

***Azolla microphylla* (a mosquitofern, no common name)**

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, March 2015
Revised, February 2017, October 2017
Web Version, 7/23/2021

Organism Type: Plant

Overall Risk Assessment Category: Uncertain



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1 Native Range and Status in the United States

Native Range

From Zimmerman et al. (1994):

“*A. microphylla* Kaulf. (MI in this paper) is the only one whose range reportedly lies entirely within the tropics. From an arbitrary focal point at the Galapagos Islands, its distribution extends north into the West Indies and Central America, and also across northern and central South America (Schofield & Colinvaux, 1969; Morton & Wiggins, 1971). Within South America, MI is purportedly "centered in the lowlands of Brazil" (Svenson, 1944).”

From Wagner (1997):

“*A. microphylla* in tropical and subtropical America, [...]”

Status in the United States

From Wagner (1997):

“*A. microphylla* in tropical and subtropical America, [...]”

No further information could be found regarding a more detailed distribution of *Azolla microphylla* in the United States. Most of the resources dealing with distributions within the United States have synonymized *A. microphylla* with *A. mexicana*, a separate valid species. Therefore, the actual extent of *A. microphylla* within the United States cannot be reliably determined. See Remarks for further discussion of the taxonomic uncertainty of this genus.

No records of *Azolla microphylla* in trade in the United States were found.

Means of Introductions in the United States

No records of introductions of *Azolla microphylla* in the United States were found.

Remarks

The taxonomy of the *Azolla* genus is not fully resolved (see references below). Ecological Risk Screening Summaries follow World Flora Online as the authority on worldwide plant taxonomy (USFWS 2020). World Flora Online (2021) considers *Azolla microphylla* as an accepted species. Other sources consider *A. mexicana* and *A. caroliniana* as synonyms of *A. microphylla* or *A. microphylla* as a junior synonym of *A. filiculoides* (e.g. GBIF Secretariat 2021; Hassler 2021; ITIS 2021; NatureServe 2021; USDA, NRCS 2021) but those names are all considered separate, accepted species by World Flora Online (2021) and are so treated within this screening.

The taxonomic uncertainty of the genus has resulted in muddled information available for this species. It was first described in 1824 but since then has been considered variously as a synonym of *A. caroliniana*, *A. filiculoides*, and *A. cirstata*, and has had *A. mexicana* synonymized with it. See Evard and Van Hove (2004) for a full discussion of the history of *Azolla* taxonomy in North America. Due to this complicated history, determining what information in the literature belongs to each World Flora Online recognized species is difficult. Efforts have been made to only include information pertaining to *A. microphylla*. In cases where there is uncertainty to the species identity it has been noted.

From Hill and Madeira (2011):

“Recently molecular analysis has shown that what we have been referring to as *A. pinnata africana* in South Africa is in fact *Azolla microphylla* Kaulf., an introduced species. Extensive surveys in South Africa and Mozambique have failed to find *A. pinnata africana* and we now believe that the species used by McConnachie (2004) was *A. microphylla* which is in the same

section of the genus as *A. filiculoides* and explains the discrepancy in the host specificity studies.”

From Hassler (2021):

“Name *Azolla microphylla* Kaulf.

[...]

Synonyms and Combinations = *Azolla mexicana* C. Presl”

From Peck (2011):

“All Arkansas material (Peck and Taylor 1995) was traditionally referred to as *Azolla mexicana* C. Presl until recently when some specimens were assigned to *A. caroliniana* Willd. (Peck 2003). Recent herbarium and molecular studies (Mickel and Smith 2004, Reid, Plunkett, & Peters 2006) showed that *Azolla microphylla* was a valid, older name than *A. mexicana* and that it was conspecific with *A. caroliniana*. Thus, all material from Arkansas is now reported as *A. microphylla*.”

From Wagner (1997):

“Hybridization between *A. microphylla* and *A. filiculoides* (male) improved annual biomass production.”

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

According to World Flora Online (2021), *Azolla microphylla* Kaulf. is the accepted name for this species.

From Hassler (2021):

Kingdom Plantae

Phylum Tracheophyta

Class Polypodiopsida

Order Salviniiales

Family Salviniaceae

Genus *Azolla*

Species *Azolla microphylla* Kaulf.

Size, Weight, and Age Range

From Ashton and Walmsley (1984):

“[...] plants small (10-20 mm long), [...]”

