Elodea (*Elodea canadensis*)

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, May 2019
Revised, May 2019
Web Version, 10/24/2019

Photo: R. H. Mohlenbrock. Public domain. Available: https://plants.usda.gov/java/largeImage?imageID=elca7_001_ahp.tif. (May 3, 2019).

1 Native Range and Status in the United States

Native Range

From Klein (2011):

"Canadian waterweed is native to much of North America, including British Columbia (Haynes 2000). In British Columbia, it is frequent south of 51°N but rarely occurs farther north (Klinkenberg 2010). It grows in 46 states of the U.S. and much of southern Canada (Haynes 2000, USDA 2011)."

Status in the United States

From Klein (2011):

"Canadian waterweed is native to much of North America, […]. It grows in 46 states of the U.S. […]"

"In Chena Slough near Fairbanks, Alaska, it has formed dense monocultures, […]"

GISD (2019) lists *Elodea canadensis* as alien, established, but invasiveness unspecified in Hawaii.

According to Maiz-Tome (2016), *Elodea canadensis* is introduced and extant in Puerto Rico.

From Carey et al. (2016):

"Until recently, the aquarium trade transported *Elodea* into and around Alaska; however, the state barred importation of both *E. canadensis* and *E. nuttallii*, […]"

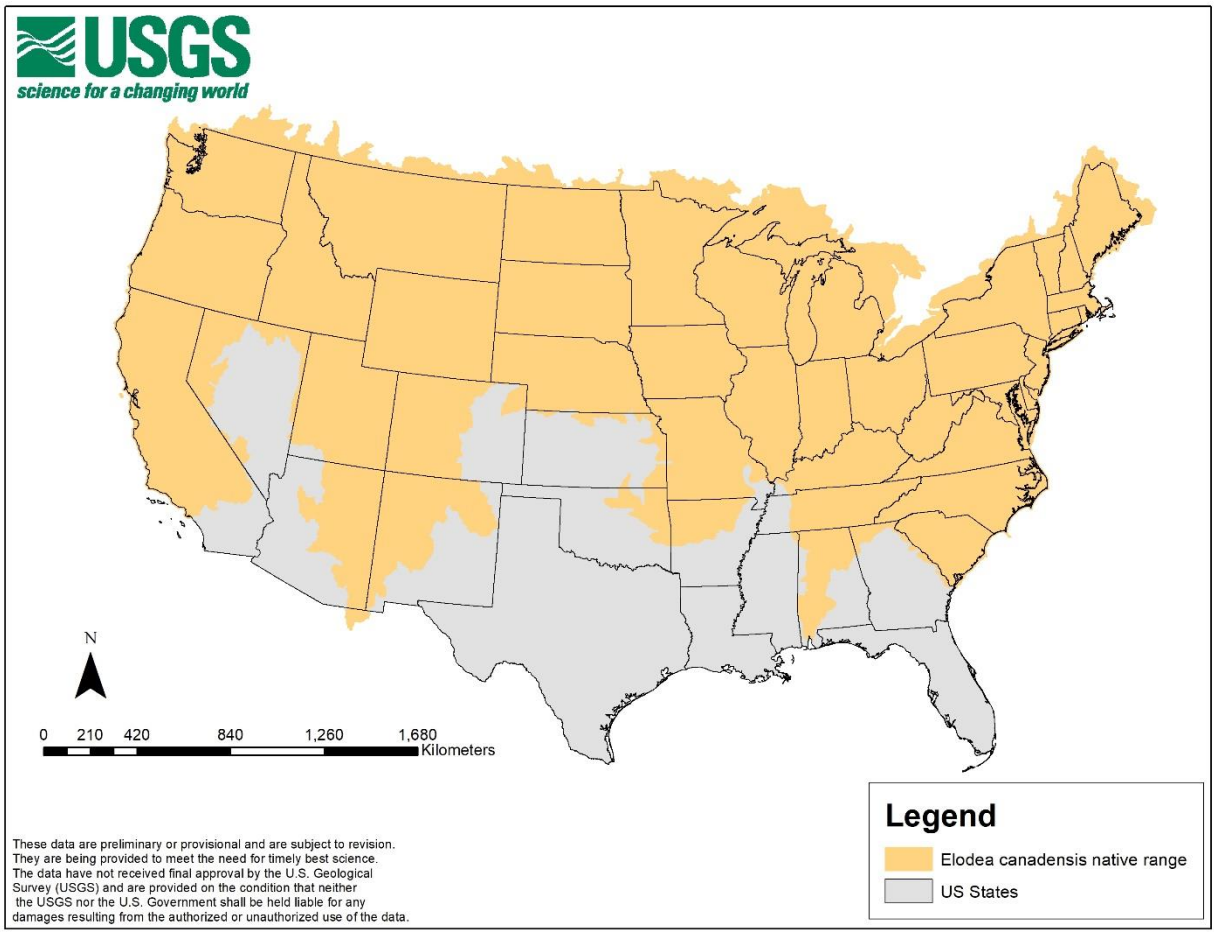

Figure 1. Map of the contiguous United States showing the native range of *Elodea canadensis* (shaded in yellow). Map from U.S. Geological Survey (personal communication W. Daniel, USGS, Gainesville, Florida).

