Water Soldiers (*Stratiotes aloides*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, January 2023
Revised, February 2023, March 2025
Web Version, 4/2/2025

Organism Type: Plant
Overall Risk Assessment Category: High

Photo: Hempel J. Licensed under CC BY-SA 3.0 DE. Available: https://commons.wikimedia.org/wiki/File:Stratiotes_aloides_LC0258.jpg (January 2023).

1 Native Range and Status in the United States

Native Range

From Suutari et al. (2009):

"*S. aloides* is a perennial whose range of occupancy includes Central, Eastern and Northern Europe and Central Asia (Cook and Urmi-König 1983)."

From Efremov and Sviridenko (2008):

“It is found in the continental water bodies of European Russia, the Caucasus [Armenia, Azerbaijan, Georgia, and Russia], Scandinavia [Sweden, Finland, and Denmark], the Baltic Region [Germany, Poland, Lithuania, Russia Latvia, and Estonia], the Mediterranean Region, Atlantic Europe [Spain, Britain, and the Netherlands], western Siberia, and northern Kazakhstan.”

From USDA (2017):

“*Stratiotes aloides* is native to Austria, Belgium, Bulgaria, Czechoslovakia, Denmark, Finland, Holland, Hungary, Italy, Sweden, Romania, the United Kingdom, Yugoslavia, and possibly Germany/Poland (Cook and Urmi-König, 1983). This species may be native to other countries in Europe, but its original native range is difficult to determine due to cultivation (Cook and Urmi-König, 1983; Forbes, 2000).”

Status in the United States

Davidson et al. (2025) list a nonnative observation of *Stratiotes aloides* in a pond along the Hudson River in New York. Population status was not reported.

Stratiotes aloides has been in trade in the United States.

From USDA (2017):

“In the early 1900s, this species was sold in the United States by at least one supplier (Tricker, 1909). Snyder et al. (2016) report that the species is still sold in the United States, which is based upon several assumptions made from the literature (Snyder, [2016; personal communication]) that may not necessarily be true. During our review of the literature and online sources, we found no evidence indicating that this species is currently present or cultivated in the United States (e.g., GBIF, 2015; NGRP, 2015; NRCS, 2015; Kartesz, 2015; Monrovia, 2016; Lowe's, 2016; Bailey Nurseries, 2011; Greenleaf Nursery Company, 2016; San Marcos Growers, 2001).

Regulations

From USDA (2017):

“*Stratiotes aloides* is regulated as an injurious or noxious weed in five states: Alabama (Harden, 2015), Florida (Smith, 2015), Illinois (17 Illinois Administrative Code § 805, 2015), Michigan (Rosenbaum et al., 2015), Washington (White et al., 2015), and Wisconsin (WDNR, 2015).”

From Fusaro et al. (2023):

“It is also prohibited for a person to possess, import, purchase, sell, propagate, transport, or introduce *S. aloides* in Minnesota (Minnesota Rule 6216.0250).”

In addition to the regulations described above, *Stratiotes aloides* is regulated in Indiana (Indiana DNR 2022), North Carolina (North Carolina DEQ 2023), Ohio (ODA 2023), Oregon (ODA

2022), and Pennsylvania (PDA 2023). Please refer back to state agency regulatory documents for details on all 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

No information on means of introduction was given for the single nonnative introduction record found in the United States.

Remarks

Stratoites aloides has a history of cultivation around the species' native range which has complicated the understanding of the native range and which areas of the species' range in Europe may be due to escapes from cultivation. This has led to differing descriptions of the native range; see the quotations below for more information.

From USDA (2017):

"In Europe, *Stratiotes aloides* has spread and naturalized outside its native range. Cultivation escapes resulting in naturalized populations of *S. aloides* have made it difficult to precisely delimit the native and introduced ranges of this species (Cook and Urmi-König, 1983; Forbes, 2000)."

From Forbes (2000):

"The status of *Stratiotes aloides* L. (Water-soldier) is a case in point, a species whose native distribution throughout its whole European range is problematic, since it has been grown as an aquatic ornamental for nearly three centuries and its native occurrence has been obscured by numerous escapes from cultivation (Cook & Urrni-Konig 1983; Preston & Croft 1997)."

"The map produced by Cook & Urmi-König (1983) [of the species' range in Europe] shows *S. aloides* occurring in the British Isles and in Europe south to Spain, Italy, Bulgaria and European Turkey, north to Finland, and east to Siberia […]. Throughout the range Urmi-König discovered it difficult to determine its status, but they reviewed the scientific opinion in relation to the fossil occurrences, floristic literature (sometimes documenting definite introductions), and herbarium records. They showed that the distribution of *S. aloides* today agrees very closely with the distribution of the 15 fossil species. The single exception was the find of *S. tuberculatus* E. M. Reid from the Pliocene in Portugal, which alone supports the two unconfirmed literature records of *S. aloides* in Spain from the 18th and 19th century (Willkomm & Lange 1861). This is a particularly interesting disjunction in the species range, as it is generally accepted that *S. aloides* is not native to France on grounds of its late first mention in the relevant literature (1810), a series of documented introductions, and the lack of any fossil finds. A similar puzzle exists with respect to Italy (where it is considered native in the eastern part of the Po Plain) and Switzerland ('certainly not native') (Cook & Urmi-König 1983)."

"Cook revised his opinion of the native range of *S. aloides* two years later, asserting that it is indigenous only in Central Europe and is introduced and established in Western Europe (Cook 1985)."

From Snyder et al. (2016):

"*Stratiotes aloides* is present in most of northern and eastern Europe extending south to northern Italy and possibly to Spain, east throughout most of European Russia and into Asia from the northern Caucasus region to the western part of Central Siberia [Nolte 1825; Cook and Urmi-König 1983; Czerepanov 1995]. Similar distribution maps were published by Meusel et al. (1965), Cook and Urmi-König (1983), and Hultén and Fries (1986), although each map shows small differences in outlying occurrences. […] Because of its long history as an ornamental plant, it is difficult to determine what the pre-cultivation natural range might have been."

