Alligator Weed (*Alternanthera philoxeroides*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, June 2015
Revised, January 2018
Web Version, 8/21/2018

Photo: Robert H. Mohlenbrock. Released to Public Domain. Available: https://plants.usda.gov/java/largeImage?imageID=alph_001_ahp.tif.

1 Native Range and Status in the United States

Native Range

From CABI (2018):

"*A. philoxeroides* is native to South America, principally the Parana River region (Julien et al., 1995), from Guyana to Brazil and northern Argentina (USDA-ARS, 2016)."

GISD (2018) lists *Alternanthera philoxeroides* as native to Argentina, Bolivia, Brazil, Paraguay, Peru, Uruguay, and Venezuela.

Status in the United States

According to GISD (2018) *Alternanthera philoxeroides* is established and invasive in Arkansas, California, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Texas, and Virginia.

From CABI (2018):

"In the USA, *A. philoxeroides* was probably introduced in contaminated ship ballast water, with the earliest herbarium specimen dating from South Carolina in 1885. In 1894 it arrived in Florida and in 1897 it was collected near Mobile, Alabama. By the early 1900s, it was recognized as a threat, but became a major threat after 1945 when chemical control of water hyacinth became effective and allowed *A. philoxeroides* to flourish (Coulson, 1977; Langeland et al., 2008). Now it is considered one of the worst aquatic weeds invading southern states (USDA-NRCS, 2016)."

"In the USA, the species has varying classifications at federal or state levels (OEPP/EPPO, 2016)."

USDA, NRCS (2018) indicates that *Alternanthera philoxeroides* is listed as a Class C noxious weed in Alabama, a prohibited noxious weed in Arizona, a noxious weed in Arkansas, on the A list (noxious weeds) in California, a Class 1 prohibited aquatic plant in Florida, and invasive aquatic plant and plant pest in South Carolina, and a noxious plant in Texas.

From Thayer and Pfingsten (2018):

"**Alabama** - All major drainages (Schardt and Schmitz 1991; Missouri Botanical Garden 2007; University of Alabama Biodiversity and Systematics 2007)
Arkansas - Boeuf-Tensas, Upper Ouachita (Madsen et al. 2010), Lower Arkansas-Fourche La Fave, Lower Ouachita, and Lower White (Smith 1988) drainages
California - Los Angeles, San Gabriel, San Luis Rey-Escondido, Santa Ana, Tulare-Buena Vista Lakes (Regents of the University of California 2015), Suisun Bay, Tulare Lake Bed, Upper Kaweah, Upper Tule, and Ventura (Calflora 2015) drainages
Florida - All drainages (Reimus and Robertson 1997; Anderson 2009; University of Connecticut 2011; Center for Invasive Species and Ecosystem Health 2015)
Georgia - Altamaha, Savannah (Newman and Thomaston 1979), Apalachicola, Ogeechee (University of Florida Herbarium 2016), St. Marys-Satilla (Carter 1999), and Suwannee (Southeast Exotic Pest Plant Council 2008) drainages
Kentucky - Kentucky Lake in Kentucky Lake drainage, and Knox County in Upper Cumberland drainage (Chester 1988)
Louisiana - All major drainages (Lynch et al. 1950; Valentine 1976; Montz 1979; Craft and Kleinpeter 1989; White 1993; Thomas and Allen 1996; Louisiana State University Herbarium 2010; Madsen 2010)
Maryland - C&O Canal near MacArthur Blvd in Middle Potomac-Catoctin drainage (Center for Invasive Species and Ecosystem Health 2015)
Mississippi - Lower Mississippi-Greenville (Madsen et al. 2010), Black Warrior-Tombigbee (Kight 1988), Middle Tennessee-Elk (Madsen 2010), Mobile Bay-Tombigbee (Mississippi River