Means of Introductions in the United States

From Klein (2011):

"Canadian waterweed is grown as an aquarium plant and has spread to new regions by trade. Many infestations, including those at Chena Slough [Alaska], have likely originated from dumped aquarium material (Bowmer et al. 1995, Josefsson and Andersson 2001, Larsen et al. 2010). Stems can become tangled on and dispersed by boat props or trailers, vehicles that cross fords (Spicer and Catling 1988, Bowmer et al. 1995), and float plane rudders (Wurtz and Lisuzzo 2011)."

Remarks

From Klein (2011):

"Canadian waterweed has been known to forms [sic] fertile hybrids with Nuttall's waterweed (*Elodea nuttallii*) in natural environments (Cook and Urmi-Konig 1985). Laboratory crosses also yield fertile hybrids with viable seed (Ernst-Schwarzenbach 1945)."

"It is often problematic in its native range in Canada, where populations reduce the navigability of waterways (Spicer and Catling 1988)."

Although *Elodea canadensis* is native to much of the contiguous United States, it is considered invasive in Alaska. As per the Service's ERSS standard operating procedures, to determine the full extent of the plant's risk to Alaska, an ERSS for the contiguous United States is completed before a more specific climate match can be completed for Alaska.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2019):

"Taxonomic Status:
Current Standing: accepted"

"Kingdom Plantae
Subkingdom Viridiplantae
Infrakingdom Streptophyta
Superdivision Embryophyta
Division Tracheophyta
Subdivision Spermatophytina
Class Magnoliopsida
Superorder Lilianae
Order Alismatales
Family Hydrocharitaceae
Genus *Elodea*
Species *Elodea canadensis* Michx."

Size, Weight, and Age Range

From Swearingen and Bargeron (2016):

"It [*Elodea canadensis*] can reach up to 9.8 ft. (3 m) in length."

Environment

From Klein (2011):

"Vegetative buds can survive desiccation and low temperatures, […]"

"It can grow slowly under ice cover and can overwinter in 1°C to 4°C water (Spicer and Catling 1988, Bowmer et al. 1995). Canadian waterweed can survive in a wide range of conditions but grows best on silts in mesotrophic waters with pH between 6.5 and 10. […] The optimal water temperature range for growth is from 10°C to 25°C (Spicer and Catling 1988)."

From CABI (2019):

"Growth of this species is greatly stimulated under eutrophic conditions (Hughes, 1976; Barko and Smart, 1983; Kraus[c]h, 1987)."

From DAISIE (2019):

"[…] and [water] temperatures from 1 to 25 °C.

From Josefsson (2011):

"*E. canadensis* can occur in brackish water and tolerates salinities up to 2.5 per mille (Sand-Jensen 2000)."

Climate/Range

From Klein (2011):

"Canadian waterweed […] is able to survive cold climates (Bowmer et al. 1995, Fairbanks Soil and Water Conservation District 2011)."

Distribution Outside the United States

Native

The native range of *Elodea canadensis* includes portions of the United States. See Section 1 for a full description of the native range.

From Klein (2011):

"Canadian waterweed is native to much of North America, including British Columbia (Haynes 2000). In British Columbia, it is frequent south of 51°N but rarely occurs farther north (Klinkenberg 2010). It grows in […] much of southern Canada (Haynes 2000, USDA 2011)."

Introduced

From Klein (2011):

"It has been introduced to Europe, Asia, Africa, Australia, and New Zealand (Spicer and Catling 1988, Bowmer et al. 1995, Thorp and Wilson 1998, Haynes 2000, Landcare Research 2011). This species is known to grow in subarctic Scandinavia (Gollasch 2006) and has been documented as far north as 65°N in Finland (University Museums of Alberta 2011)."

"In Lake Steinsfjord in Norway, it covered 79% of the lake bottom between 0 and 6 m depth (Rørslett et al. 1986), and it has created a new layer of dense aquatic vegetation in several rivers in New Zealand (Wells 2008)."

From GISD (2019):

"*Elodea canadensis* has spread rapidly in the irrigation systems of south-eastern Australia (Bowmer, Jacobs & Sainty, 1995)."

"New invasions and explosive growth of *Elodea canadensis* are still occurring [in the Czech Republic and Norway] (Bowmer, Jacobs & Sainty, 1995)."

"*Elodea canadensis* was first observed at the end of the 70s (Kozhova & Izboldina, 1993). The expansion of *E. canadensis* may be considered a catastrophic phenomenon, and its effect now covers practically the whole perimeter of Lake Baikal [Russia] (Kozhova & Izhboldina, 1993)."

"The first year of known introductionof [*sic*] *Elodea canadensis* was in 1871 in the Swedish lake, Malaren (Josefsson & Andersson, 2001). *E. canadensis* is widely distributed within Sweden and is often found in mass developments. It is common in most parts of Sweden (Larson, 2007)."

"*Elodea canadensis* is widespread almost throughout the entire country [Switzerland] with the exception of the Alps (CABI, 2005)."

In addition to above locations, GISD (2019) lists *Elodea canadensis* as alien, invasive, and established in Austria, Denmark, Estonia, France, Germany, Ireland, Italy, Latvia, Lithuania, Poland, Portugal, Spain, and the United Kingdom; and as alien, established, but invasiveness unspecified in Mexico and South Africa. Maiz-Tome (2016) lists *E. canadensis* as introduced and extant in Belarus, Belgium, Bulgaria, Cuba, Egypt, Hungary, Jamaica, Morocco, Netherlands, Romania, Turkey, and Ukraine. CABI (2019) lists *E. canadensis* as present and introduced in China, India, Malaysia, Saudi Arabia, Singapore, Taiwan, Thailand, Mauritius, Argentina, Chile, and Ecuador, and as present in Belize. DAISIE (2019) lists *E. canadensis* as alien and established in Corsica, Luxembourg, and Slovakia; as alien and status unknown in Israel, Liechtenstein, Moldova, Scotland, and Wales; and as alien in Slovenia. Pagad et al. (2018) list *E. canadensis* as alien and verified in Albania, Croatia, and Swaziland; and as alien in Bosnia and Herzegovina, Serbia, and Macedonia.