"*Stratiotes aloides* is considered a noxious weed in some regions of Australia (Weeds Australia 2015) and import of either seed or nursery stock is prohibited in both Australia and New Zealand (Australian Government 2015; New Zealand Government 2015)."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2023):

Kingdom Plantae
Subkingdom Viridiplantae
Infrakingdom Streptophyta
Superdivision Embryophyta
Division Tracheophyta
Subdivision Spermatophytina
Class Magnoliopsida
Superorder Lilianae
Order Alismatales
Family Hydrocharitaceae
Genus *Stratiotes*
Species *Stratiotes aloides* L.

According to WFO (2023), *Stratiotes aloides* L. is the current valid name for this species.

Size, Weight, and Age Range

From Fusaro et al. (2023):

"Stem length: 10-18mm long, Leaf length: 40-60 cm long, 1-4 cm wide (Cook and Urmi-König 1983)."

Environment

From Fusaro et al. (2023):

"*Stratiotes aloides* usually inhabits shallow stagnant waters, mainly eutrophic and mesotrophic, with substratum of mud and organic deposits (Strzalek and Koperski 2009). *Stratiotes aloides* can grow in depths of up to 6.5m (Tarkowska-Kukuryk 2006). *Stratiotes aloides* is found mainly in sheltered bays of larger lakes, backwater ponds, ditches and canals (UK Natural History Museum 2013). *Stratiotes aloides* is limited to freshwater."

From Snyder et al. (2016):

"Substrates along the Trent River where *S. aloides* occurs are sandy to organic. The substrate of the pond in Trent Hills is organic detritus over clay at the edges and sloping to bedrock at the deepest (1.75 m) central portion. In Europe, plants are generally found under lentic conditions in sheltered freshwater bays or inlets of large lakes, ponds, or slow-moving streams or canals at depths of 2–5 m where they may float or can become rooted in nutrient-rich bottom mud or sapropel (oxygen-depleted organic sediment) of fine to course sediments (Erixon 1979a; Prins and De Guia 1986; Strzałek 2004; Efremov and Sviridenko 2008); and, can persist submerged in deep water or under ice. […] Surface waters in *Stratiotes* habitats are frequently rich in electrolyte ions, notably calcium (Ca), magnesium (Mg), sodium (Na), iron (Fe) and potassium (K) (Kornatowski 1976; Brammer and Wetzel 1984) or with high concentrations of calcium and sulphate ions and poor in phosphate ions (Kłosowski et al. 2011). Habitats are characterized by a moderate pH (6–8), moderate alkalinity 1–4 mol m−3, and a high content of dissolved inorganic carbon and high free CO2 concentration (Prins and De Guia 1986)."

Climate

From Snyder et al. (2016):

"Today the species is present mainly in inland aquatic sites between 45° and 55° N in Eurasia but has reached up to 67° N in […] northern Finland (Kotilainen 1954) and Sweden (Erixon 1976, 1979b), and to 64° N in river basins of arctic western Russia (Vekhoff 1994). […] In Canada, its presence in Ontario is at roughly 44° N in a continental climate zone where submerged plants will overwinter under ice, as in the more northerly parts of its habitat in Eurasia."

Distribution Outside the United States

Native

From Suutari et al. (2009):

"*S. aloides* is a perennial whose range of occupancy includes Central, Eastern and Northern Europe and Central Asia (Cook and Urmi-König 1983)."

From Efremov and Sviridenko (2008):

"It is found in the continental water bodies of European Russia, the Caucasus [Armenia, Azerbaijan, Georgia, and Russia], Scandinavia [Sweden, Finland, and Denmark], the Baltic

Region [Germany, Poland, Lithuania, Russia Latvia, and Estonia], the Mediterranean Region, Atlantic Europe [Spain, Britain, and the Netherlands], western Siberia, and northern Kazakhstan."

From USDA (2017):

"*Stratiotes aloides* is native to Austria, Belgium, Bulgaria, Czechoslovakia, Denmark, Finland, Holland, Hungary, Italy, Sweden, Romania, the United Kingdom, Yugoslavia, and possibly Germany/Poland (Cook and Urmi-König, 1983). This species may be native to other countries in Europe, but its original native range is difficult to determine due to cultivation (Cook and Urmi-König, 1983; Forbes, 2000)."

Introduced

From Fusaro et al. (2023):

"The only wild populations of *S. aloides* in North America [at the time of publication] occur in five locations within the Trent River and Black River in Ontario, Canada: (1) In the Trent River approximately between the town of Trent River and the south end of Crowe Bay, but scattered plants have been found as far as the east end of Percy Reach, County of Northumberland; (2) in a watering pond for cattle in Trent Hills, County of Northumberland; (3) in a pond at Blackstock in the Township of Scugog, Regional municipality of Durham; (4) in an artificial pond near Bayfield, Huron County; and (5) in the Black River, near Sutton, Regional Municipality of York (Snyder et al. 2016)."

From Minchin et al. (2021):

"An expansion of an introduced female clone of *Stratiotes aloides* L. (Water-soldier) was located in a delta region on the western side of Lough Derg, Co Galway (v.c.H15), Ireland in 2007."

From Snyder et al. (2016):

"Because of its long history as an ornamental plant, it is difficult to determine what the pre-cultivation natural range might have been. However, *S. aloides* is believed to have been introduced to France, Switzerland, and Turkey (Egloff 1974; Cook and Urmi-König 1983; Davis et al. 1984) and its native status in Northern Ireland is controversial (Forbes 2000)."

