australia, New Zealand, Fiji, the Philippines, India, Indonesia, Malaysia, Singapore, and Papau New Guinea. It also plagues aquatic systems in Africa (the Ivory Republic, Ghana, Zambia, Kenya, Namibia, Botswana, South Africa, and Madagascar), South America (Columbia and Guyana), and two Caribbean countries (Cuba and Trinidad; cf. syntheses by Oliver 1993; Storrs and Julien 1996). Historically notable infestations

have occurred in the Sepik River of Papua New Guinea, and in Africa in the Zambezi River, Lake Naivasha, Kariba Lake, and the Chobe River System. Most recently, *S. molesta* was reported in southern Kalimantan [Indonesia] (formerly Borneo), where rivers, swamps, and rice paddies are becoming increasingly overgrown (Jacono and Pitman 2001)."

According to POWO (2023), *Salvinia molesta* has also been introduced in Europe: Austria, Azores, Belgium, Denmark, France (including Corsica), Germany, Hungary, Italy, Netherlands, Portugal; Asia: Bangladesh, Nepal, New Caledonia, New Guinea, Pakistan, Taiwan, Thailand, Turkey, Vanuatu; Africa: Benin, Burkina Faso, Cameroon, Comoros, Eswatini, Lesotho, Malawi, Mali, Mauritania, Mozambique, Nigeria, Senegal, Tanzania, Uganda, Zimbabwe; Central America: Guatemala; and the Caribbean: Leeward Is., and Trinidad-Tobago. Establishment status in these locations was not given.

Means of Introduction Outside the United States

From Thayer et al. (2023):

"The species continued to be introduced to other warm regions of the world intentionally as an aquarium and water garden plant, and unintentionally as a contaminant in shipments of other aquatic plants (Oliver 1993; Nelson 1984). Once established in a new region, the plant is likely spread as a hitchhiker on boats, trailers and other recreational gear. Local movement between waterbodies may be facilitated by birds and aquatic mammals (Mitchell and Thomas 1972)."

"Spread will continue through natural drainage and flow in river and stream systems. In lakes and large water-bodies [sic] upright well buoyed leaves are effectively dispersed by wind and currents to infest new coves."

Short Description

From Thayer et al. (2023):

"Free floating, aquatic fern. Consists of horizontal stems that float just below the water surface, and produce a whorl of three leaves (technically fronds) at each node. The upper pair of floating or emergent leaves are green in color and ovate to oblong in shape. The lower submerged leaf is brown, highly divided and resembles and functions as a root. The lower leaves may grow to great lengths (up to 25 cm), and by creating drag, act to stabilize the plant (Mitchell and Tur 1975; Room 1983)."

"Upper surfaces of green fronds are covered with rows of white, bristly hairs (papillae) (Mitchell 1972), which divide into four thin branches that soon rejoin at the tips to form a cage. The resulting structures resemble tiny eggbeaters. This characteristic eggbeater structure can reliably distinguish *S. molesta* from the morphologically similar *S. minima* that has unjoined hairs (Wunderlin and Hansen 2011). These specialized hairs create a water repellent, protective covering (Mitchell and Thomas 1972)."

Biology

From CABI (2013):

"*S. molesta* is a sterile pentaploid hybrid fern that forms spore sacs containing abortive spores due to anomalies during meiosis. Since the spores and megagametophytes that are produced are fairly short-lived, reproduction is exclusively vegetative (Mitchell, 1972). There is therefore speculation that all *S. molesta* infestations worldwide may be clones of a single genetic individual (Werner, 1988; Barrett, 1989)."

"Although *S. molesta* is sterile, it undergoes rapid vegetative reproduction by growth and fragmentation (Oliver, 1993). Mitchell (1979) reported that plant biomass can double in as little as 3-4 days in sterile culture and 8.1 days on Lake Kariba in Zimbabwe. Additional studies found doubling times of 6.2–5.3 days (dry weight) and 4.8–3.8 days (leaf area) (Sale et al., 1985). Mean relative growth rates, under a range of artificial and natural environmental conditions, may be as high as a 21.64% per day increase in leaf number and 17.16% per day increase in dry weight (Mitchell and Tur, 1975). Under favourable conditions, *S. molesta* can completely cover lakes and slow-moving streams and rivers with thick mats up to 1 m thick (Thomas and Room, 1986a). Live biomass ranges from 250-600 g per m^2 dry weight (Mitchell, 1979)."

"*S. molesta* exhibits no lignification of tissues and therefore the plant must remain turgid for mechanical support of its organs. Air is trapped by the birdcage-like hairs that grow in close, parallel rows on the upper surface of the floating leaves, allowing *S. molesta* to float (Kaul, 1976)."

From McFarland et al. (2004):

"Rhizomes of the plant can break very easily and daughter plant arise [sic] from buds that number up to five per node. In calm waters, fragmentation occurs when older ramets senesce, causing the plant to break, as a result of deterioration of the rhizome, into two or more daughter plants (Room 1983)."

Human Uses

From CABI (2013):

"Potential uses of the plant [*Salvinia molesta*] include as a compost and mulch, and as a supplement to livestock feed (Thomas and Room, 1986a; Oliver, 1993). […] *S. molesta* has also been investigated as a feed for tilapia (King et al, 2004), chickens (Ma'rifah et al, 2013), ducks (Sumiati and Nurhaya, 2003) and swine (Leterme et al, 2009)."

"*S. molesta* is not only efficient at removing nutrients from water but also in removing heavy metals, making it potentially useful in a variety of wastewater applications (Shimada et al., 1988). […] *S. molesta* has been used in a variety of mining remediations around the world (Sukumaran, 2013; Ashraf et al, 2011; Prasad, 2010), and has also been used in treating high-nutrient swine farm runoff water (Yang and Chen, 1994)."