Means of Introduction Outside the United States

From GISD (2019):

"*E. canadensis* was probably introduced by aquarists or by transport vehicles and transport together with fishes taken from lakes (Kozhova & Izhboldiana, 1993). Introduction of *E. canadensis* into a country has almost certainly been via the trade in live aquarium plants, legal or otherwise (Bowmer, Jacobs & Sainty, 1995). *E. canadensis* can be dispersed via ships as fragments attached to anchor chains or fenders."

From Carey et al. (2016):

"Earlier introduction to the British Isles is suspected from contaminated timber for railway construction (Cook & Urmikonig, 1985)."

Short Description

From Klein (2011):

"Canadian waterweed is a perennial, freshwater, aquatic plant with submerged leaves and fibrous roots. Stems are branched at the nodes, slender, leafless near the base, and usually 20 to 100 cm long. Leaves are usually arranged in whorls of three but are occasionally opposite on the lower stem. Whorls are up to 2 cm apart on the lower stem but become crowded towards the upper stem. The ends of stems form densely crowded overwintering buds. Leaves are recurved, thin, broadly lanceolate to oblong, 5 to 17 mm long, and 1.75 to 5 mm wide with minutely toothed margins. Flowering plants are rare. Solitary flowers arise from leaf axils on long (3 to 20 cm), thread-like stalks. Male and female flowers are borne on different plants. Male flowers are longer and separate from the stems before or during flowering. Flowers consist of three sepals and three petals. Sepals are green, elliptic, 3.5 to 5 mm long and 2 to 2.5 mm wide in male flowers, and 2 to 3 mm long and 1 mm wide in female flowers. Petals are white, 3.5 to 5 mm long and 0.3 to 0.7 mm wide in male flowers, and 2.4 to 2.8 mm long and 1.3 to 1.7 mm wide in female flowers. Bracts on male flowers are 6 mm of greater. Capsules are narrowly ovoid, 5 to 6 mm long, and 2 to 3.2 mm wide with 5 to 6 mm long beaks (Spicer and Catling 1988, Haynes 2000, Klinkenberg 2010, Fairbanks Soil and Water Conservation District 2011)."

From Swearingen and Bargeron (2016):

"The fruit is an ovoid capsule, about 0.23 in. (0.58 cm) long containing several seeds that ripen underwater. The seeds are 0.16 to 0.2 in. (0.4-0.5 cm) long."

Biology

From Swearingen and Bargeron (2016):

"It lives entirely underwater, the only exception being the small white or pale purple flowers which float at the surface and are attached to the plant by delicate stalks. […] Flowering will occur from May to October."

From Klein (2011):

"Vegetative buds remain dormant on the bottom sediment over winter (Spicer and Catling 1988). Buds have relatively high starch contents. […] Stem fragments containing at least four nodes were able to regenerate after storage in greenhouse water pans for more than ten weeks."

From CABI (2019):

"*E. canadensis* is an aggressively competitive weed, which spreads mainly by vegetative plant fragments, but also to some extent by seeds. Over-wintering buds and fragments of the brittle

branches are easily detached by waves, currents, foraging animals and boat traffic. New roots develop quickly on the nodes of these fragments which are carried downstream to form new stands. […] Sexual reproduction in the field is believed to be very rare because of infrequent flowering and the differing abundance of the two sexes in nature. In Europe, only female flowers occur, making sexual reproduction impossible, so that spread occurs entirely by vegetative fragments."

"Perennation is by densely leaved crowded apices or turions. During autumn, apices cease to elongate and come to bear tightly clustered dark green leaves, which contain much starch and are slightly more cuticularized than the normal foliage leaves. These apices may be liberated when the parent stems disintegrate and sink to the bottom, or remain attached throughout winter. The apices remain dormant until spring, when the leaves expand, adventitious roots develop from the lower nodes, the axis elongates and a new plant is formed. *E. canadensis* begins to grow during the spring season in temperate zones as the temperature rises to between 10-15°C. At ambient light levels, shoot biomass increases with temperature up to 28°C; root biomass shows an opposite tendency (Barko et al., 1982)."

"Erhard and Gross (2006) suggested that the production by both of allelochemicals that interfere with the growth of cyanobacteria and algae by *E. canadensis* and the closely related *E. nuttallii* could at least play some role in the success of these two species as invasives."

Human Uses

From GISD (2019):

"*Elodea canadensis* is economically important as an ornamental species. It is sold in garden shops as "oxygen weed" for private ponds to improve water quality and pond scenery."

Diseases

No records were found of diseases associated with *Elodea canadensis*.

Threat to Humans

From Josefsson (2011):

"No known effects to the human health."

3 Impacts of Introductions

From Mjelde et al. (2012):

"However, the photograph-based decrease in average species richness corresponded to the range of maximum *E. canadensis* abundance in 2004 (i.e., the 2–4-m depth interval), suggesting that *E. canadensis*'s invasiveness may have led to a decline in local biodiversity through displacement of some species [in Lake Steinsfjorden, Norway]."

