

FIRST RECORD OF NAJAS MARINA (HYDROCHARITACEAE) FOR MONTANA AND AN UPDATE ON THE NORTH AMERICAN DISTRIBUTION

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ABSTRACT

Three recent collections of *Najas marina* (spiny water-nymph) from Missoula Co., Montana, are documented and illustrated. These collections are the first records for Montana and for the Pacific Northwest region. The occurrence of *N. marina* in Montana reflects a significant northward expansion of this species in the Mountain West. The North American distribution of this species is also updated.

Najas marina is widespread, occurring on every continent except Antarctica (Hultén 1962). In the Americas, the species inhabits disparate but disjunct regions in the USA, Canada, Mexico, Guatemala, El Salvador, Panama, Argentina, Venezuela, Ecuador, Bolivia, Brazil, and the Caribbean (Lowden 1986). The distributional history of *N. marina* in North America was described by Haynes (1979) and Stuckey (1985) and includes the Caribbean region from Florida to Antigua, the Great Lakes region from the Dakotas to New York, the Sonoran Desert region from northern California to Texas south to Baja California Sur and Guerrero, Mexico, and Pacific island occurrences in Hawai'i, Clipperton, and the Galapagos (Fig. 1; Pfingsten 2021). It has not previously been collected in the Pacific Northwest (Giblin 2018).

The fossil record indicates that *Najas marina* is native to North America (Fig. 1). Fossil fruits have been recovered from lake sediments with estimated age ranging from 3,000 to 13,000 years B.P. (summarized in Stuckey 1985). Stuckey (1985) proposed two possible explanations for the observed distribution of *N. marina* — recolonization from a relict population following glacial recession or introduction to North America from another region. Mills et al. (1993) concluded that the observation of *N. marina* in industrialized Central New York in 1864 is best explained by the introduction of the species from elsewhere associated with salt production activity.

The earliest specimens of *Najas marina* in North America came from Antigua in the 1840s (vouchered in 1938 [Box 1424 (US)]), Arizona in 1867, Baja California, Mexico in 1884, California in 1863, Cuba in the 1860s, Florida in 1874, Minnesota in 1891, Nevada in 1878, New York in 1864, and Utah in 1875 (Stuckey 1985; Lowden 1986). In the 20th century the recorded range of *N. marina* increased in North America (Fig. 1; Pfingsten 2021). Information on initial observations is presented in Table 1. Stuckey (1985) reported observations in New Mexico prior to 1980 citing Martin and Hutchins (1980), but the first confirmed collections are from 2004 [Heil & Clifford 24121 (SJNM)].

Table 1. 20th Century initial reports of *N. marina* in North America by country, state, or province (CA = Canada, FR = France, MX = Mexico, US = United States).