“A few studies have also investigated using *S. molesta* for biogas production (Thomas and Room, 1986). The potential energy of eight common aquatic weeds was determined in India by anaerobic digestion to produce methane, the energy production potential of *S. molesta* was approximately 108 Kcal/ha (Abbasi et al., 1990). Experimentally, *S. molesta* fermented aerobically at 32°C yielded 8.8 litres of biogas per kilogram of fresh weight. A 3:1 mixture of water hyacinth (*Eichhornia crassipes*) and *S. molesta* increased the yield of biogas to 11.2 litres per kilogram of fresh weight (Abbasi and Nipaney, 1984).”

From GISD (2017):

“Floating aquatic weeds have been used for mulch, compost, fodder, paper making, handcrafts and bio-gas generation (Howard and Harley, 1998).”

Diseases

No information was found regarding diseases or parasites of *Salvinia molesta*.

Threat to Humans

From CABI (2013):

“Infestations of *S. molesta* contribute to human health problems. Dense mats of *S. molesta* are an important plant host of *Mansonia* spp. mosquitoes (Diptera: Culicidae), which have been identified as vectors of West Nile Virus, St. Louis Encephalitis, Venezuelan Equine Encephalitis and rural elephantiasis (Pancho and Soerjani, 1978; Chow et al., 1955; Ramachandran, 1960; Lounibos et al., 1990). It also shelters mosquito species that are responsible for the transmission of encephalitis, malaria and dengue fever in other areas (Creagh, 1991/92). Infestations also harbour snails that transmit schistosomiasis (Holm et al., 1977).”

“Thick mats of *S. molesta* prevent the passage of boats, and even a single layer of plants is a major obstacle to canoes. […] Large mats block access to drinking water by humans, domestic stock and wildlife, clog irrigation and drainage canals, and sweep fences and other light structures ahead of them during floods (Holm et al., 1977; Thomas and Room, 1986b). Entire villages that depended on aquatic transportation were abandoned along the Sepik River in Papua New Guinea when infestations of *S. molesta* limited access to healthcare, education and food (Gewertz, 1983).”

From The Weeds Australia (2020):

“Dense mats of Salvinia can be mistaken for solid ground by people and animals with reported instances of animals falling into the water body beneath. The dense mats impede water flow, restrict stock access […]”

3 Impacts of Introductions

From Thayer et al. (2023):

"*Salvinia molesta* has the potential to alter aquatic ecosystems in several ways. Rapidly expanding populations can overgrow and replace native plants resulting in dense surface cover that prevents light and atmospheric oxygen from entering the water. Decomposing plant material drops to the bottom, consuming dissolved oxygen needed by fish and other aquatic life (Divakaran et al. 1980). Flores and Carlson (2006) noted a 2.5 fold increase in dissolved oxygen by removing 90% of *S. molesta* at five east Texas sites."

"Floating mats of *S. molesta* can be up to one meter thick (Whiteman and Room 1991), impeding navigation, reducing water flow and interfering with fishing and recreational activities (Mitchell and Thomas 1972). This could be significant in areas where economic or subsistence fishing is important (Mitchell et al. 1980). Like dense floating mats of waterhyacinth [sic] dense floating mats of *S. molesta* support secondary colonizing plants, leading to the formation of floating islands or tussocks (McFarland et al. 2004; Mitchell et al. 1980)."

From Weeds Australia (2020):

"Commercial fisheries suffers [sic] dramatically with Salvinia plants blocking nets and impeding the passage of boats (Agriculture & Resource Management Council of Australia & New Zealand et al. 2003; CRC 2003). […] *Salvinia* can clog pump intakes and cause water losses from storage areas by increasing levels of evapo-transpiration (increased water evaporating from the plant leaves)."

From CABI (2013):

"*S. molesta* is a pest of rice paddies in India, where it competes for water, nutrients and space, resulting in poor crop production (Anonymous, 1987). In studies on transplanted rice, *S. molesta* was found to cause a 12.5% yield loss due to reduction in panicle-bearing tillers (Azmi, 1988) […]"

"[…] *S. molesta* has become a major problem in irrigated lowland rice. Spread of *S. molesta* has been facilitated through its introduction into ponds as fish feed as well as into rice fields as an organic manure (mistaken for azolla) (Pablico et al., 1989)."

"Sudd islands (thick vegetation mats of *S. molesta* and other plants) can lead to the death of livestock in some areas after they have attempted to walk on them (Harper, 1986; in McFarland et al. 2004)."

"Thick mats of *Salvinia* spp. cut off light to submerged plants, often outcompeting rooted and submerged native plants and reducing vascular plant diversity (Sculthorpe, 1985). The formation of mats also lowers dissolved O2 and pH, whilst simultaneously increasing CO2 and H2S, in waters beneath them (Mitchell, 1979). Benthic fauna usually decrease [sic] under well-established mats (Coates, 1982). As plants in the mat die and sink to the bottom, benthic fish can be impacted by changes in O2 concentrations and water depth as material accumulates

(Sculthorpe, 1985). In India, *S. molesta* has invaded wetlands and reportedly replaced native flora (Gopal, 1988)."

From Lal (2016):

"In 1999, *S. molesta* invaded Hawaii where it has been negatively affecting endangered birds, such as *Fulica alai* (Hawaiian coot), *Gallinula chloropus* (Hawaiian gallinule), *and Himantopus mexicanus knudseni* (Hawaiian stilt) (McFarland et al., 2004). *S. molesta* took away suitable habitat for these birds and changed the food web dynamics by decreasing their abundance (McFarland et al., 2004)."

Salvinia molesta is listed as a Federal Noxious Weed. Arizona, California, Colorado, Connecticut, Florida, Idaho, Illinois, Indiana, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, North Carolina, New Mexico, Nevada, Oklahoma South Carolina, Tennessee, Texas, Virginia, Wisconsin, and West Virginia regulate *Salvinia molesta*. See section 1.