From USDA (2017):

"In Europe, *Stratiotes aloides* has spread and naturalized outside its native range. Cultivation escapes resulting in naturalized populations of *S. aloides* have made it difficult to precisely delimit the native and introduced ranges of this species (Cook and Urmi-König, 1983; Forbes, 2000)."

Means of Introduction Outside the United States

From Fusaro (2023):

"The infestation in the Trent River [Ontario] began as an accidental escape (Ontario Ministry of Natural Resources 2009, 2014)."

From USDA (2017):

"Within Europe, it has naturalized in many areas due to cultivation escapes (Cook and Urmi-König, 1983; Preston and Croft, 1997)."

Short Description

From Fusaro et al. (2023):

"Water Soldiers, *Stratiotes aloides* (Family: Hydrocharitaceae), is a loosely rooted aquatic species with emergent and submerged growth forms (Cook and Urmi-König 1983; Erixon 1979). *S. aloides* has depressed conical stems with a complex but regular branching system that can resemble the household spider plant (Campbell 2009). Water soldiers' serrated leaf edges distinguish it from similar looking aquatic plants in the Great Lakes (MNRF 2014). Submerged leaves are thin, brittle and droop at an angle. Submerged leaves can grow up to 60 cm (or rarely 110 cm long) and up to 1 cm wide with somewhat weak spines. Emergent leaves are thick, rigid, brittle, and dark green and are usually less than 40 cm long and 1-4 cm wide, with well-developed spines along leaf margins. The emergent form develops rosettes at the surface of the water (Cook and Urmi-König 1983). The roots of *S. aloides* can be up to 180 cm long but are usually less."

From Snyder et al. (2016):

"Inflorescence with flowers solitary to several, borne within a spathe consisting of two carinate and overlapping (conduplicate) bracts; bracts (17–) 26–44 mm long; sepals 3, ovate; petals 3, white with a yellow base; nectar secreted at the abaxial base of the staminodes. Pistillate flowers are usually solitary (sometimes two, rarely more) on a stout pedicel up to 20 cm long; […] Staminate flowers 2–6 per inflorescence, the upper flower subtended by a floral bract; peduncle flattened and up to 30 cm long (longer than female inflorescence); […] The fruit is a berry-like capsule, ovoid or somewhat barrel-shaped, tapering to a cone-like apex, outer pericarp thick, leathery, brownish-green to green, with 12–24 seeds, locules filled with mucilage."

Biology

From Fusaro et al. (2023):

"This species has vegetative reproduction. Vegetative propagules are formed as axillary buds. When the bottom leaves of the rosette decay, these buds are released. On average 4.7 (±0.28 SE) buds are formed per mature rosette (n = 83) (Sarneel 2013). Buds have high capacity to disperse over long distances via water (84% of propagules re-sprouted, and 92% were still floating after 187 days) (Sarneel 2013)."

From Snyder et al. (2016):

“Plants are dioecious (with either staminate or pistillate flowers) or very rarely monoclinous (pistillate flowers with a few stamens), perennial, submersed to more or less emergent at anthesis.”

Human Uses

From Snyder et al. (2016):

“In continental Europe, *S. aloides* has been regarded as an attractive aquatic ornamental since the mid Eighteenth Century, if not before, when its planting was promoted in moats, ponds, and canals (Miller 1754). Today it continues to be planted in ornamental ponds and botanic gardens (Egloff 1974; Cook and Urmi-König 1983). The species became an ornamental novelty in North America early in the [20th] century and is valued as a water garden plant in parts of Canada today. A 2008 survey of members of the Ontario water garden industry identified four large distributors that both grow and sell *S. aloides* and seven distributors or retailers that sell it (E. Funnell, unpublished data).”

“[…] in northwestern parts of the former Soviet Union and in Poland it has been harvested both for the fertilization of fields and market gardens, and as a component in fodder for cattle or pigs (Fedchenko 1968; Gałczyñska et al. 2011). It appears to have a very minor history of use as human food, having been reported from a few locations in Poland right after World War II when near famine conditions would have existed (Łuczaj 2010).”

From Gawlik-Dziki et al. (2020):

“Although it occurs over a large area of Poland, *S. aloides* was an important famine plant in central Poland, where it was commonly collected from the bottom of lakes and cooked until the turn of the 20th century [Łuczaj 2010].”

“As reported by [Grieve 2018], *S. aloides* is effective against St. Anthony’s Fire and alleviates swelling and inflammations in wounds. An ointment containing the plant has been found to heal wounds effectively. The author also reported its effective use to cure ‘bruised’ kidneys. In the past, it had the reputation of being an unfailing cure for all wounds made by iron weapons. Studies of the biological activity of *S. aloides* show that this plant can be used as a new potential source of active compounds with anti-inflammatory and anti-gout effects [Sugier and Gawlik-Dziki 2009].”

Diseases

From Fusaro et al. (2023):

“*S. aloides* is […] vulnerable to fungi such as *Fusarium roseum* (Cook and Urmi-Konig 1983) […]”

Threat to Humans

From Fusaro et al. (2023):

"*Stratiotes aloides*'s sharp leaves can cut skin (Campbell 2009). Dense floating mats of water soldier can hinder recreational activities, such as boating, angling, and swimming."

From USDA (2017):

"Thick growth could potentially increase the risk of flooding and the cost of water delivery (Oregon Department of Agriculture, 2015), as well as limiting recreational activities such as boating and fishing."

3 Impacts of Introductions

From Minchin et al. (2021):

"It was possible to follow the expansion of *S. aloides* [in Ireland] using historical aerial images due to the distinctive colour of emergent plants."

"The overall expansion of the emergent population within the Rossmore Bay and the Canal grew from c.0.6 ha in 2007 to c.3.3 ha in 2019 (Fig. 3 [in source material])."