Basin ANS Regional Panel 2006), Pascagoula (University of Florida Herbarium 2016), Pearl, and Yazoo (Aurand 1982) drainages
North Carolina - Albemarle-Chowan, Pamlico (Radford et al. 1968), Cape Fear (University of Florida Herbarium 2016), Lower Pee Dee, Neuse, Onslow Bay, and Roanoke (North Carolina Division of Water Resources 1996) drainages
Oklahoma - Chouteau Wildlife Management Area in Lower Verdigris drainage (Hoagland and McCarty 1998)
Puerto Rico - Mayaguez in Culebrinas-Guanajibo drainage, and Lago Loiza and Rio de la Plata in Eastern Puerto Rico drainage (Zeiger 1976)
South Carolina - All major drainages (Radford et al. 1968; Hooker and Westbury 1991; University of Florida Herbarium 2016)
Tennessee - Hatchie-Obion, Lower Cumberland (Chester et al. 1997), Lower Tennessee (Wofford 1977), Middle Tennessee-Hiwassee (Aurand 1982), and Upper Tennessee (Woffard and Dennis 1976) drainages
Texas - Big Cypress-Sulphur, Galveston Bay-Sabine Lake, Guadalupe, Lower Brazos, Lower Trinity, Middle Brazos-Bosque, Neches, San Jacinto (Helton and Hartmann 1996), Little (New York Botanical Garden 2015), Middle Colorado-Llano, San Bernard Coastal, Upper Trinity (Texas Invasive Plant and Pest Council 2015), Sabine (University of Florida Herbarium 2016), and Southwestern Texas Coastal (Missouri Botanical Garden 2007) drainages
Virginia - Albemarle-Chowan, James, Lower Chesapeake (Ware 1998), and Potomac (Chester 1988) drainages"

"Established in all previously mentioned areas."

No records of *A. philoxeroides* in trade in the United States were found.

Means of Introductions in the United States

From Swearingen and Bargeron (2014):

"[*Alternanthera philoxeroides*] was first introduced into the United States around 1900 in ballast water."

From Thayer and Pfingsten (2018):

"*Alternanthera philoxeroides* was first recorded in the US in 1897 near Mobile, Alabama. The plant was present in New Orleans in 1898 (Zeiger 1967; Coulson 1977). Plants are believed to have been contaminants in ship ballast water (Zeiger 1967)."

Remarks

From GISD (2018):

"Alligator weed was recently discovered being mistakenly grown as the leafy vegetable mukunu-wenna or sessile joyweed (*Alternanthera sessilis*), a popular leafy vegetable in Sri Lanka, in all Australian states."

From CABI (2018):

"There are two biotypes of *A. philoxeroides* in Florida which differ morphologically: broad- and narrow-stemmed forms. Another two biotypes exist in Argentina which are morphologically similar but differ in chromosome number, the wild form being tetraploid (2n=68) and the weedy form being hexaploid (2n=102) (Parsons and Cuthbertson, 1992)."

"The risk of introduction of *A. philoxeroides* is very high. Because this species is able to grow in both aquatic and terrestrial habitats, grows vigorously and spreads from floating fragments, it has a great potential to increase its present distribution into new areas. According to Julien et al. (1995) much of Africa, Asia and southern Europe provide a suitable habitat for this weed."

"It has been suggested that the populations of *A. philoxeroides* within and outside its native distribution range are composed of a complex of hybrids. Consequently, the chromosome number for *A. philoxeroides* differs among populations with reports varying from 2n=66 to 2n=100 (Xu et al., 1992; Sosa et al., 2008)."

From Thayer and Pfingsten (2018):

"After its introduction into the US in the late 1800's, *A. philoxeroides* quickly spread throughout the Southeast creating problems similar to those described for *Eichhornia crassipes* (Penfound and Earle 1948; Zeiger 1967). Following the development of the herbicide 2,4-D in the 1940's, aggressive herbicide spraying initiated against *E. crassipes* allowed for *A. philoxeroides*, which was more resistant to the herbicide, to replace the niche formerly occupied by *E. crassipes*. By 1963, as estimated 65,700 hectares of waters throughout the Southeast were infested (Buckingham 1996). As a result, in 1959, the US Army Corps of Engineers (USACE), under the "Expanded Project for Aquatic Plant Control" authorized by Public Law 85-500, 85th Congress, requested the Agricultural Research Service, USDA, to begin surveys for *A. philoxeroides* natural enemies in South America (Zeiger 1967). In 1964, the USDA began releasing imported insects from South America as a biocontrol for this pest. Extensive testing and quarantine procedures were completed prior to release (Zeiger 1967). By all accounts, the insects that were approved and subsequently released against *A. philoxeroides* have been successful in managing this pest plant, although the effectiveness of alligatorweed thrips (*Amynothrips andersoni*), which are flightless and rarely seen on wild populations, is questionable (Stratford Kay, pers. comm.)."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2014):

"Taxonomic Status:
Current Standing: accepted"

"Kingdom Plantae
Subkingdom Viridiplantae
Infrakingdom Streptophyta
Superdivision Embryophyta
Division Tracheophyta
Subdivision Spermatophytina
Class Magnoliopsida
Superorder Carypphyllanae
Order Caryophyllales
Family Amaranthaceae
Genus *Alternanthera*
Species *Alternanthera philoxeroides* (Mart.) Griseb."