4 History of Invasiveness

Salvinia molesta has been introduced and established in numerous countries. The established populations have many impacts, including changes to water quality, reductions in biodiversity, alterations of flow impacting infrastructure and flooding, recreational activities, and agriculture. Therefore, the History of Invasiveness for *Salvinia molesta* is classified as High.

5 Global Distribution

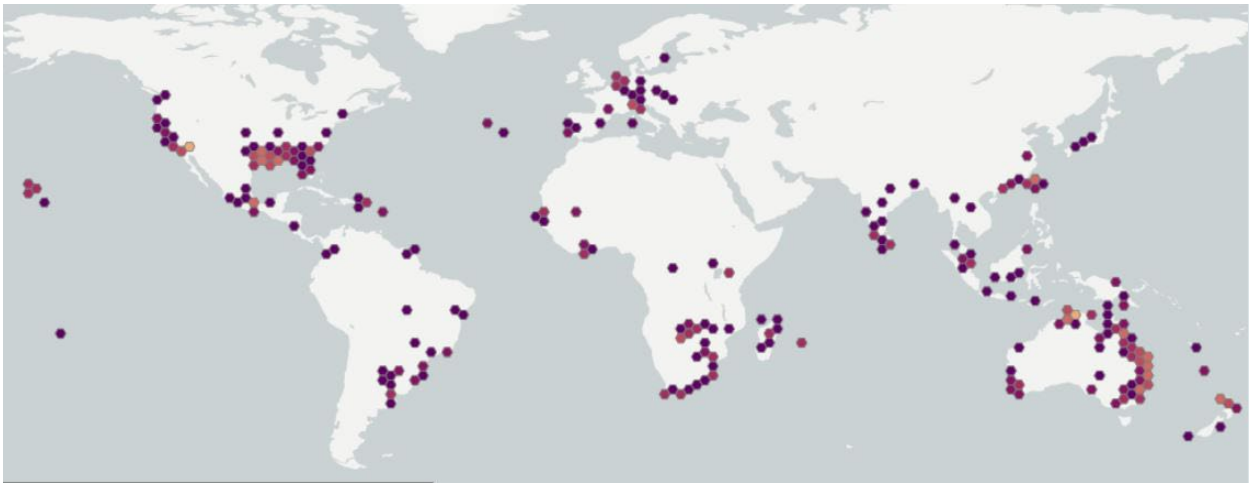

Figure 1. Reported global distribution of *Salvinia molesta*. Map from GBIF Secretariat (2022). Observations are reported throughout southern United States, Mexico, the Caribbean, Central America, South America, Africa, western and central Europe, southern Asia, Australia, New Zealand, and some Pacific Islands. Points in the U.S. States of Washington, Kansas, Missouri, Connecticut, and the District of Columbia do not represent established populations and were not used in the climate matching analysis. The observation in Sweden was from a captive collection and was not included in the climate matching analysis.

Salvinia molesta was reported to be introduced in Tanzania, Guatemala, Cameroon, Mauritania, Malawi, Mozambique, Venezuela, Paraguay, Nigeria, Benin, Burkina Faso, Denmark, and Trinidad and Tobago but no georeferenced observations were found to represent these locations.

CABI (2013) provided location descriptions for *Salvinia molesta* in Cuba, Guyana, Ghana, Israel, Pakistan, Fiji, Vanuatu, New Caledonia, Canary Islands, Philippines, Indonesia and the island of Okinawa in Japan. These locations were used to select source points for the climate matching analysis.

6 Distribution Within the United States

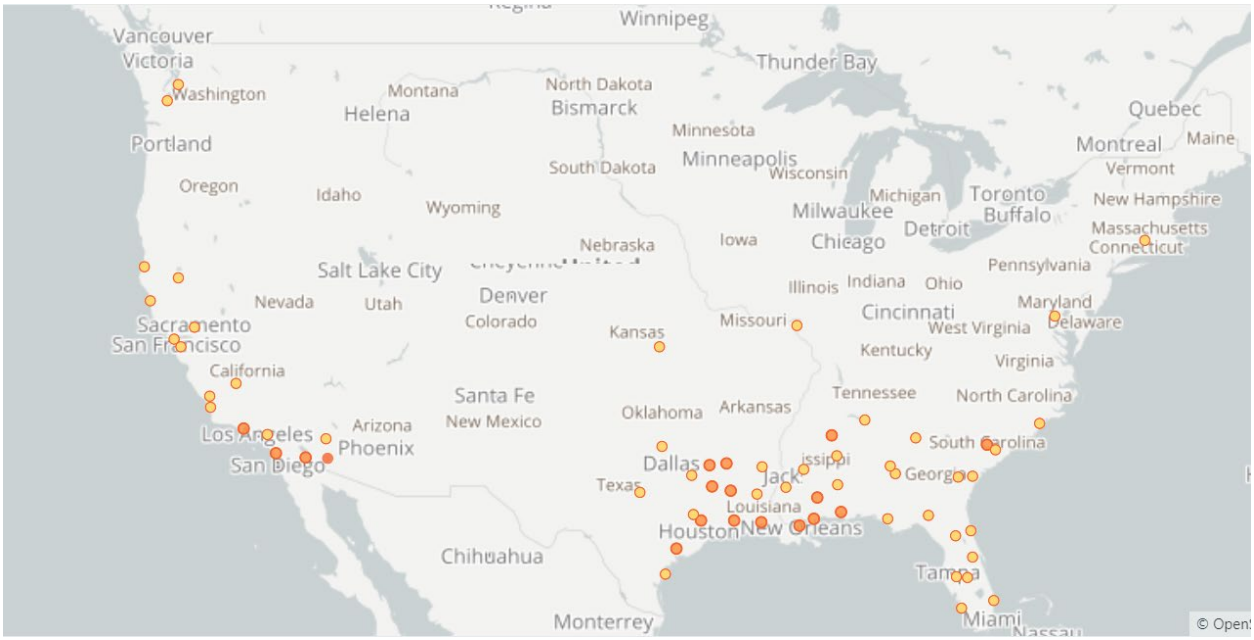

Figure 2. Reported distribution of *Salvinia molesta* in the contiguous United States. Map from GBIF-US (2023). Observations are reported from California, Arizona, Texas, North Carolina, South Carolina, Georgia, Florida, Louisiana, Mississippi, Alabama, and Arkansas. Points located in Washington, Kansas, Missouri, Connecticut, and the District of Columbia do not represent established populations and were not used in the climate matching analysis.