Environment

From Wagner (1997):

“Kushari and Watanabe (1992) showed that *A. pinnata* was less affected by phosphorus-deficient conditions than was *A. microphylla*, *A. mexicana*, *A. filiculoides*, and *A. nilotica*.”

From Alfasane et al. (2019):

“*Azolla microphylla* Kaulf can grow in the edges of Kunier Haor [wetland in Bangladesh]. This species also grows in rice fields, shallow wetlands, slow moving streams, irrigation reservoirs or canals, edges of lakes, ponds, sloughs, or backwaters. *A. microphylla* Kaulf can grow in water surface and tolerates any range of water levels. It can also develop in higher water levels and high-nutrient environments (<http://www.theplantlist.org/tpl1.1/record/tro-26608433>).”

Climate

From Wagner (1997):

“*A. microphylla* in tropical and subtropical America, [...]”

“Transferring *Anabaena* [symbiotic blue-green algae] from temperature-tolerant *A. microphylla* to *Anabaena*-free *A. filiculoides*, resulted in high-temperature tolerance in the latter, indicating that heat tolerance may be partly controlled by the symbiont.”

Distribution Outside the United States

Native

From Wagner (1997):

“*A. microphylla* in tropical and subtropical America, [...]”From Zimmerman et al. (1994):

“*A. microphylla* Kaulf. (MI in this paper) is the only one whose range reportedly lies entirely with- in the tropics. From an arbitrary focal point at the Galapagos Islands, its distribution extends north into the West Indies and Central America, and also across northern and central South America (Schofield & Colinvaux, 1969; Morton & Wiggins, 1971). Within South America, MI is purportedly "centered in the lowlands of Brazil" (Svenson, 1944).”

From Wagner (1997):

“*A. microphylla* in tropical and subtropical America, [...]”

Introduced

From Hill and Madeira (2011):

“Recently molecular analysis has shown that what we have been referring to as *A. pinnata africana* in South Africa is in fact *Azolla microphylla* Kaulf., an introduced species. Extensive surveys in South Africa and Mozambique have failed to find *A. pinnata africana* [...]”

From Alfasane et al. (2019):

“*Azolla microphylla* Kaulf was not reported earlier in the previous studies or literature, viz. Hooker (1888), Prain (1903), Ahmed et al. (2009) from the areas that now fall under the territory of present Bangladesh. Hence, it is reported here as a new record for Bangladesh.”

From Langa (2013):

“The aquatic weeds, water hyacinth (*Eichhornia crassipes*), red water fern (*Azolla microphylla*), water lettuce (*Pistia stratiotes*) and salvinia (*Salvinia molesta*) were found in most watercourses in Mozambique and are becoming aggressive in some watercourses, especially in the Umbeluzi and Incomati rivers.”

Means of Introduction Outside the United States

No information on the means of introduction for *Azolla microphylla* was found.

Short Description

From Ashton and Walmsley (1984):

“Glochidia multi-septate; plants small (10-20 mm long), pinnately branched, with nearly orbicular leaves 1 mm long; megaspore smooth.”

From Alfasane et al. (2019):

“Prostrate, floating on the water's surface, long, stalk less, alternate, often overlapping, like shingles, along branching stems. Stem up to about 1.3 cm long, usually branched, typically fan-shaped in outline in well-developed plants; new growth bright green to blue-green, often turning dark red later in the season, or having at least some red-tinged leaves. [...] Leaves 65-72 x 22-38 µm, divided into 2 lobes, folded, upper lobe above the water's surface, blunt to pointed at the tip, somewhat succulent and covered in short, glass-like hairs, the lower lobe submersed, more membranous and rounded at the tip, the distance between two leaves is around 12-18 µm.”

Biology

From Alfasane et al. (2019):

“Plants can form large surface area colonies, which sometime cover entire aquatic body, and may form multi-layer mats, up to 3.81 cm thick.”

“Numerous rooting of *A. microphylla* Kaulf were observed in the surface of the Kunier Haor [Bangladesh]. *A. microphylla* requires no rooting in bottom sediments.”

Human Uses

From Arora and Saxena (2005):

“Study was conducted on recycling municipal wastewaters for cultivation of *Azolla microphylla* biomass, which is used for inoculation into paddy fields as N [nitrogen] biofertiliser and has other applications as green manure, animal feed and biofilter.”