Size, Weight, and Age Range

From EDDMapS (2018):

"Plants have hollow stems and can grow to 3 ft. (1 m) tall."

From Thayer and Pfingsten (2018):

"Floating stems up to 15 meters long (Zeiger 1967)."

Environment

From CABI (2018):

"*A. philoxeroides* grows as a weed in both aquatic and terrestrial habitats, and often grows at the interface between these two environments (OEPP/EPPO, 2016)."

"It has been observed growing in water with pH ranging from 4.8 and 7.7 and it is fairly salt tolerant and can survive in upper tidal beaches and other saline conditions (10-30% that of sea water [3.5–10.5ppt]). *A. philoxeroides* grows well in high-nutrient (eutrophic) conditions, but can survive in areas with low nutrient availability (Weber, 2003; Langeland et al., 2008)."

CABI (2018) lists the optimum minimal water temperature as 10°C and the optimal maximum water temperature as 20°C.

Climate/Range

From Commonwealth of Australia (2015):

"Alligator Weed can survive in tropical and sub-tropical regions […]."

From CABI (2018):

"When growing in terrestrial conditions, this species can survive without any water for several months (Gunasekera and Adair, 2000)."

"*A. philoxeroides* prefers to grow at temperatures around 30°C [air temperature], and growth is suppressed at temperatures below 7°C. However, the species can tolerate mean annual temperatures ranging from 10 to 20°C (OEPP/EPPO, 2016). The photosynthetic optimum for this species occurs between 30°C and 37°C and light saturation at 1000 µmol photons m-2 s-1 (OEPP/EPPO, 2016), but it can adapt to low light conditions (Weber, 2003). It can tolerate cold winters, but cannot survive prolonged freezing temperatures (Langeland et al., 2008)."

CABI (2018) lists the absolute minimum air temperature as -12°C, mean annual air temperature as 10–20°C, mean maximum air temperature of hottest month as 13–25°C, and mean air minimum temperature of coldest month as 7–15°C.

Distribution Outside the United States

Native

From CABI (2018):

"*A. philoxeroides* is native to South America, principally the Parana River region (Julien et al., 1995), from Guyana to Brazil and northern Argentina (USDA-ARS, 2016)."

GISD (2018) lists *Alternanthera philoxeroides* as native to Argentina, Bolivia, Brazil, Paraguay, Peru, Uruguay, and Venezuela.

Introduced

From CABI (2018):

"It has been introduced into Europe, North and Central America, the Caribbean, tropical Asia, and Oceania (DAISIE, 2016; ISSG, 2016 OEPP/EPPO, 2016; USDA-ARS, 2016)."

"*A. philoxeroides* is present in Asia where it is widespread principally across warm temperate regions. In Sri Lanka *A. philoxeroides* was identified in 1998 and by 2004 it reached provinces at elevations > 2500 m (Jayasinghe, 2008). In China it is spreading across Beijing, Fujian, Guangxi, Hebei, Hubei, Hunan, Jiangsu, Jiangxi, Sichuan, Taiwan, and Zhejiang where it is causing serious impacts on aquatic habitats and famous scenic areas (Flora of China Editorial Committee, 2016). In India, *A. philoxeroides* is spreading across Assam, Bihar, West Bengal, Tripura, Manipur, Andhra Pradesh, Karnataka, Maharashtra, Delhi and Punjab. By 2008, *A. philoxeroides* was reported invading Wular Lake, the largest freshwater lake in India (Masoodin and Khan, 2012)."

"In Europe, *A. philoxeroides* was first recorded in 1971 in France. Initially this species was confined to the southwest of France between the middle of the Gironde Estuary and the middle course of the River Garonne. However in the 2000s new populations were found on the Tarn River and in Sorgues (Provence) in 2013. In Italy *A. philoxeroides* was discovered in 2001 near Pisa, Tuscany. Currently, this species can also be found along the Arno River from Signa to Florence, in Lazio, and in Rome along the Tevere River (OEPP/EPPO, 2016)."