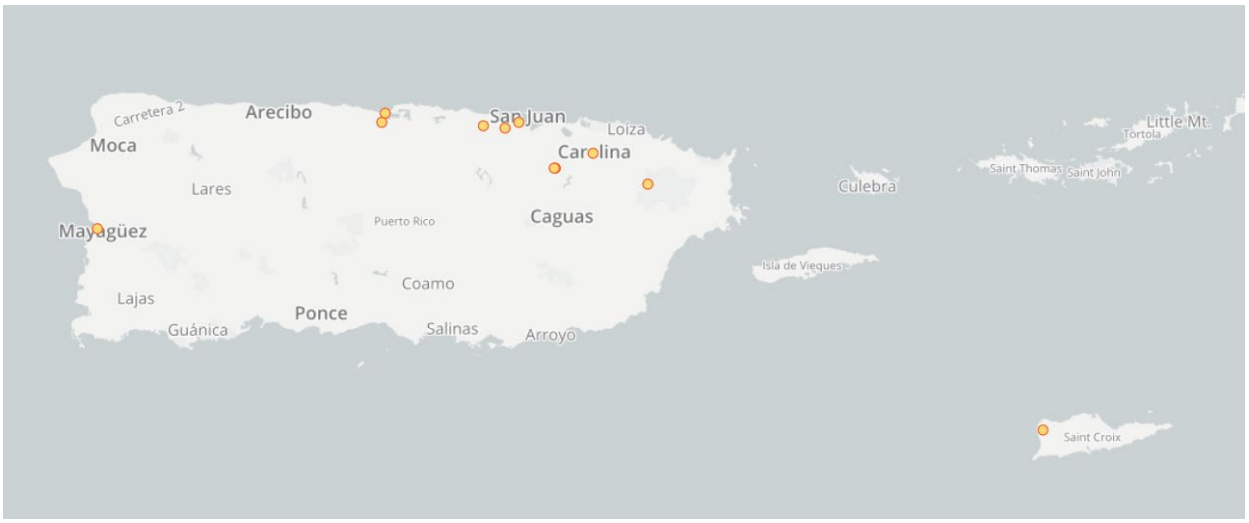

Figure 3. Reported distribution of *Salvinia molesta* in Puerto Rico and U.S. Virgin Islands. Map from GBIF-US (2023). Observations are reported along the northern and western coast of Puerto Rico and from Saint Croix of the U.S. Virgin Islands.