Year	Location	Specimen (Holding)	Reference
1966	Bahamas	<i>Bowen 26801</i> (US)	Lowden 1986
1974	Caicos	<i>Correll 43208</i> (F, MO, NY)	Lowden 1986
1997	CA: Ontario	<i>Oldham 20525</i> (MICH)	MICH Herbarium 2020
1973	Dominican Republic	<i>Lowden 3259</i> (UCMM)	Lowden 1986
1924	El Salvador	<i>Hildebrand & Foster s.n.</i> (US)	Lowden 1986
1989	Guatemala	<i>Haynes 9388</i> (GA)	GA Herbarium 2021
1920	Haiti	<i>Leonard 3537</i> (GA, GH, NY, US)	Lowden 1986
1958	Jamaica	<i>Loveless 3702</i> (IJ)	Lowden 1986
1938	FR: Clipperton Island	<i>Schmitt 102</i> (US)	Lowden 1986
1968	MX: Coahuila	<i>Lewis s.n.</i> (LL, NY)	Lowden 1986
1960	MX: Guerrero	<i>Saunders 428</i> (US)	Lowden 1986
1939	MX: Veracruz	<i>LeSueur 139</i> (F, US)	Lowden 1986
1993	MX: Sonora	<i>Felger & Reyna 93-214</i> (TEX)	Felger et al. 1997
1939	Panama	<i>Elmore L38</i> (NY)	Lowden 1986
1905	US: Hawai'i	<i>Limu Woman 269</i> (US)	Shannon and Wagner 1996
1964	US: Illinois	<i>Winterringer 22493</i> (ILLS)	Winterringer 1966
1979	US: Indiana	<i>Davenport 1424</i> (UNA)	Davenport 1980
1937	US: Michigan	<i>Bazuin 442</i> (HAM)	Stuckey 1985
1992	US: Nebraska	<i>Rolfsmeier 10713</i> (BRY, BRIT)	Rolfsmeier 1993
1949	US: Ohio	<i>Core & Anderson 10</i> (BH)	Anderson 1950
1979	US: Oklahoma	<i>Couch & Nelson 103</i> (OKL, OKLA)	Nelson and Couch 1981
1982	US: Pennsylvania	<i>Kunsman 5292</i> (CM, PAC, PH)	Kunsman and Keener 1986
1923	US: Puerto Rico	<i>Britton & Britton 7878</i> (GH, NY, US)	Lowden 1986
1964	US: Tennessee	<i>Hunter 433</i> (MUR)	MUR Herbarium 2021
1923	US: Texas	<i>Weed & Camp s.n.</i> (F)	Stuckey 1985
1941	US: Wisconsin	<i>Posekany s.n.</i> (WIS, MIN)	Ross and Calhoun 1951

Voucher specimens. Montana. Missoula Co.: Abundant in near-shore, E of Frenchtown Pond swimming dock, Frenchtown Pond State Park, 966 m, 47.023° N, 114.258° W, 14 Sep 2020, *Freeman 9979* (WTU); abundant in silt, near-shore, alkaline (pH 8.56) waters E of Frenchtown Pond swimming dock, Frenchtown Pond State Park, 966 m, 47.023° N, 114.258° W, 5 Aug 2020, *Freeman T78F* (WTU); few plants in gravel, shallow alkaline water (ca. 1 m deep), private pond 0.4 km N of Frenchtown Pond, 966 m, 47.0271° N, 114.2554° W, 5 Aug 2020, *Freeman 80520* (WTU). Figure 2.

On 11 July 2018, Scott Freeman and Cody Olson collected an unidentified plant fragment floating near the shoreline of Frenchtown Pond, Montana, while conducting surveys for the Montana Fish, Wildlife & Parks, Aquatic Invasive Species Program. Scott Freeman posted photographs of the plant to iNaturalist, and it was first identified as *Najas marina* by Megan Weber on 27 May 2019 and later confirmed by Ian Pfingsten (iNaturalist 2019).

Scott Freeman and Brian Hagan conducted a survey at Frenchtown Pond on 24 June 2019 but did not detect *Najas marina*. Scott Freeman conducted a survey of a pond located 0.5 km north of Frenchtown Pond on 28 October 2019 and observed *N. marina* growing in shallow water but did not make a collection. Scott Freeman made collections from both locations in August and September of

2020 and identifications of the vouchers were confirmed by Peter F. Zika at the herbarium of the University of Washington in Seattle (WTU Herbarium 2020).

Scott Freeman conducted an abundance survey in Frenchtown Pond on 14 September 2020. The sampling method consisted of throwing a thatch-rake on a 15-m rope from shore and estimating the percent of the rake that was covered by each plant species, separately. Tosses were made at 100-m intervals along the shoreline for a total of 17 sampling locations. *Najas marina* was collected at each sampling location with an average rake coverage of 25%. *Chara* spp. was collected at 16 locations with an average rake coverage of 67%. Other species that were encountered at much lower frequency and abundance included *Myriophyllum sibiricum*, *Ceratophyllum demersum*, *Potamogeton richardsonii*, and *Stuckenia pectinata*.