From GISD (2018):

"*A. philoxeroides* has been reported on the banks of the river Garonne at la Magistère (Tarn-et-Garonne, South-West of France). The plant seems only present in the Gironde estuary and on the river Garonne."

"Some sizable populations of *A. philoxeroides*, […] were recorded in a canal (Fosso Oncinetto, Madonna dell Acqua) close to Pisa [Italy].This is the first record for Italy and apparently for the whole Europe, according to the literature examined."

"Alligator weed was located in Sri Lanka in 1999. Mainly located in some lakes and drainage systems in Colombo, Nuwara Eliya (Hill country town), Hambantota and Embilipitiya (dry zone towns)."

GISD (2018) also lists *Alternanthera philoxeroides* as alien in Australia, China, India, Indonesia, Myanmar (Burma), New Zealand, Papua New Guinea, Singapore, and Thailand.

Alternanthera philoxeroides is listed as an invasive alien weed in Bangladesh, Nepal, and Sri Lanka (Pallewatta et al. 2003).

Means of Introduction Outside the United States

From CABI (2018):

"*A. philoxeroides* seed has been found in Europe as a contaminant in bird seed originating from outside the EU, and seedlings have been found contaminating bonsai plants imported from China (OEPP/EPPO, 2016)."

"*A. philoxeroides* has been intentionally introduced by humans to be used as an aquarium plant and ornamental aquatic plant (USDA-ARS, 2016)."

From GISD (2018):

"It was probably introduced into Australia at Carrington (Newcastle docks area) in NSW when ship's ballast was dumped. It was first recorded there in 1946 (Commonwealth of Australia, 2000).The movement of contaminated plant mulch was identified as one reason for the recent spread (Coventry et al. 2002)."

"It is thought that the possible origin or pathway of entry of the plant may be an accidental introduction related to portuary activities, or a voluntary introduction as an ornamental plant for ponds and aquaria."

Short Description

From CABI (2018):

"Decumbent or ascending glabrate aquatic perennials, the simple or branched, often fistulose stems to 100 cm. long. Leaves glabrous or glabrate, lanceolate to narrowly obovate, apically rounded to acute, basally cuneate, rarely denticulate, 2-10 cm. long, 0.5-2 cm. broad; petioles 1-3 mm. long. Inflorescences of terminal and occasionally axillary white glomes, 10-18 mm. long, 10-18 mm. broad, the usually unbranched peduncles 1-5 cm. long. Flowers perfect, bracts and bracteoles subequal, ovate, acuminate, 1-2 mm. long; sepals 5, subequal, oblong, apically acute and occasionally denticulate, neither indurate nor ribbed, 5-6 mm. long, 1.5-2.5 mm. broad; stamens 5, united below into a tube, the pseudostaminodia lacerate and exceeding the anthers; ovary reniform, the style about twice as long as the globose capitate stigma. Fruit an indehiscent reniform utricle 1 mm. long, 1-1.5 mm. broad (Flora of Panama, 2016)."

From Thayer and Pfingsten (2018):

"*Alternanthera philoxeroides* is a perennial with prostrate, sprawling, floating hollow stems, often in a dense tangled mass, rooted in shallow water or growing from the shoreline, occasionally free-floating (Long and Lakela 1971; Godfrey and Wooten 1981). The hollow stems provide considerable buoyancy of the mat (Buckingham 1996). Roots form at stem nodes. Morphology and habit of *A. philoxeroides* are similar to many aquatic primose (e.g., *Ludwigia palustris*) and hygrophila (e.g., *Hygrophila costata*) species.

While recognized as a major pest in aquatic environments where it has been introduced, *A. philoxeroides* may also grow terrestrially in moist cultivated soils (Zeiger 1967). When growing as a terrestrial, stems are smaller in diameter, more lignified, with shorter internodes. Additionally, there is variability with stems and leaves of the two recognized biotypes of *A. philoxeroides*. The narrow-stemmed alligatorweed (NSA) biotype have relatively slender stems and longer internodes when compared to stems of the broad-stemmed alligatorweed (BSA) biotype, which have broader stems and longer internodes (Kay and Haller 1982). There is a line of hairs on each side of the stem internodes, originating from the leaf axils and extending to the base of the next distal node (Stratford Kay, pers. comm.).