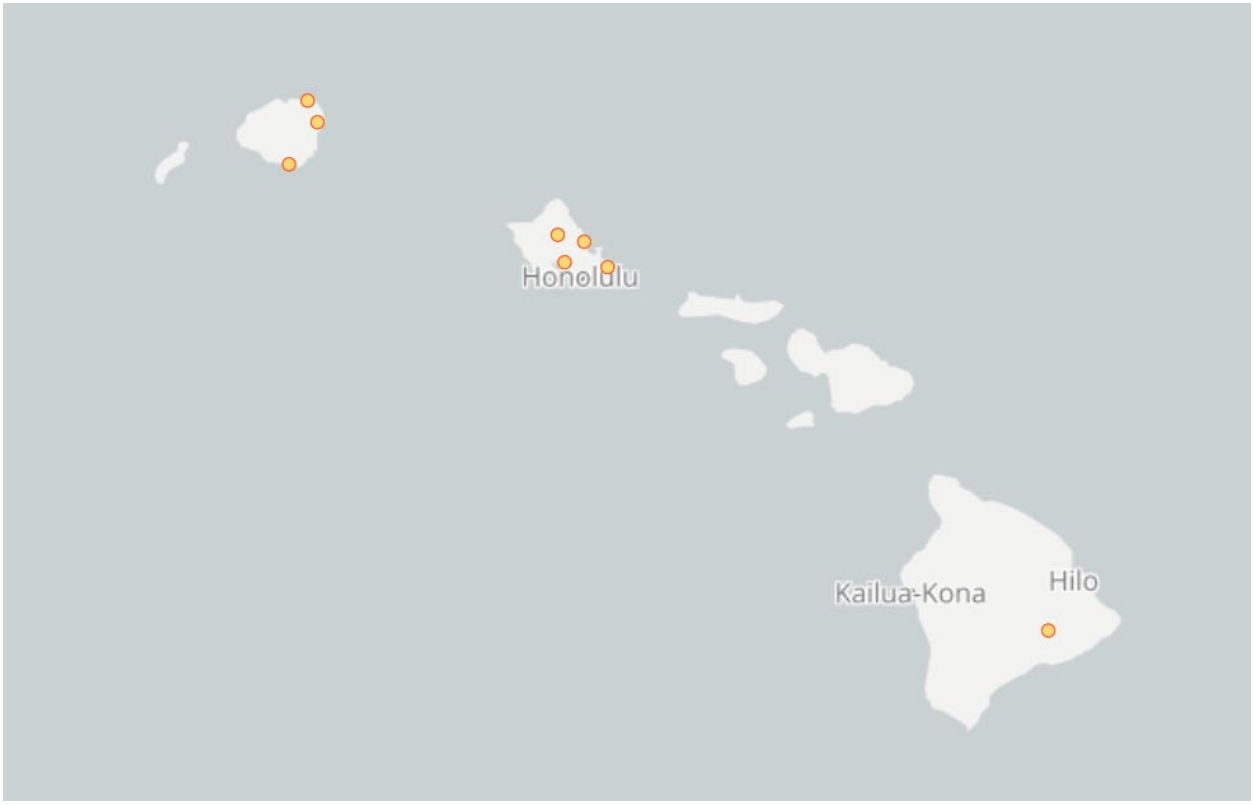

Figure 4. Reported distribution of *Salvinia molesta* in Hawaii. Map from GBIF-US (2023). Observations are recorded on Lihue, Oahu, and main island of Hawaii.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Salvinia molesta* to the contiguous United States found areas with high climate match in the Southeast along the Atlantic and Gulf Coasts. Areas of high match were found in the Southwest and along the southern Pacific Coast as well. Portions of the Great Lakes (specifically Lake Michigan and Lake Huron) also showed a high climate match. Smaller areas of low match were found in the Pacific Northwest. The remainder of the contiguous United States had medium to medium-high climate matches. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.932, indicating that Yes, there is establishment concern for this species. The Climate 6 score is calculated as: (count of target points with scores ≥ 6)/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024).

Projected climate matches in the contiguous United States under future climate scenarios are available for *Salvinia molesta* (see Appendix). These projected climate matches are provided as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.

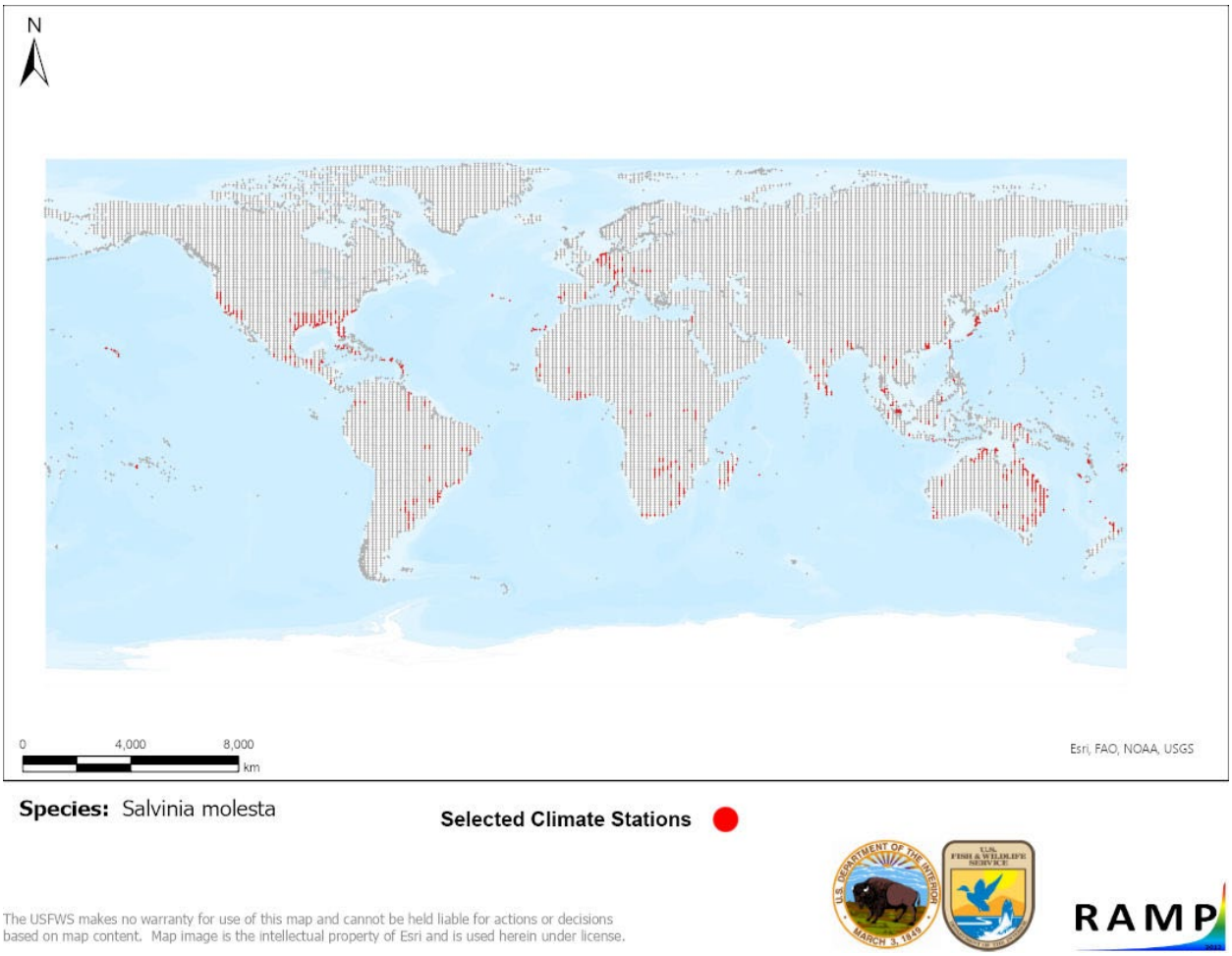

Figure 5. RAMP (Sanders et al. 2023) source map of the world showing weather stations selected as source locations (red; throughout southern United States, Mexico, the Caribbean, Central America, South America, sub-Saharan Africa, western and central Europe, southern Asia, Australia, northern New Zealand and Pacific Islands) and non-source locations (gray) for *Salvinia molesta* climate matching. Source locations from CABI (2013) and GBIF Secretariat (2022). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