"The subdominant taxa whose cover-weighted mean depth overlapped with *E. canadensis* at the onset of its colonization in 1979–80, either shifted to deeper water (*P. berchtoldii*, *P. perfoliatus* and *P. crispus*) or apparently went locally (near) extinct (*P. pusillus*, *N. flexilis* and *C. hermaphroditica*). This seems to have happened despite the fact that some of these taxa had higher cover than *E. canadensis* in 1979–80. In addition, some species with mean depth in the area covered by mass stands of *E. canadensis* in 2004 (*C. globularis* and *I. lacustris*) seem to have moved further up, and have greatly reduced their depth range. […] *N. flexilis* and *P. pusillus* therefore appear to have been brought to local (near) extinction by *E. canadensis* rather than by *M. alterniflorum*."

"The 30% reduction in sediment nutrients since 1979–80 (Berge et al., unpublished data) suggest that *E. canadensis* is the reason for the decrease of *N. flexilis* in Steinsfjord, *N. flexilis* obtaining the bulk of its nutrients from the sediments (Moeller et al., 1988). Dramatic seasonal (May–October) decreases in phosphorus and especially nitrogen concentrations were observed in the top 5 cm of sediments in a dense littoral macrophyte stand dominated by *E. canadensis* by Pokorný et al. (1984)."

"In addition, the mass invasion of *E. canadensis* in Steinsfjord raised the water-column pH to 8.5 (summer average) via extensive photosynthesis (Rørslett et al., 1985, 1986), and to a maximum pH of 10.2 inside the *E. canadensis* stands (Berge, 1986). In water with such pH values, no free CO_2 can be found (Golterman et al., 1978). *N. flexilis* is an obligate CO_2 user (Wetzel, 1969), and is not able to use HCO^-_3, which instead can be utilized by *E. canadensis* (Ondok et al., 1984). Intense photosynthesis in *E. canadensis*-dominated stands can lead to CO_2 depletion in the water column (Ondok et al., 1984), thus impairing growth for the CO_2-obligate *N. flexilis*. The depletion of water-column CO_2 by *E. canadensis*, coupled with the likely competition for sediment nutrients, support our hypothesis that *E. canadensis* may be the main reason for the decrease of *N. flexilis* in Steinsfjord."

From Klein (2011):

"Canadian waterweed can form dense mats, especially on iron-rich substrates (Spicer and Catling 1988), displacing native plant species, decreasing planktonic productivity, and reducing local biodiversity (Rørslett 1986, Podraza 2010). […] This species reduces the amount of light available to surrounding vegetation, thereby reducing the density of or eliminating underlying layers (Rørslett 1986, Spicer and Catling 1988). In Chena Slough near Fairbanks, Alaska, it has formed dense monocultures, creating a new layer of tall aquatic vegetation (Larsen et al. 2010). Canadian waterweed provides a food source for many freshwater organisms, including aquatic insects and fish (Spicer and Catling 1988, Gollasch 2006). However, this species is expected to degrade natural fish habitat in Alaska (Fairbanks Soil and Water Conservation District 2011)."

"Canadian waterweed accumulates nutrients while reducing nutrient availability in the substrate. Dense populations can restrict water flow (Spicer and Catling 1988, Gollasch 2006). Infestations increase the turbidity and pH of water and cause significant variations in phosphorous concentrations. This species reduces oxygen concentrations within 5 cm of the substrate but increases oxygen concentrations above 5 cm (Spicer and Catling 1988)."

"Floating plants can extend their roots through established vegetation into the substrate and outcompete surrounding vegetation for light (Spicer and Catling 1988)."

From CABI (2019):

"[…] *E. canadensis* […] have the potential to develop into dense submerged beds. This prevents the use of water for recreational and professional purposes (Larson, 2003), navigation and port infrastructure (CPS-SKEW, 2008). The plant can also clog and impede drainage waterways. Water flow in irrigation channels may slow and become blocked, reducing water supply to irrigation fed crops, such as rice in Asiatic countries and cotton in the USA. In Australia, Elodea is one of the main problems in 8000 km of canals and irrigation channels which feed the farm areas of Victoria (Bill, 1969). […] Elsewhere, infestations have been reported to reduce water flow in canals and streams by up to 80%, this in turn may interfere with water traffic, disturb hydroelectric and urban water supplies, limit recreational water use and change the aquatic environment. Blockage of larger channels may inhibit ship movements, thus affecting trade."

From Josefsson (2011):

"Crayfish populations have been observed to have been drastically reduced as a result of habitat loss after *E. canadensis* colonized a lake in Norway (Hessen, Skurdal & Braathen 2004). Abiotic conditions may also have contributed to the decrease in the crayfish population, as large fluctuations in oxygen content and pH can be found within dense stands of *E. canadensis*, due to the intense primary production within the canopy and subsequent higher respiration during the night."

From Carey et al. (2016):

"In New Zealand, lakes invaded by E. canadensis had higher zoobenthic density due to more biomass and physical structure from the increased amount of submerged aquatic vegetation (Kelly & Hawes, 2005). In Norway, E. canadensis reduces crayfish population size by interfering with movement and creating poor water quality conditions of low dissolved oxygen and high pH (Hessen et al., 2004)."