Frenchtown Pond, with an area of 7.3 ha, is entirely contained within Frenchtown Pond State Park, established in 1972 (Montana Fish, Wildlife & Parks 2021). The pond is the result of gravel excavation for construction of Interstate 90 in the 1960s; it fills from groundwater and has no outlet. Water levels are lowest in spring, and highest in July during peak irrigation season (Mike Kustudia, Montana Fish, Wildlife & Parks, pers. written comm., 2021). Recreational use is heavy in the summer, and though there is no boat ramp, hand-launch of small watercraft is common. Frenchtown Pond is used by at least 15 species of waterfowl and waterbirds including mallards and redheads (eBird 2021).

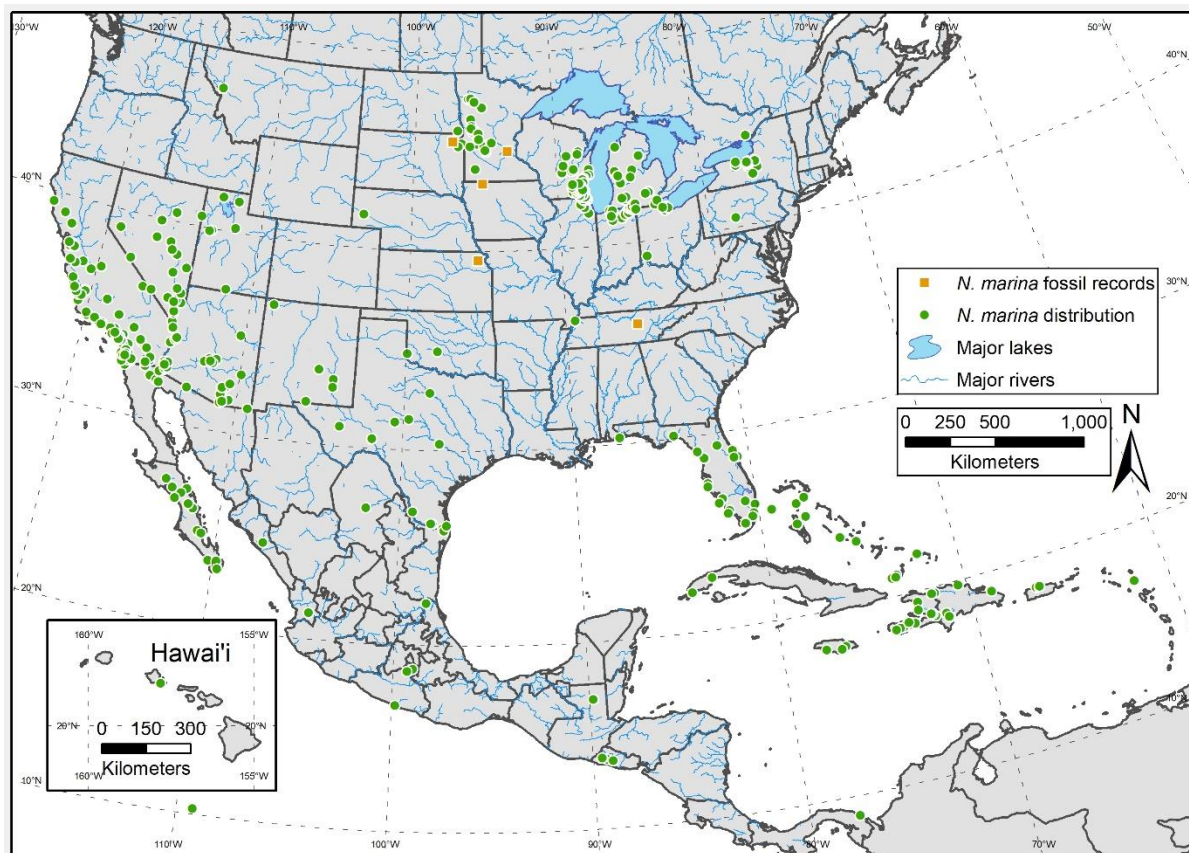


Figure 1. Range map of *Najas marina* in North America, Hawai'i, and the Caribbean Islands (Stuckey 1985; Lowden 1986; iNaturalist 2019; US National Herbarium 2019; Calflora 2021; SEINet 2021; aggregated in Pfingsten 2021). Fossil record locations are approximated from Stuckey (1985). Major lakes are from the Watershed Boundary Dataset (USGS and USDA 2013). Major rivers are from HydroSHED (Lehner and Grill 2013).



Figure 2. Detail of *Najas marina* collection from Frenchtown Pond, Missoula Co., Montana. Photo by Peter F. Zika (WTU Herbarium 2020).

Najas marina is often associated with saline, brackish, or alkaline waters (Moyle 1945; Stuckey 1985; Les 2020), and is found in waters with a pH range of 7.8–10.2 (mean 8.6) (Les 2020). Measurements of pH at Frenchtown Pond taken during sampling events from 2018 to 2020 average 8.66 (SD = 0.22, N = 4). A single pH measurement of 9.17 was recorded at the pond north of Frenchtown Pond in 2018. Western Montana is characterized by alkaline lakes and ponds. Of 109 water bodies sampled during invasive species monitoring visits from 2017 to 2020, 84% had average recorded pH greater than 8.0, and 34% had average recorded pH greater than 8.5 (unpubl. data, Montana Fish, Wildlife & Parks, Aquatic Invasive Species Program).