The leaves of NSA are smaller and more blunt-tipped than BSA leaves, which are larger, longer, and have an acute leaf tip (Kay and Haller 1982). In general, leaves are bright green, arranged in opposite pairs (90 degree angles), entire, elliptic-linear to ovate, 5-11 cm long and 1-2 cm wide. A leaf mid-vein is prominent on both sides of the leaf (Godfrey and Wooten 1981).

Flowers perfect (with both male and female reproductive structures), on a terminal spike (5-6 cm long), white to greenish-white, 8-10 mm in diameter, with a clover-like shape (Long and Lakela 1971; Godfrey and Wooten 1981)."

Biology

From CABI (2018):

"*A. philoxeroides* is a perennial, fast-growing, amphibious herb (ISSG, 2016.) Maximum growth of *A. philoxeroides* occurs during the warmer summer months with growth initiating from parent stock, usually rooting in a solid substrate and spreading in a tangled mat over the water surface. In early winter, emergent stems lose many leaves and become prostrate forming part of the mat that supports the next season's growth. Flowering occurs from mid to late summer (Julien and Broadbent, 1980)."

From Sainty et al. (1998):

"As an aquatic, it roots in soil near the water's edge and extends hollow stems over the surface of water, forming tangled mats. Sections may break away and exist as free-floating mats."

"Alligator Weed does not produce viable seed under field conditions (Center and Balciunas, 1975; Sainty, 1973; Julien, 1995). Consequently reproduction is entirely vegetative and relies on the production of nodes. Each node has two axillary buds. Stem nodes, portions of thicker roots, and underground stems are all capable of growth. Dispersal is by fragmentation."

From GISD (2018):

"*Alternanthera philoxeroides* is a perennial stoloniferous herb found in both aquatic to terrestrial habitats. Rui-Yan and Ren (2004) have found *A. philoxeroides* infesting rivers, lakes, ponds, and irrigation canals, as well as many terrestrial habitats.Sainty [sic] et al. (1998) state that, \"*A. philoxeroides* grows on a wide range of substrata, from sand to heavy clay. When floating on water, it may be rooted in the bank or substrate, or free floating.\""

From Thayer and Pfingsten (2018):

"Vogt et al. (1992) noted wild seed production in Arkansas, Lousiana [sic], and Mississippi populations, though none germinated."

"Alligatorweed may grow in waters deeper than 2.5 meters (Stratford Kay, pers. comm.), but must remain rooted in hydrosoil for optimum growth (Sculthorpe 1967). Plants can uproot, drift, and establish in new locations, but they cannot compete if unrooted for long periods of time (Sculthorpe 1967). The mat can extend up to 15 meters from where it is rooted in the soil (Zeiger 1967), but mats were observed much further from banks in Mississippi and North Carolina populations where they rooted into stumps and small trees (Stratford Kay, pers. comm.)."

Human Uses

CABI (2018) states that *Alternanthera philoxeroides* is grown as a food crop in many countries.

From CABI (2018):

"In Australia, it is a prohibited species whose propagation and supply is prohibited, and legislation requires the species to be controlled and/or eradicated."

From GISD (2018):

"*A. philoxeroides* is included in the First Schedule of the National Pest Plant Accord. All plants on the list are designated as Unwanted Organisms, and are banned from sale, propagation and distribution throughout New Zealand."

From IBP (No date):

"Folk medicine, Traditional chinese medicine [Ved et al. 2016]"

From NIES (2018):

"Import, transport and keeping are legally restricted in Japan."

Diseases

CABI (2018) lists *Nimbya alternantherae* as a pathogen of *Alternanthera philoxeroides*.

Poelen et al. (2014) list *Cephaleta australiensis*, *Aeromona media*, Tobacco curly shoot virus, Alternanthera yellow vein virus, *Trichoderma viride*, and *Hydrophylita bachmanni* as parasites and pathogens of *Alternanthera philoxeroides*.

Threat to Humans

From CABI (2018):

"Thick mats of *A. philoxeroides* prevent access to and use of water, cause health problems by providing habitats for mosquitoes […]. Also, the thick mats of the weed create a dangerous hazard for swimming, boating, rowing and other water sports."

"The ability of *A. philoxeroides* to absorb heavy metals is a problem in countries such as Myanmar, Sri Lanka, Australia, and Philippines where it is used as food (Parsons and Cuthbertson, 1992)."

From GISD (2018):

"Alligator weed may cause health problems in Australia by providing habitats for mosquitoes."