"The emergent expansion of *S. aloides* will have overgrown other aquatic plants; but did not appear to have reduced the extent of the *P. australis*. Two small populations of *H. palustris*, one in each of the bays, occurring in water < 1m, were no longer seen. Other plants gradually declined with the expansion of the emergent front over time. This surface dominance and crowding at the surface most probably outcompeted other plants for light and space, as was found by Forbes (2000)."

From Canning (2017):

"*S. aloides* colonization has been shown to decrease the diversity and species richness of existing macrophytes both in Ontario (Canning, 2012) […]"

"The economic impacts associated with *S. aloides* include the costs of monitoring, management, and public education and outreach as the species introduction progresses. Management costs alone for *S. aloides* in Ontario are estimated at between $1500 and $48 000 per hectare (OMNRF, 2013)."

From Weissflog and Sager (2016):

"The CC [*Stratiotes aloides*] population in the Trent River was also observed in this study to have developed association with the invasive zebra mussel (*Dresseina polymorpha*), which is consistent with observed behavior in its native range (Lewandowski and Ozimek 1997). The lengthy, wide, and robust leaves of CC seem to provide an excellent surface for the zebra mussel,

thus contributing to the perpetuation of another invasive (Lewandowski and Ozimek 1997, Toma 2006)."

The following sources discuss primarily potential impacts of *Stratiotes aloides* introductions.

From Gawlik-Dziki et al. (2020):

"*Stratiotes aloides* L. (also called the water soldier) is now common in many water bodies where they often dominate. The water soldier plays a significant role in small aquatic ecosystems, being a rapid colonizer and a highly productive, most expansive aquatic macrophyte forming dense floating carpets. In Europe, a number of lakes and ponds throughout the UK have seen an invasion of the water soldier. *S. aloides* is indicated as a high impact (HI) species in the Norwegian Black List [Gederaas et al. 2012]. […] Due to its expansive character and high productivity, the plant may strongly affect the functioning of a water body and other macrophytes [Kufel et al. 2010]."

From Fusaro et al (2023):

"*Stratiotes aloides* has been described by government agencies as likely to crowd out native vegetation (Ontario Ministry of Natural Resources 2009, 2014), though no primary literature exists to support this in introduced habitats. It does form 'dense, almost monospecific stands' in native habitat (Strzalek and Koperski 2009)."

"*Stratiotes aloides* has the potential to alter surrounding water chemistry, which may harm phytoplankton and other aquatic organisms (Ontario Ministry of Natural Resources 2009). The exact mechanism has not been elucidated, but the likely cause is allelopathy (Mulderij et al. 2006)."

From Snyder et al. (2016):

"Growth of *S. aloides* has the potential to crowd out other aquatic plant species and to inhibit navigation and recreational activities on inland waterways (Renman 1989; Minchin and Boelens 2011; OISAP 2015; E. Snyder, personal observation). The first reported instance of such detrimental impact in North America is from the Trent River, Ontario, where the species was discovered in 2008 and has since spread to new locations downstream. It is now an invasive species of concern, not only to the Ontario Government, but also to the United States since invasive species in the Great Lakes watershed are of concern on both sides of the border."

"*Stratiotes aloides* is considered a noxious weed in some regions of Australia (Weeds Australia 2015) and import of either seed or nursery stock is prohibited in both Australia and New Zealand (Australian Government 2015; New Zealand Government 2015)."

Stratiotes aloides is regulated in Alabama (Harden 2015), Florida (Smith 2015), Illinois (17 Illinois Administrative Code § 805, 2015), Indiana (Indiana DNR 2022), Michigan (Rosenbaum et al. 2015), Minnesota (Minnesota Rule 6216.0250), North Carolina (North Carolina DEQ

2023), Ohio (ODA 2023), Oregon (ODA 2022), Pennsylvania (PDA 2023), Washington (White et al. 2015), and Wisconsin (WDNR 2015). See section 1.

4 History of Invasiveness

There is still uncertainty in the literature about where *Stratiotes aloides* is native and introduced in Europe and Asia. It has been utilized in the ornamental trade for a long time in Europe and more recently within the United States and Canada. *Stratiotes aloides* has been introduced and become established in Ontario, Canada, and in at least one location in Ireland. It has also been introduced in New York. There may be other areas of introduction and establishment in Europe and western Asia but determining the species' status in those regions is difficult due to the long history of cultivation of this species. Impacts associated with the established nonnative populations include exclusion of native plant species, large monocultures, and facilitation of *Dreissena polymorpha*, an introduced bivalve. This species is regulated in 12 U.S. States. The History of Invasiveness is classified as High.