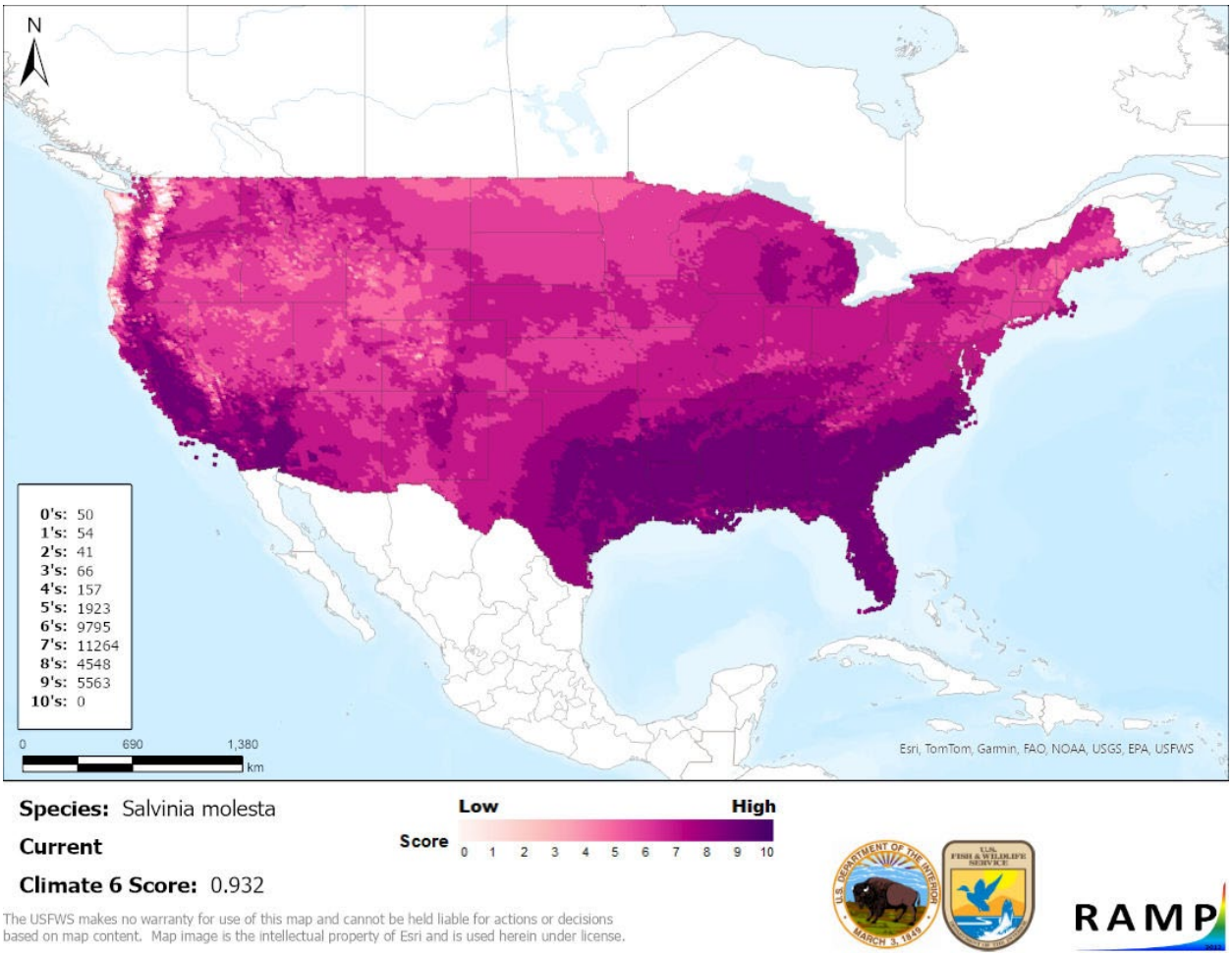

Figure 6. Map of RAMP (Sanders et al. 2023) climate matches for *Salvinia molesta* in the contiguous United States based on source locations reported by CABI (2013) and GBIF Secretariat (2022). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Salvinia molesta* is classified as High. There is a reasonable amount of information regarding the distribution and ecology of *S. molesta* as well as an ample amount of reliable evidence concerning the negative impact of established populations.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Salvinia molesta, Giant Salvinia, is an aquatic fern that is native to South America. Depending on water conditions, *S. molesta* has been known to grow double its size in a matter of 2 to 6 days and can completely cover the surface of a slow-moving body of water with dense mats up to 1 meter thick. It is intolerant to salinity and ice. Giant Salvinia can be used as compost, fodder, crafting material, mulch, and for wastewater treatment and biogas generation. It is also present in the aquarium trade. *Salvinia molesta* has been listed as a Federal Noxious Weed since 1981 and

is regulated in 24 U.S. states. *Salvinia molesta* has been introduced around the world, as well as to numerous states within the western and southern United States. It has established populations in many of those locations. *S. molesta* impacts submerged native plant species by altering water chemistry. Native benthic fish are affected as well by accumulated decomposed material and changes in water quality. Floating mats of *S. molesta* are known to impede waterflow, watercraft navigation, and is hazardous for people and livestock as it can be mistaken for solid ground. Economically, introduced populations impact commercial fishing, and recreational activities such as fishing, boating, and swimming. *S. molesta* can also clog pump intakes, irrigation, drainage canals, and block access to drinking water for humans, livestock, and wildlife. *S. molesta* is an important host for mosquitos known to be vectors of West Nile virus, St. Louis encephalitis, Venezuelan equine encephalitis, rural elephantiasis, malaria, and dengue fever. The History of Invasiveness for *Salvinia molesta* is classified as High due to these negative impacts of established populations. The climate matching analysis indicates establishment concern for this species. Areas of high match were mainly found in the Southeast and Southwest but most of the contiguous United States had a medium to medium-high match. The Certainty of Assessment for this ERSS is classified as High due to the high amount and quality of information available. The Overall Risk Assessment Category for *Salvinia molesta* in the contiguous United States is High.