From Wagner (1997):

“*Azolla* can also be used in the control of mosquitoes, for a thick *Azolla* mat on the water surface can prevent breeding and adult emergence. [...] Rajendran and Reuben (1991) found that immature mosquito populations of *Anopheles subpictus* Grassi, *Culex pseudovishnui* Colless, and *C. tritaeniorhynchus* Giles were reduced by a 90% cover of *Azolla microphylla*.”

Diseases

No information on the pathogens of *Azolla microphylla* was found.

Threat to Humans

No information on threats to humans from *Azolla microphylla* was found.

3 Impacts of Introductions

From Langa (2013):

“The most problematic plants were *E. crassipes* and *A. microphylla* because, in most cases, they showed high density [...] and a high percentage cover, reaching almost 95% [...]”

“Red water fern (*Azolla microphylla*) affected the quality of water for domestic use by changing the odour, taste and colour.”

4 History of Invasiveness

The history of invasiveness is classified as Data Deficient. There are known introductions that have resulted in established populations in South Africa, Mozambique, and Bangladesh. Impacts to water quality for human consumption were reported from a survey of residents near a large infestation of *Azolla microphylla* but this perception by the residents was not investigated through independent means.

5 Global Distribution

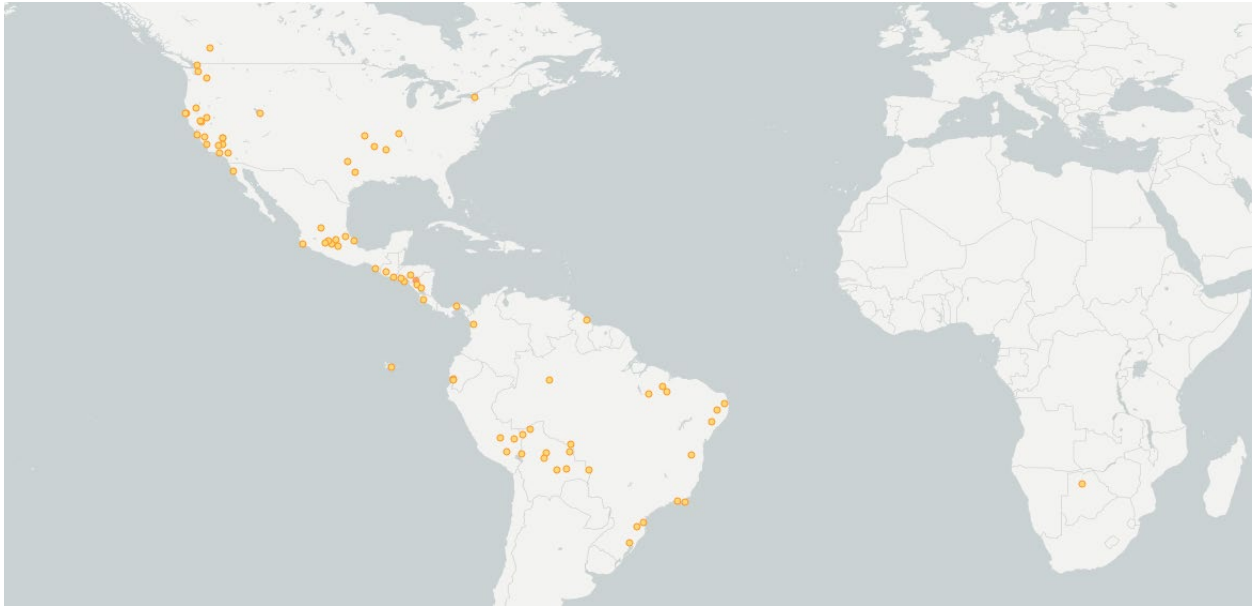
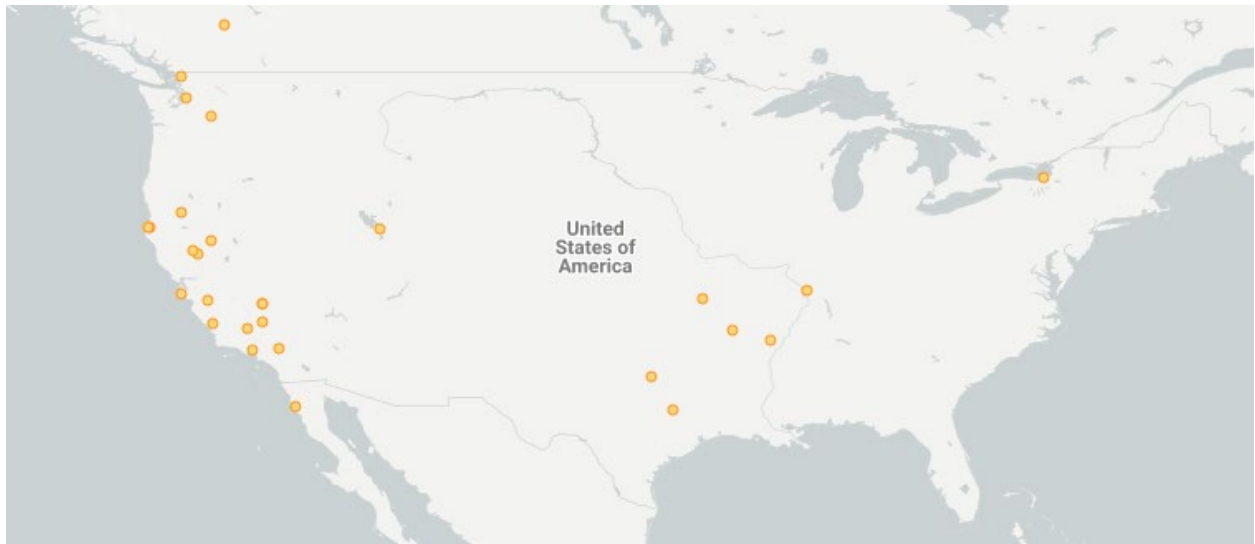