3 Impacts of Introductions

From CABI (2018):

"It also grows in terrestrial habitats where its high growth-rates allow it to displace native vegetation and easily become the dominant species."

"The plant can be a problem in rice paddies (Waterhouse, 1993) and is seen as a major threat to rice crops in southwestern New South Wales (Weeds of Australia, 2016). It has been estimated that the costs to agriculture in New South Wales could be as high as Aus$250 million per annum if the species was to reach its potential distribution in this state (Weeds of Australia, 2016)."

"*A. philoxeroides* infestations have been reported to reduce production of rice by 45%, wheat by 36%, maize 19%, sweet potato 63% and lettuce 47% (OEPP/EPPO, 2016). On average vegetable production is reduced by 5-15% (www.weeds.org.au/natsig.htm).

A. philoxeroides mats impede stream flow and lodge against structures thereby promoting sedimentation which contributes to flooding and structural damage. Infestations can disrupt recreational activities including boating, fishing and swimming."

"In China, *A. philoxeroides* has been shown to decrease the stability of the plant community and, over time, permanently displace native species (Guo and Wang, 2009). In India, *A. philoxeroides* is reducing macrophyte species richness by up to 30% when the infestation was high. In New Zealand, an increasing cover of *A. philoxeroides* decreased the cover of native plant species, resulting in loss of native species (Bassett et al., 2012). In a study at different latitudes in China, small-scale invasion of *A. philoxeroides* was associated with higher species diversity, but community diversity was lower when *A. philoxeroides* species cover exceeded 36% (Wu et al., 2016). Zhang et al. (2010) also demonstrate reduced plant species diversity in severely invaded communities."

"Thick mats of *A. philoxeroides* prevent access to and use of water, cause health problems by providing habitats for mosquitoes and degrade natural aesthetics. Also, the thick mats of the weed create a dangerous hazard for swimming, boating, rowing and other water sports. Excessive growth of *A. philoxeroides* affects irrigation and fisheries; it also covers waterways affecting navigation, preventing access, disrupting flow and adversely affecting the aquatic flora and fauna (Julien and Chan, 1992). Cultural services can be degraded by the infestation of scenic areas and waterbodies by *A. philoxeroides* (OEPP/EPPO, 2016).

The ability of *A. philoxeroides* to absorb heavy metals is a problem in countries such as Myanmar, Sri Lanka, Australia, and Philippines where it is used as food (Parsons and Cuthbertson, 1992)."

From GISD (2018):

"Gunasekera (1999) states that, \"*Alternanthera philoxeroides* is considered to be one of the worst aquatic weeds in the world. The aquatic form of the plant has the potential to become a serious threat to waterways, agriculture and the environment. The terrestrial form grows into a dense mat with a massive underground rhizomatous root system. The canopy can smother most other herbaceous plant species.\" Buckingham (1996) states that, \"Floating stems grow across the surface of the waterway forming a dense interwoven mat. This mat clogs the waterway and out competes native plants along the shore.\" The Commonwealth of Australia (2000) states that, \"Alligator weed disrupts the aquatic environments by blanketing the surface of the water impeding penetration of light, gaseous exchange (sometimes leading to anaerobic conditions) with adverse affects [*sic*] on flora and fauna. Mats impede flow and lodge against structures thereby promoting sedimentation and contributing to flooding. They prevent access to and use of water, promote health problems by providing habitats for mosquitoes and degrade natural aesthetics.\" Control of this species has proven to be an expensive and complicated ordeal wherever it has established."

"In Australia, alligator weed may invade important agricultural systems such as irrigation areas and significantly reduce production. In New Zealand and Australia it also has the potential to cause photosynthesisation of the skin in cattle, resulting in cancerous lesions. When the Barren Box Swamp (NSW) infestation was found in 1994, it was estimated that the potential costs to the irrigation farming community could be as high as $250 million per year. An annual control programme would have cost $6 to $8 per mega L of water at the farm gate, an increase of 30% delivery cost. Hence an eradication programme of this relatively small infestation was undertaken, costing more than $3 million to date and continuing. In the Hawkesbury/Nepean catchment the weed threatens the $35 million per year turf industry and the $50 million per year vegetable industry, as well as recreational use and in-stream extraction.