Assessment Elements

- **History of Invasiveness (see section 4): High**
- **Establishment Concern (see section 7): Yes**
- **Certainty of Assessment (see section 8): High**
- **Remarks, Important additional information: *S. molesta* is important habitat of *Mansonia* spp. (mosquitos) that are vectors of West Nile virus, St. Louis encephalitis, Venezuelan equine encephalitis, rural elephantiasis, malaria, and dengue fever.**
- **Overall Risk Assessment Category: High**

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.

Aquarium Roots. 2023. *Salvinia molesta* (1/2 cup portion). Aquarium Roots. Available: https://aquariumroots.com/products/salvinia-molesta-1-2-cup-portion (January 2023).

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Appendix

Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by CABI (2013) and GBIF Secretariat (2022).

Under the future climate scenarios (figure A1), on average, high climate match for *Salvinia molesta* was projected to occur in the Appalachian Range, California, Great Lakes, Gulf Coast, Mid-Atlantic, Southeast, Southern Atlantic Coast, Southern Florida, and Southwest regions of the contiguous United States. Small areas in the Pacific Northwest consistently had a low match in all scenarios. Under SSP5 in 2085 there was also an area of low match in the Northern Plains. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.789 (model: MPI-ESM1-2-HR, SSP5, 2085) to a high of 0.971 (model: GFDL-ESM4, SSP5, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.932, figure 6) falls within the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Under one or more time step and climate scenarios, areas within the Northeast saw a large increase in the climate match relative to current conditions. Additionally, areas within the Appalachian Range, Colorado Plateau, Great Lakes, Northern Pacific Coast, and Western Mountains saw a moderate increase in the climate match relative to current conditions. Under one or more time step and climate scenarios, areas within the Appalachian Range, California, Gulf Coast, Northern Plains, Southeast, Southern Atlantic Coast, Southern Florida, Southern Plains, and Southwest saw a moderate decrease in the climate match relative to current conditions. The areas of decrease were more prominent in time step 2085 than 2055. No large decreases were observed regardless of time step and climate scenarios. Additional, very small areas of large or moderate change may be visible on the maps (figure A3).

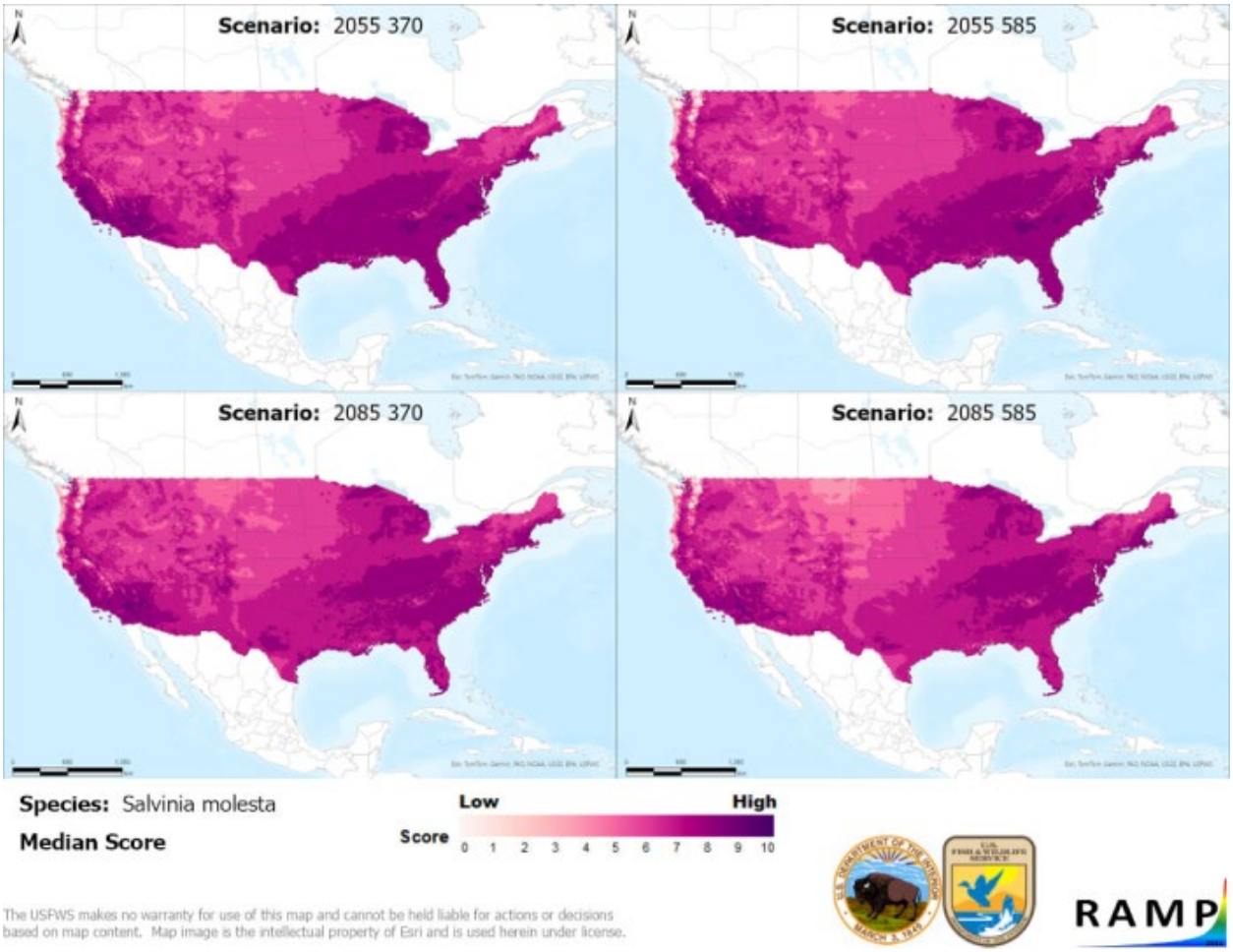

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Salvinia molesta* in the contiguous United States. Climate matching is based on source locations reported by CABI (2013) and GBIF Secretariat (2022). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