Figure 1. Known global distribution of *Azolla microphylla*. Locations are in North and South America, and Botswana. Map from GBIF Secretariat (2021). GBIF Secretariat (2021) synonymizes *A. mexicana* with *A. microphylla*. Filters were used so that observations recorded under the name *A. microphylla*, and not *A. mexicana*, are shown on this map and used in the climate match. The observation in Botswana could not be confirmed with another source and was not used to select source points for the climate match.

The geographic location of the introduction in Bangladesh was reported in Alfasane et al. (2019) and was used to select source points in the climate match. Collection locations for *A. microphylla* in Mozambique were reported in Langa (2013) and were used to select source points for the climate match.

No specific information on locations of *Azolla microphylla* in South Africa was available therefore no locations in that country were able to be used as source points for the climate match.

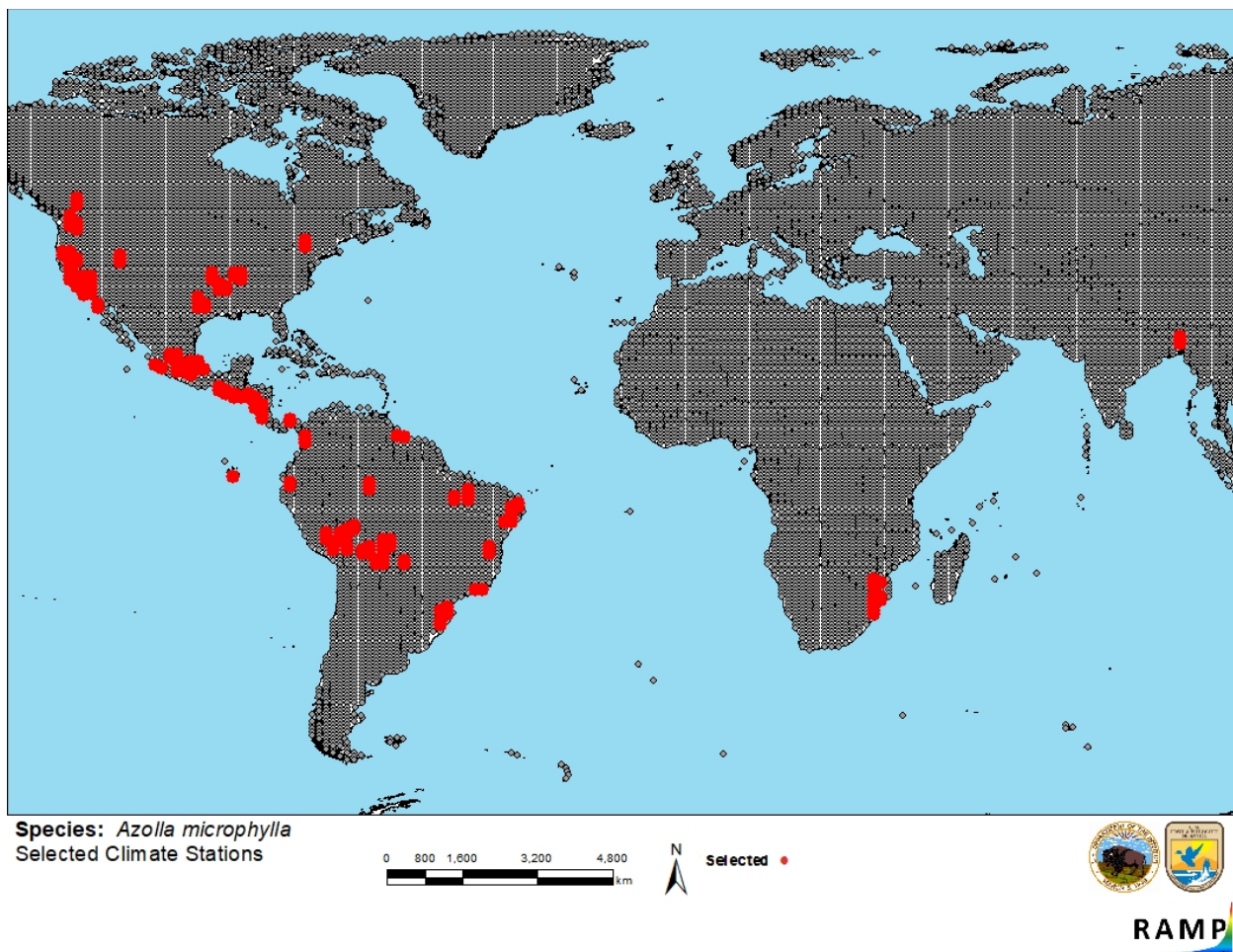
6 Distribution Within the United States



7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Azolla microphylla* had areas of low match in the upper Mid-west and northern Great Plains, as well as in the southwestern deserts stretching eastward into western Texas. A few small areas of low match were found scattered in the Appalachian and Rocky Mountain ranges. Everywhere else had medium to high matches, with medium matches concentrated in the Plains States. High matches extend beyond areas of the United States where *A. microphylla* is reported, especially in the East. The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for the contiguous United States was 0.688. (Scores of 0.103 or greater are classified as high.) Every state had an individually high Climate 6 score, except Minnesota, North Dakota, and Rhode Island, which had low scores, and South Dakota, which had a medium score.