Najas marina is considered thermophilic; germination and maturation are regulated by water temperature. Water temperatures of more than 15 C are required for germination and more than 20 C for maturation (Van Vierssen 1982, Agami and Waisel 1984, Hoffman et al. 2013). Water temperatures recorded at Frenchtown Pond during July and August sampling events were 22.2 C and 25.6 C respectively. Small lakes and ponds in Western Montana generally reach temperatures above 20 C in mid-summer, but some large lakes, lakes at higher elevation, and most rivers and streams do not (unpubl. data, Montana Fish, Wildlife & Parks, Aquatic Invasive Species Program). Western Montana presents significant opportunities for further colonization by *N. marina*.

Seed transport by waterfowl has been postulated as a mechanism for the dispersal of *Najas* species in North America (Meriläinen 1968; Stuckey 1985; Les 2020). *Najas flexilis* and *N. guadalupensis* are important components of waterfowl diet (Knapton & Petrie 1999) and *N. marina* seeds are consumed by blue-winged teal (*Spatula discors*), mallards (*Anas platyrhynchos*), and redheads (*Aythya americana*) (Les 2020). In a study of mallards it was found that the seeds of *N. marina* can remain in the gut for up to 10 hours, can pass through unharmed, and that the process improves the germination of surviving seeds (Agami & Waisel 1986). The hard-coated seeds of *N. marina* also can remain viable for up to 4 years (Agami & Waisel 1984) and can remain viable in lake sediments for up to 3 years (Handley & Davey 2005). Though mallards and other waterfowl make their northward migration from the southern USA to Canada and Alaska each spring (Fink et al. 2020), before annual production of seeds, the consumption of seeds from the previous year is a possible vector for the northward expansion of *N. marina* in the Rocky Mountain West.

The abundance of *Najas marina* in Frenchtown Pond only two years after first detection may be indicative of a rapid expansion of this population to become the dominant vascular plant in the pond. Alternatively, limited sampling effort, lack of familiarity with the taxa, and the timing of sample events may have contributed to non-detection of the species well after introduction. Further sampling will be required to assess the seasonal abundance of *N. marina* in Frenchtown Pond and to search for additional populations in the near vicinity and farther afield.

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