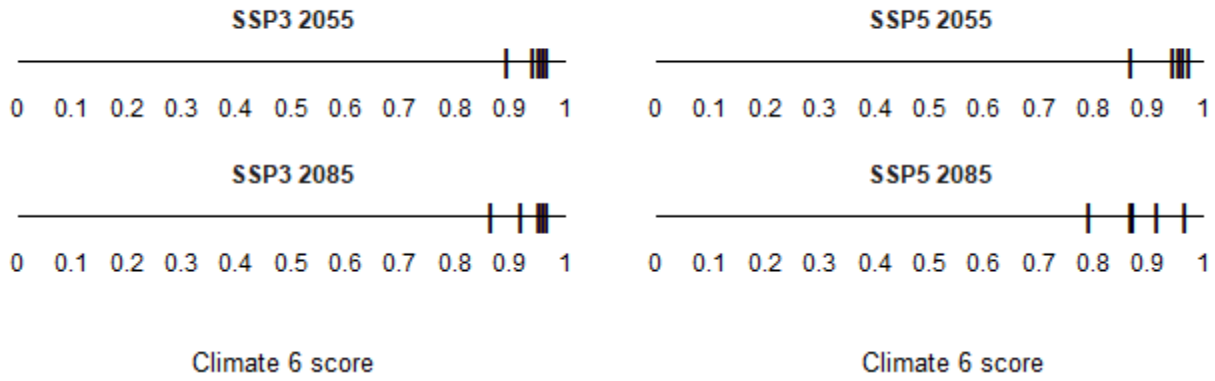

Figure A2. Comparison of projected future Climate 6 scores for *Salvinia molesta* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.

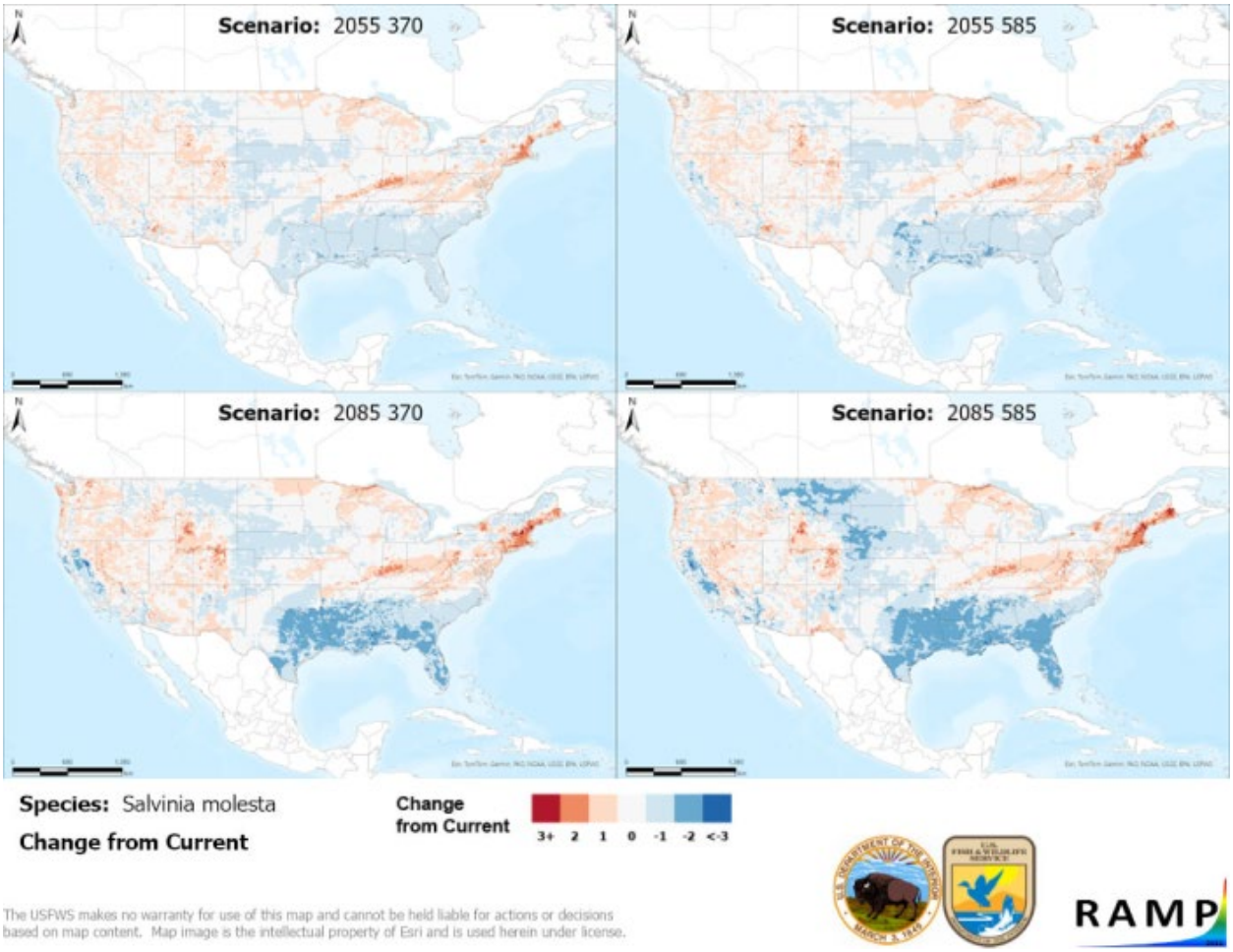

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 6) and the median target point score for future climate scenarios (figure A1) for *Salvinia molesta* based on source locations reported by CABI (2013) and GBIF Secretariat (2022). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

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