5 Global Distribution

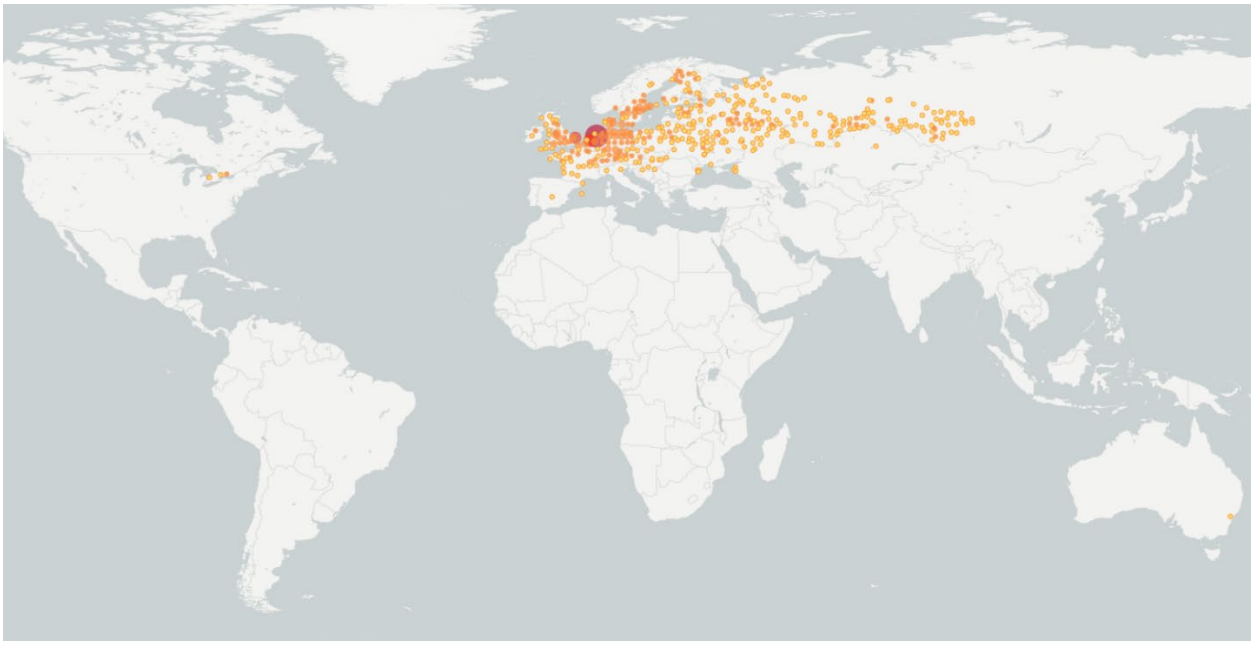

Figure 1. Reported global distribution of *Stratiotes aloides*. Map from GBIF Secretariat (2023). Observations are reported from Ontario, Canada, across Eurasia, and Australia. Records in Australia did not represent a wild established population and were not included in the climate matching analysis.

6 Distribution Within the United States

Figure 2. Map of the know distribution of *Stratiotes aloides* in the contiguous United States. An observation is reported from New York. Map from Davidson et al. (2025). The establishment status of this introduction is unknown and therefore the location was not used to select source points in the climate matching analysis. Map also depicts known observations in Ontario, Canada.

7 Climate Matching

Summary of Climate Matching Analysis

The climate matching analysis for *Stratiotes aloides* to the contiguous United States found mainly medium and high climate match scores. Areas with high match were found in the Northeast, the Great Lakes region, and the Midwest with isolated pockets in the Great Plains, Rocky Mountains, and Southwest region. The southeastern coast from eastern Texas to Florida had low matches. The northwestern coast, the Cascades, and the Sierra Nevada range all had low climate match scores. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.862, 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 *Stratiotes aloides* (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.