4 Global Distribution

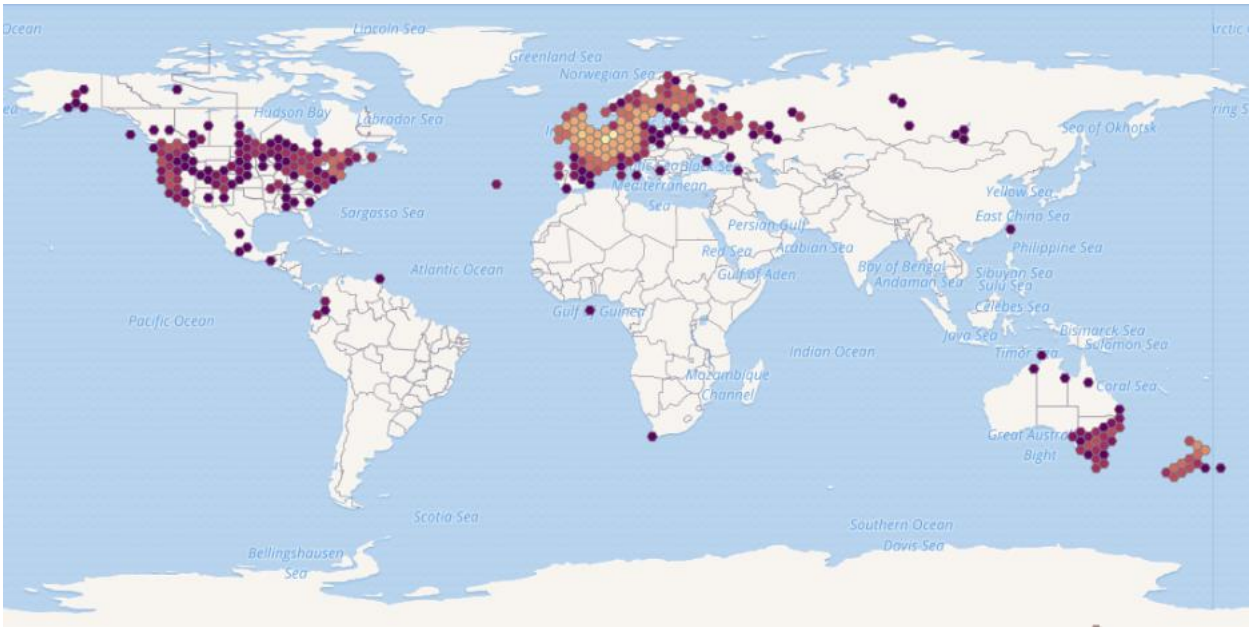

Figure 2. Known global distribution of *Elodea canadensis*. Map from GBIF Secretariat (2019). The locations in Colombia, the northernmost location in Canada, and just off the west coast of Africa were not used to select source points for the climate match. The specimens in Colombia were collected from botanical gardens (GBIF Secretariat 2019) and do not represent established, wild populations. The specimen in Canada was collected in 1883 and the most precise location recorded was the province name (Auckland Museum accessed through GBIF Secretariat 2019). The location just off the coast of Africa is based on incorrect coordinates for a specimen collected in Iowa (GBIF Secretariat 2019). The location that looks to be in the ocean to the north of Venezuela is actually on the island of Grenada. The location in the middle of the Atlantic Ocean represents valid observations in the Azores Islands. These points are valid locations that were used to select source points for the climate match.

Elodea canadensis has also been reported from Bulgaria, Cuba, Egypt, Hungary, Jamaica, Morocco, Romania, India, Malaysia, Saudi Arabia, China, Thailand, Argentina, Chile, Belize, Israel, Moldova, Swaziland, Bosnia and Herzegovina, Serbia, and Macedonia (Maiz-Tome 2016; Pagad et al. 2018; CABI 2019, DAISIE 2019) but no georeferenced points were available to use in selecting source points for the climate match. The remainder of the distribution of *E. canadensis* is well documented with georeferenced source points and the author does not consider the lack of source points in these locations to lower the confidence in the results of the climate match.

Elodea canadensis has also been reported form Singapore and Mauritius (CABI 2019). No georeferenced observations were found in these countries, however, the countries themselves are small geographically with only one or two source points available to select for the climate match (Sanders et al. 2018). Those points were used in the climate match.