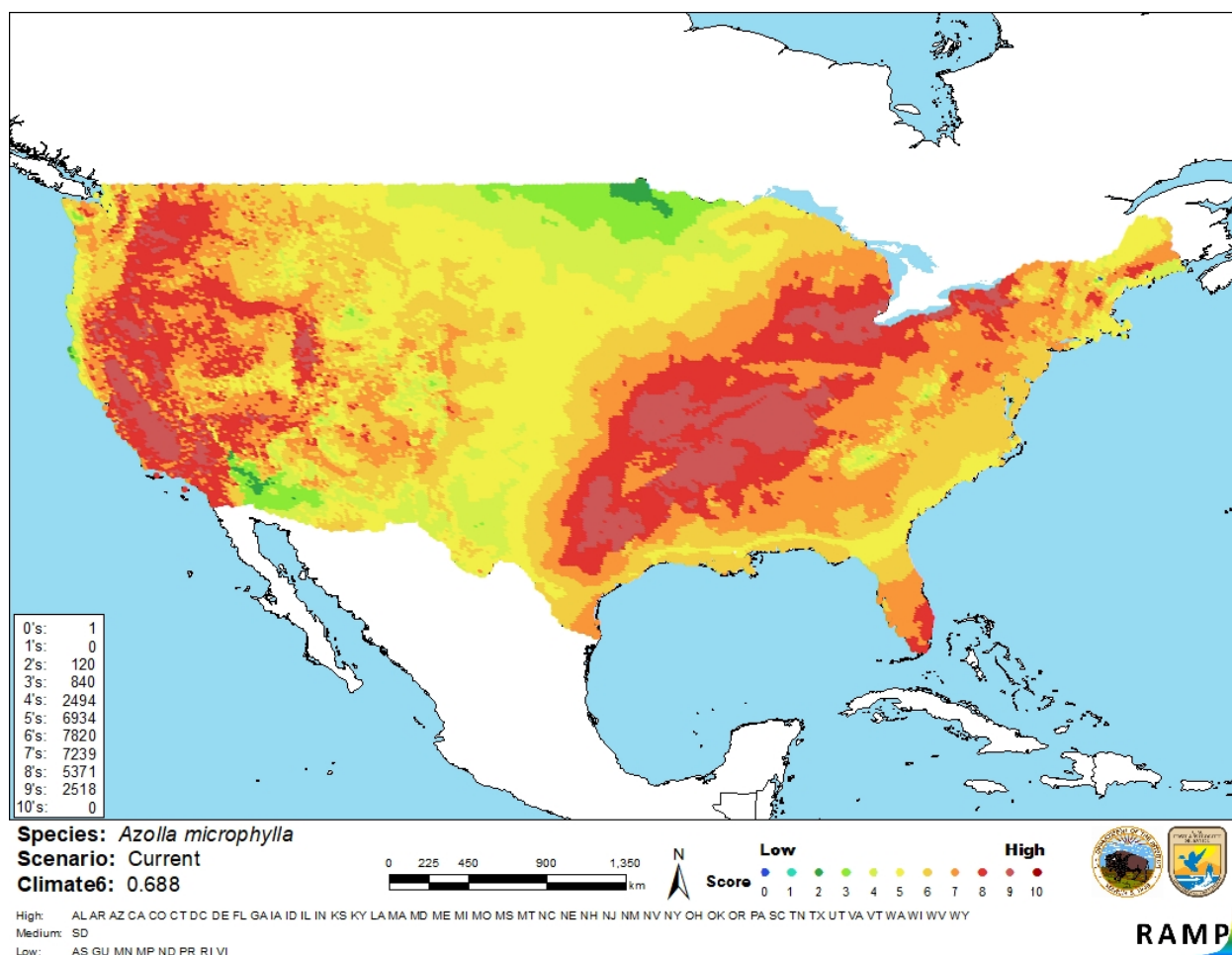


Figure 4. Map of RAMP (Sanders et al. 2018) of a current climate match for *Azolla microphylla* in the contiguous United States based on source locations reported by Langa (2013), Alfasane et al. (2019), and GBIF Secretariat (2021). Counts of climate match scores are tabulated on the left. 0/Blue = Lowest match, 10/Red = Highest match.

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

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

8 Certainty of Assessment

The certainty of assessment is low. The taxonomic issues of the genus *Azolla* result in difficulty determining what information pertains to *Azolla microphylla* specifically, what pertains to other species that have been synonymized with *A. microphylla* by different authors, and what might refer to combinations of currently recognized species. This uncertainty extends to the range

information, including that used in the climate match, which reduces the certainty in the interpretation of the climate match results. There is some information on impacts of introduction, but it is generalized and not scientifically defensible.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Azolla microphylla is an aquatic fern species that is potentially native to parts of both North and South America. *A. microphylla* has been used as a green fertilizer, animal feed, natural filter for waste treatment, and large populations may be useful for reducing mosquito populations. The taxonomic confusion within the *Azolla* genus has made it difficult to determine what information can be correctly attributed to this species. The history of invasiveness is classified as Data Deficient. Introductions have resulted in established populations in South Africa, Mozambique, and Bangladesh. Some information regarding impacts to water quality for human consumption were reported from a survey of residents near a large infestation. The climate match with the contiguous United States is high. The climate match indicates that there is suitable climate for an expansion of this species outside the known current range. The certainty of this assessment is low because of a lack of information reliably pertaining to *A. microphylla*, and the taxonomic confusion of *Azolla* in general, which also reduces the certainty in the information regarding the range of the species and the interpretation of the climate match results. The overall risk assessment category is Uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 4): Data Deficient**
- **Overall Climate Match Category (Sec. 7): High**
- **Certainty of Assessment (Sec. 8): Low**
- **Remarks, Important additional information:** The taxonomy of the *Azolla* genus is unresolved.
- **Overall Risk Assessment Category: Uncertain**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 11.

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11 Literature Cited in Quoted Material

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

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