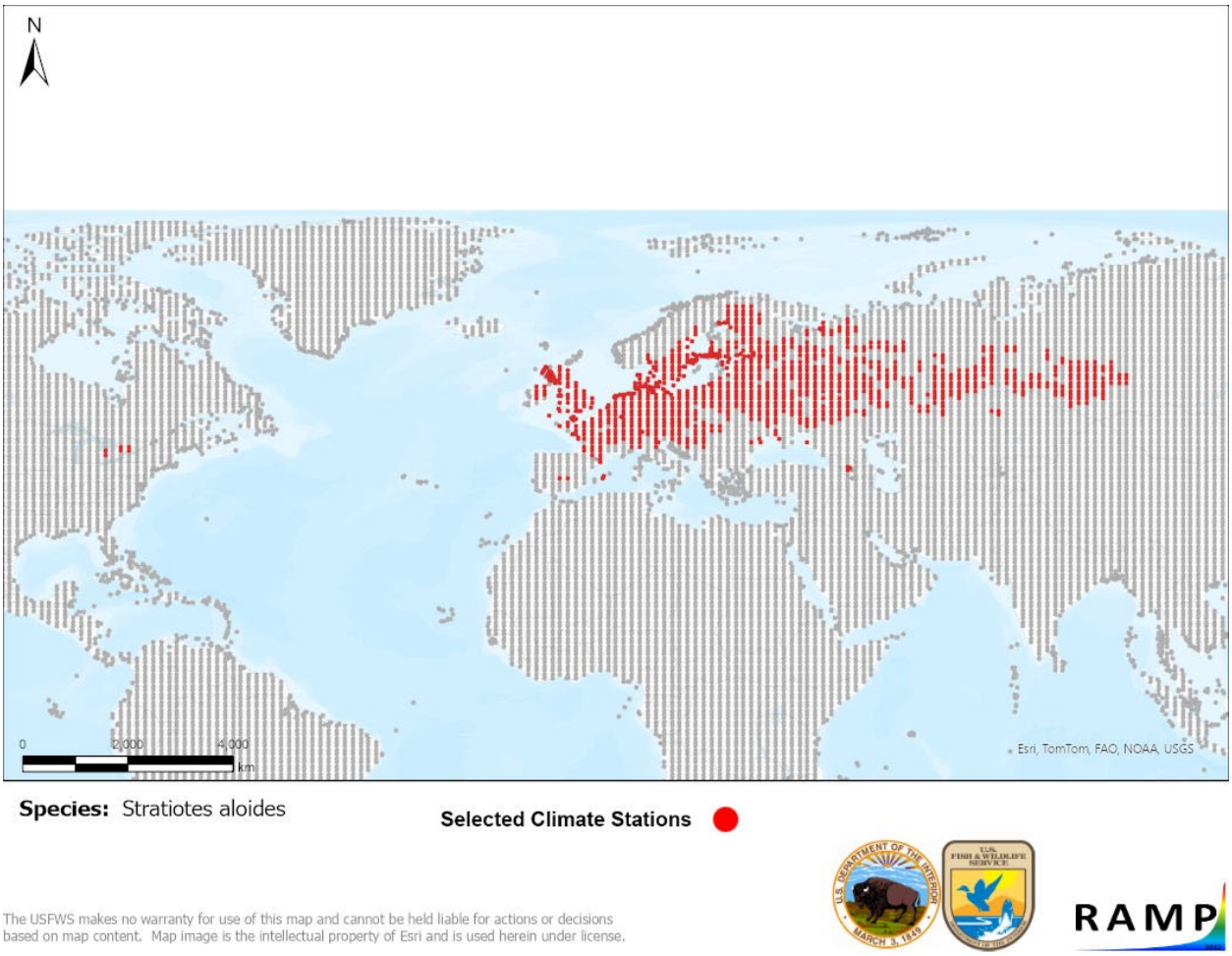

Figure 3. RAMP (Sanders et al. 2023) source map showing weather stations in the world selected as source locations (red; Canada, across northern Eurasia) and non-source locations (gray) for *Stratiotes aloides* climate matching. Source locations from GBIF Secretariat (2023). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

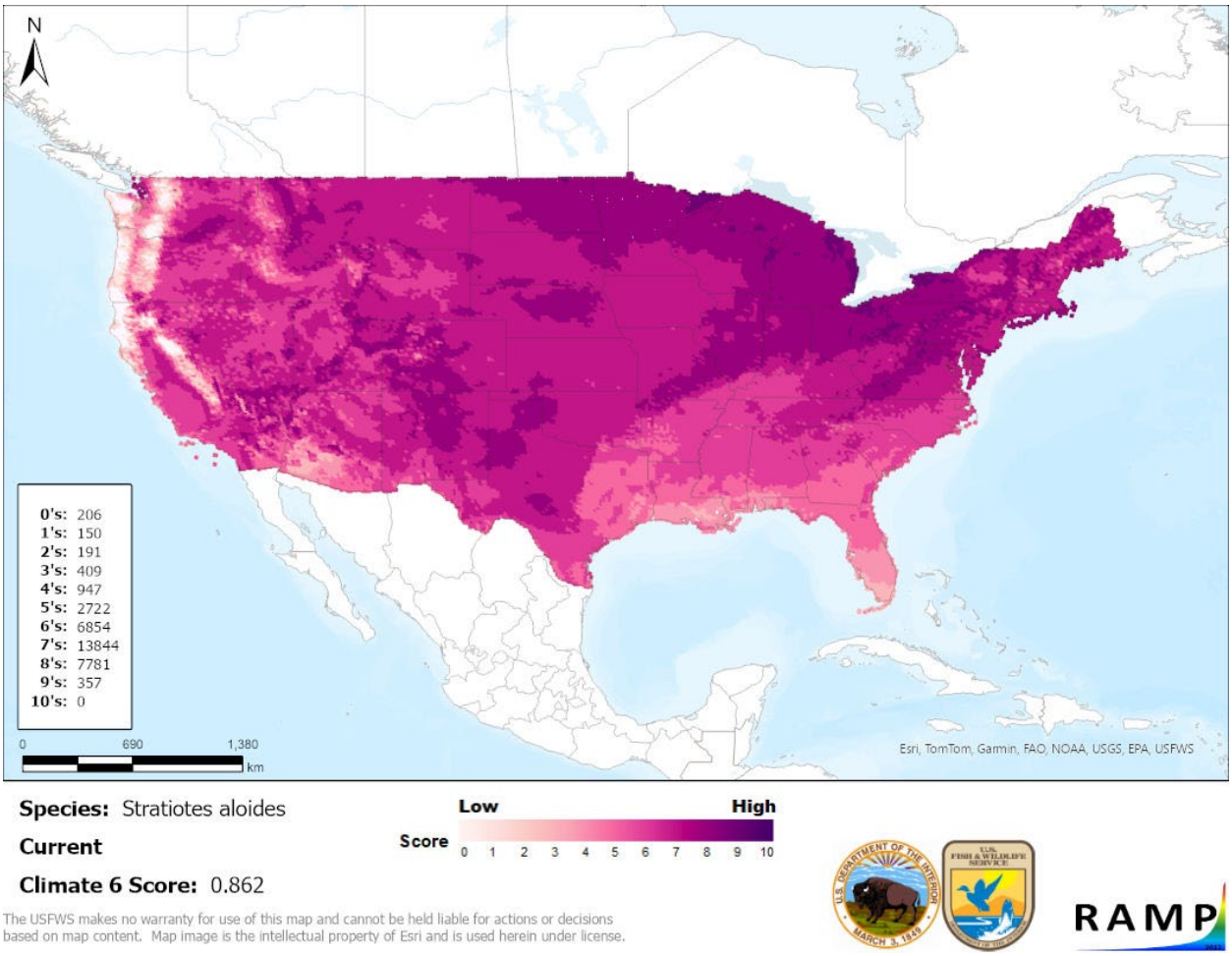

Figure 4. Map of RAMP (Sanders et al. 2023) climate matches for *Stratiotes aloides* in the contiguous United States based on source locations reported by GBIF Secretariat (2023). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

Information regarding the biology, ecology, and distribution of *Stratiotes aloides* was readily available. Records of introduction resulting in established nonnative populations were found. Information regarding impacts was available but sparse. The unclear history of introductions in Europe and western Asia complicate the understanding of which populations in those areas may be native or introduced. Due to the limited impact information and uncertainty in the understanding of the species' native range, the Certainty of Assessment for this species is Medium.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Stratiotes aloides, Water Soldiers, is a rooted, flowering aquatic plant native to Eurasia. The precise native range of this species is unclear because of its long history of ornamental

cultivation in Europe. *S. aloides* is still in trade today, including in Canada and possibly the United States. In Canada, it has escaped into the wild and has formed nonnative populations in the Trent and Black rivers in Ontario. An introduction was also reported from New York in 2024, with population status unknown. Introductions and establishment of nonnative populations have resulted in loss of native plant diversity and abundance. *S. aloides* is regulated in 12 U.S. States. The history of invasiveness for this species is High. The climate matching analysis for the contiguous United States indicates establishment concern for this species. Areas of high match were found in the Northeast, the Great Lakes region, and the Midwest, with isolated pockets in the Great Plains, Rocky Mountains, and Southwest region. The Certainty of Assessment was Medium due to the limited information about negative impacts of introduction of *S. aloides* and uncertainty in understanding the history of introductions around the species' native range. The Overall Risk Assessment Category for this species is High.