5 Distribution Within the United States

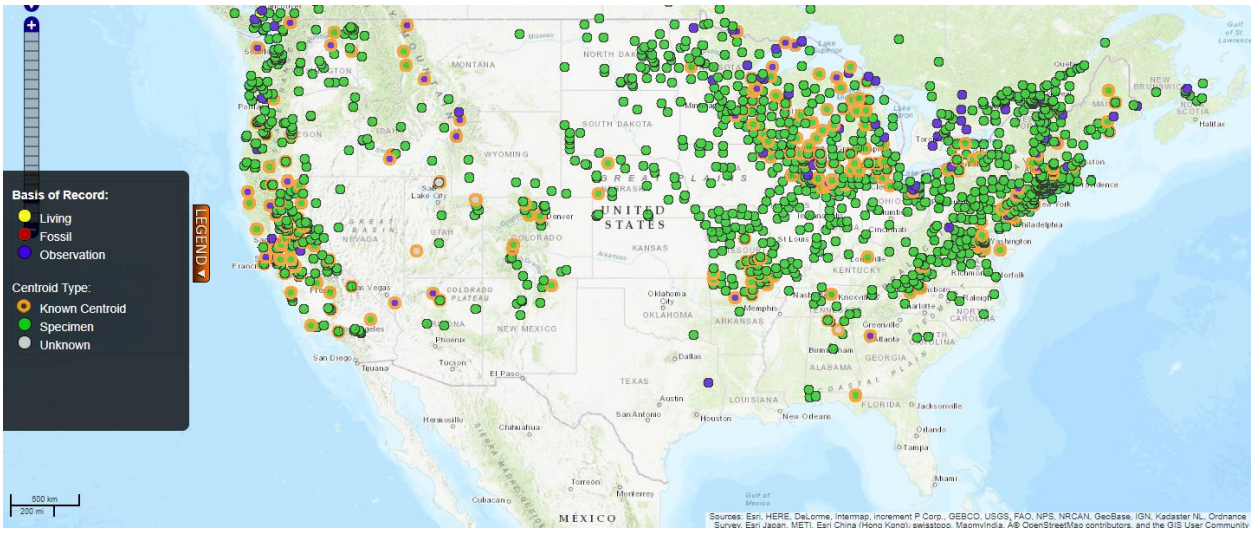

Figure 3. Known distribution of *Eldoea canadensis* in the contiguous United States. Map from BISON (2019).

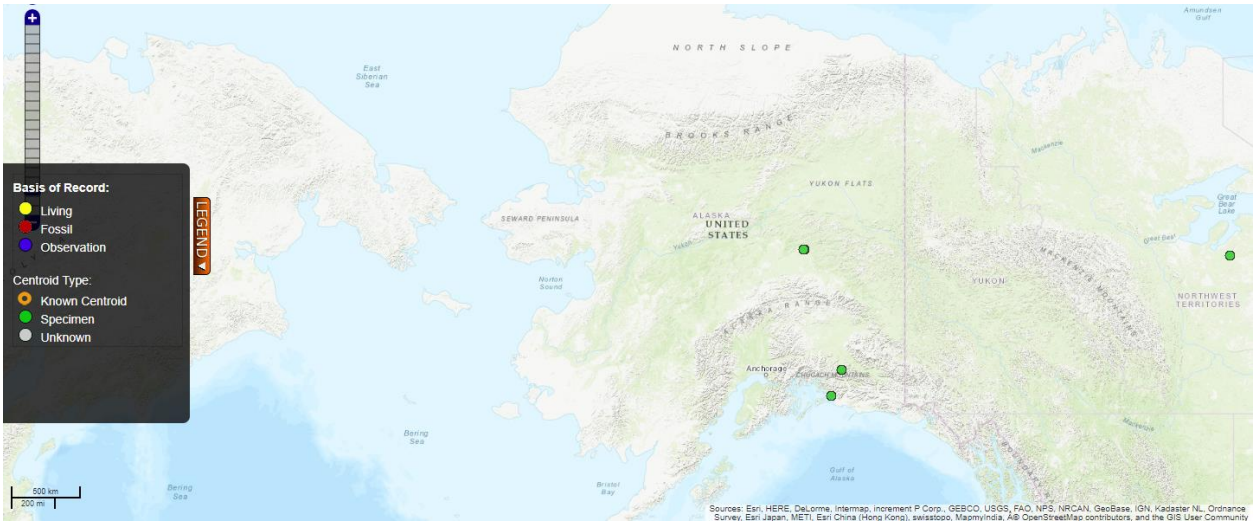

Figure 4. Known distribution of *Elodea canadensis* in Alaska. Map from BISON (2019).

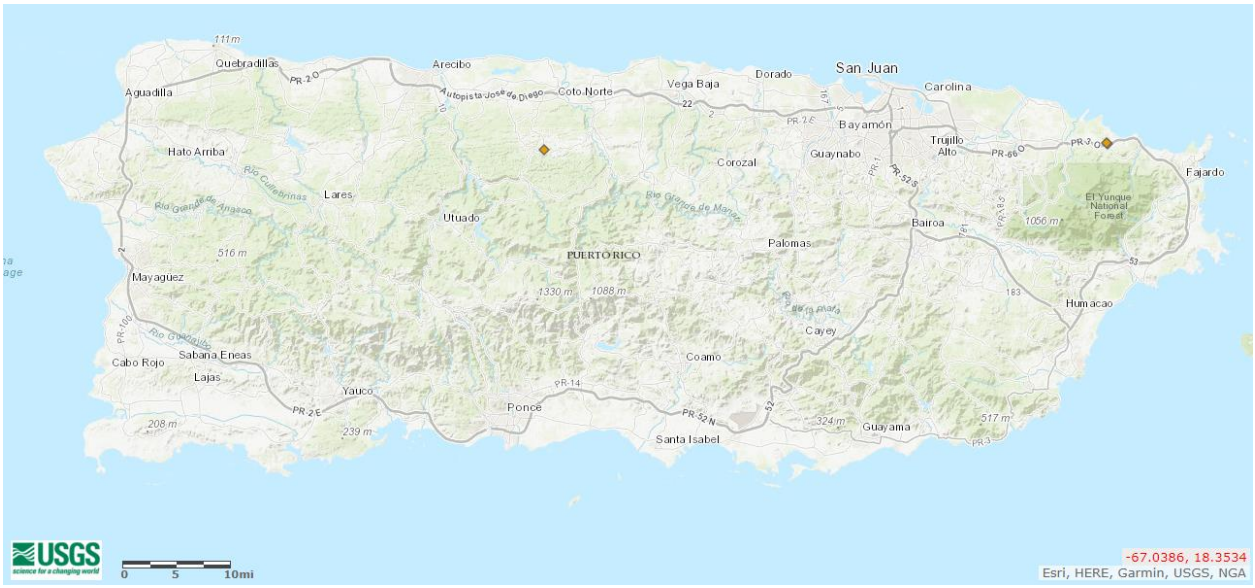

Figure 5. Known distribution of *Elodea canadensis* in Puerto Rico. Map from U.S. Geological Survey (2019).

Although GISD (2019) reported that *Elodea canadensis* has been introduced to Hawaii, no other records or georeferenced observations were found for that State. Therefore, it could not be included in the climate match.

6 Climate Matching

Summary of Climate Matching Analysis

Elodea canadensis is native to much of the lower 48 States and the corresponding climate match was very high for virtually all of the contiguous United States. There were areas of medium match in peninsular Florida, central and southern Texas, a small area in the southern Appalachian Mountains, and along the northern Pacific Coast. There was a small area of low match on the Olympic Peninsula in Washington. The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for contiguous United States was 0.996, high. The range for a high climate score is 0.103 and above. All States had high individual Climate 6 scores.

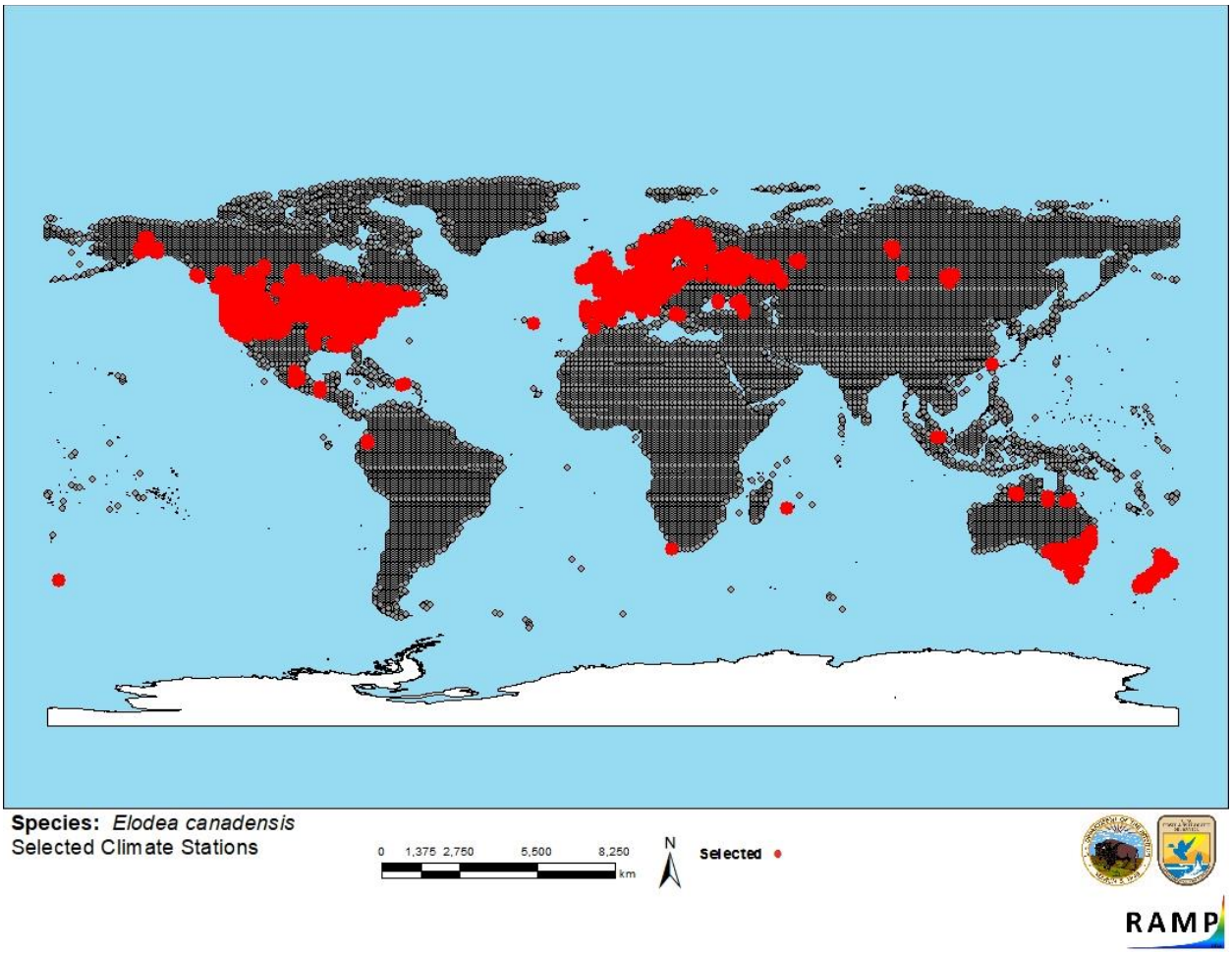

Figure 6. RAMP (Sanders et al. 2018) source map showing weather stations across the world selected as source locations (red) and non-source locations (gray) for *Elodea canadensis* climate matching. Source locations from BISON (2019), GBIF Secretariat (2019), and U.S. Geological Survey (2019). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