Assessment Elements

- **History of Invasiveness (see section 4): High**
- **Establishment Concern (see section 7): Yes**
- **Certainty of Assessment (see section 8): Medium**
- **Remarks, Important additional information: No additional remarks.**
- **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.

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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 GBIF Secretariat (2023).

Under the future climate scenarios (figure A1), on average, high climate match for *Stratiotes aloides* was projected to occur in the Great Lakes region of the contiguous United States. Areas of low climate match were projected to occur in the Northern Pacific Coast region, along the Cascade-Sierra Range, and in southern Florida. The Southeast had a low climate match under both SSP3 and SSP5, mainly in the 2085 time step. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.283 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.777 (model: MPI-ESM1-2-HR, 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 (0.862, figure 4) falls above 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 Southwest saw a moderate increase in the climate match relative to current conditions. No large increases were observed regardless of time step and climate scenarios. Under one or more time step and climate scenarios, areas within the Appalachian Range, California, Great Lakes, Gulf Coast, Mid-Atlantic, Northeast, Northern Plains, Southeast, Southern Plains, and Southwest regions saw a large decrease in the climate match relative to current conditions. Additionally, areas within the Colorado Plateau, Great Basin, Northern Pacific Coast, Southern Atlantic Coast, Southern Florida, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. Additional, very small areas of large or moderate change may be visible on the maps (figure A3).

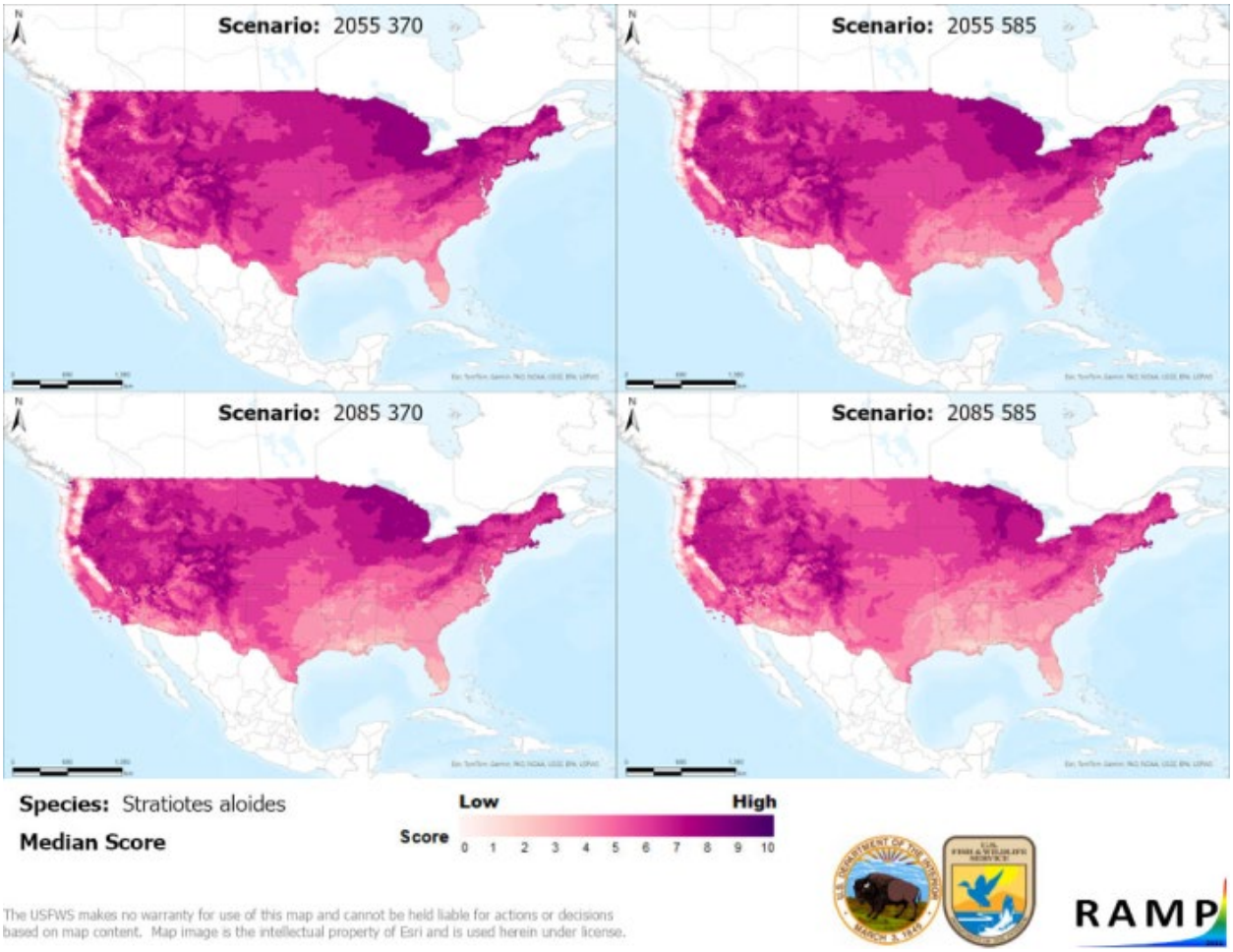

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Stratiotes aloides* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2023). Shared 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.