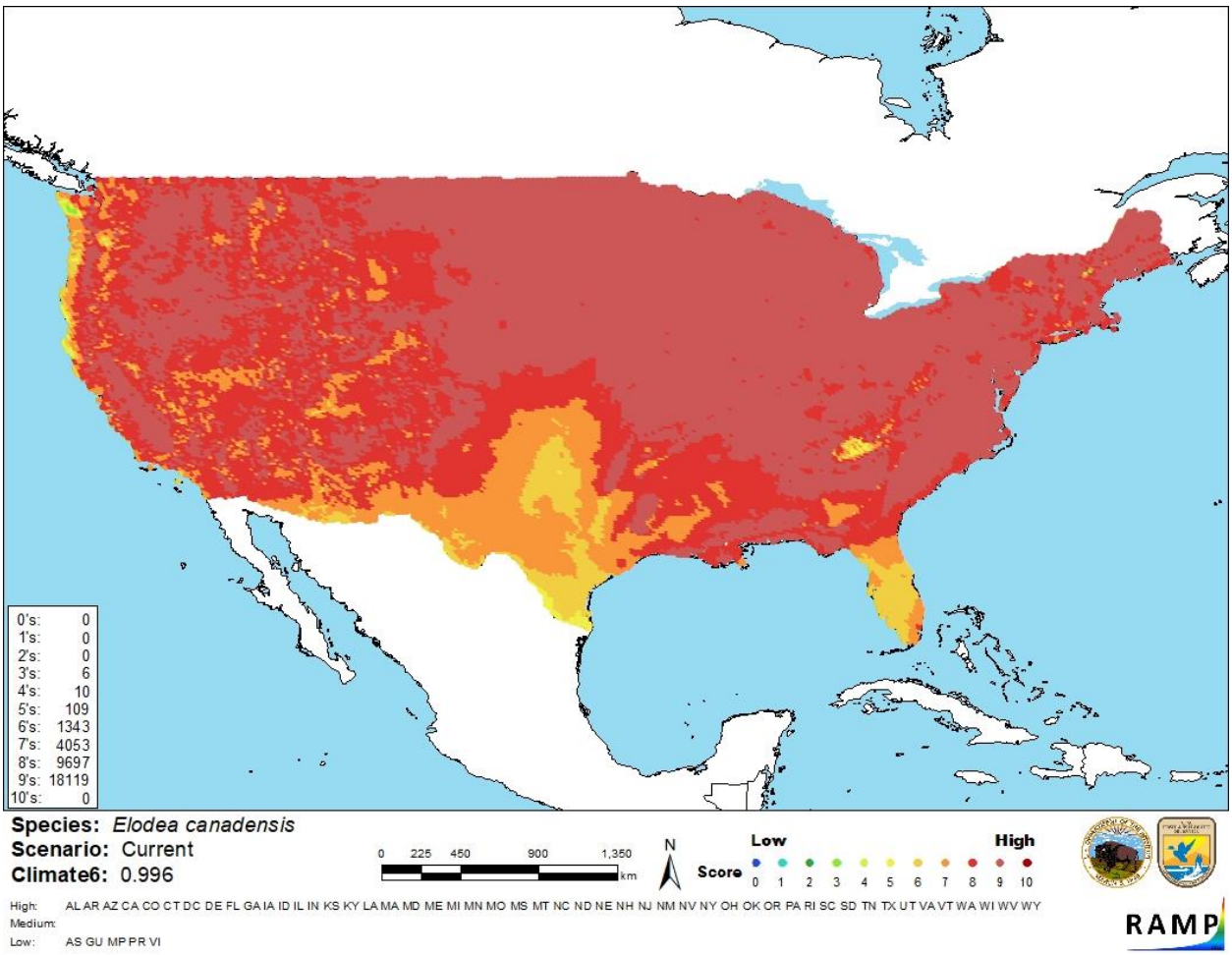

Figure 7. Map of RAMP (Sanders et al. 2018) climate matches for *Elodea canadensis* in the contiguous United States based on source locations reported by BISON (2019), GBIF Secretariat (2019), and U.S. Geological Survey (2019). Counts of climate match scores are tabulated on the left. 0 = Lowest match, 10 = Highest match.

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

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
$0.000 \leq X \leq 0.005$	Low
$0.005 < X < 0.103$	Medium
≥ 0.103	High

7 Certainty of Assessment

The certainty of assessment is high. There is peer-reviewed information available for the biology, ecology, native range, history of introductions, and impacts from introductions. Not all countries listed as having introductions were represented by the available georeferenced observations. However, all general areas of distribution and climates with populations of *Elodea*

canadensis were represented by the source points used for the climate match, therefore, there is no reduction in confidence in the results of the climate match.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Elodea (*Elodea canadensis*) is a freshwater, aquatic plant that is native to North America. The plant grows fully submerged except for its flowers. *E. canadensis* is a popular plant sold in the aquarium trade to increase the available oxygen in a tank. The history of invasiveness is high. *E. canadensis* has been introduced around the world, mainly as an escapee from captivity, and has established populations on every continent except for Antarctica. *E. canadensis* invasions have resulted in local extirpations or near extirpation of native plant species, changes in use of lake depth by native species, decreases in crayfish populations, and altered abiotic conditions of a lake (pH, dissolved CO_2 and O_2, turbidity, phosphorus). Dense beds of *E. canadensis* can interfere with commercial (preventing navigation) and recreational (fishing, swimming, boating) usage of waterways, clog irrigation channels, and interfere with hydropower and municipal water supplies. *E. canadensis* is native to much of the lower 48 and there are established populations across the contiguous United States; it has a correspondingly high climate match across the same area. The certainty of assessment is high, peer-reviewed literature is available regarding the assessment elements. The overall risk assessment category is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information:** No additional remarks.
- **Overall Risk Assessment Category: High**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

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10 References Quoted But Not Accessed

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