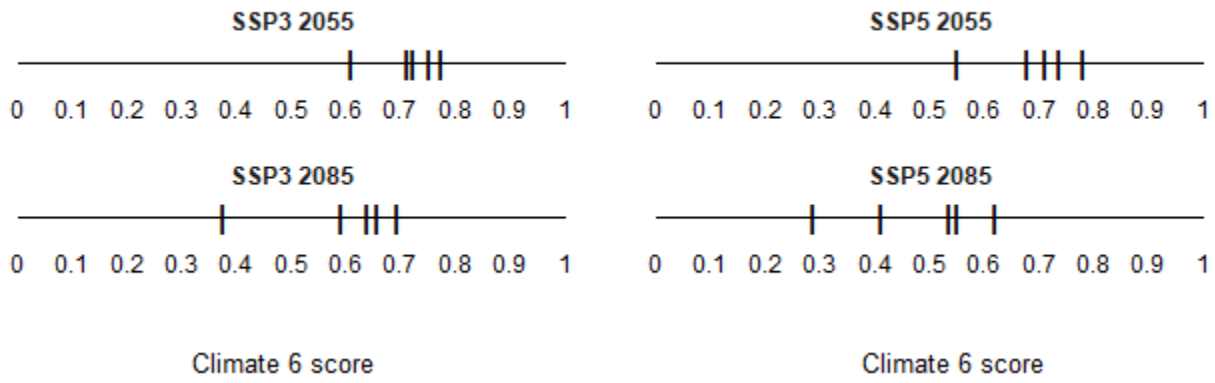

Figure A2. Comparison of projected future Climate 6 scores for *Stratiotes aloides* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; 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.

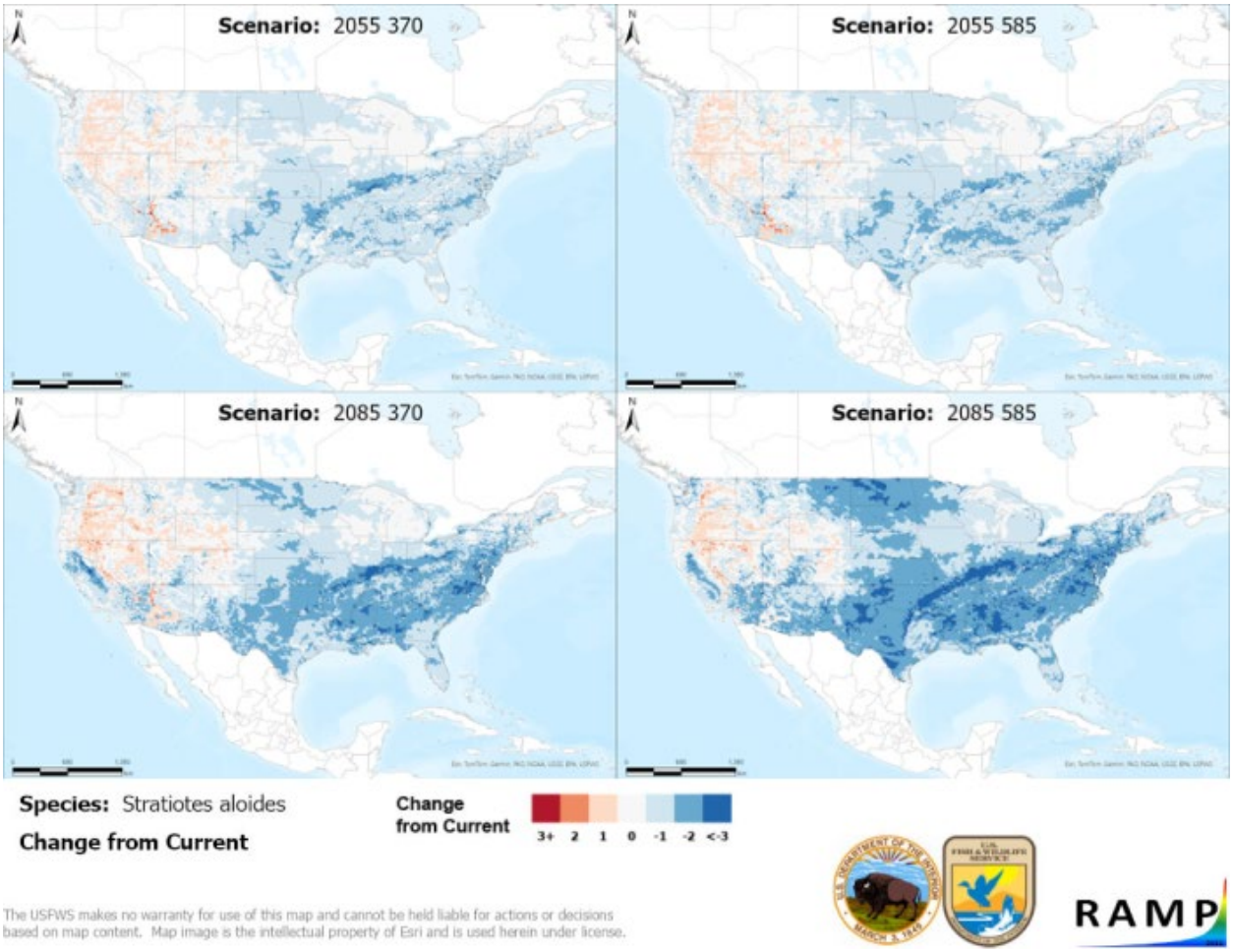

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Stratiotes aloides* based on source locations reported by GBIF Secretariat (2023). 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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