In Australia, alligator weed disrupts natural aquatic ecosystems by blanketing the surface of the water with thick mats and impeding penetration of light to the ground. Mats promote sedimentation and flooding and prevent gaseous exchange (which may lead to anaerobic conditions). Flow-down affects [*sic*] of these significant ecosystem changes (on native flora and fauna) are certain.

Alligator weed may prevent access to water bodies in Australia, thereby disrupting various recreational activities as well as potentially threatening livelihoods and industries dependent on clear waterways. For example, Liverpool City Council spent $8,000 annually to reduce the visual impact of alligator weed and to maintain a section of the river available for use by a rowing club."

"Alligator weed currently infests 2,500 hectares of terrestrial and 500 hectares of aquatic area in the Lower Hunter region (Commonwealth of Australia, 2000). "Alligator weed has eliminated small crop and turf farming from parts of the Lower Hunter" (Commonwealth of Australia, 2000)."

"*Alternanthera philoxeroides* is a pasture and horticulture weed. Stock sometimes suffer from a skin complaint, with increased sensitivity to sunlight, after contact with *Alternanthera philoxeroides*. It blocks drains and increases flood damage.

Alternanthera philoxeroides negatively affects recreational water use (Bassett, I., pers. comm. July 2005)."

“In the USA floating alligator weed caused major impediments to navigation on the Mississippi River (Commonwealth of Australia, 2000).”

4 Global Distribution

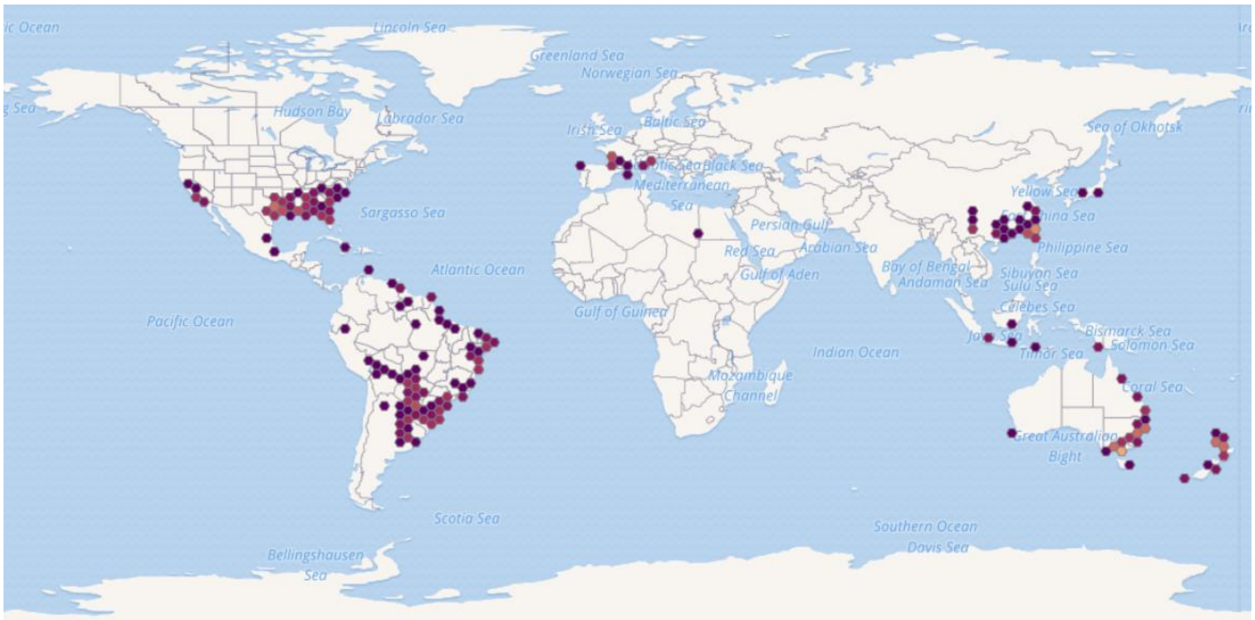

Figure 1. Known global distribution of *Alternanthera philoxeroides*. Map from GBIF Secretariat (2018).

Figure 2. Known locations of *Alternanthera philoxeroides* in India. Blue dots indicate observations and green dots indicate species occurrence from species list. Map from IBP (No date).

5 Distribution Within the United States

Figure 3. Known distribution of *Alternanthera philoxeroides* in the contiguous United States. Map from Thayer and Pfingsten (2018).

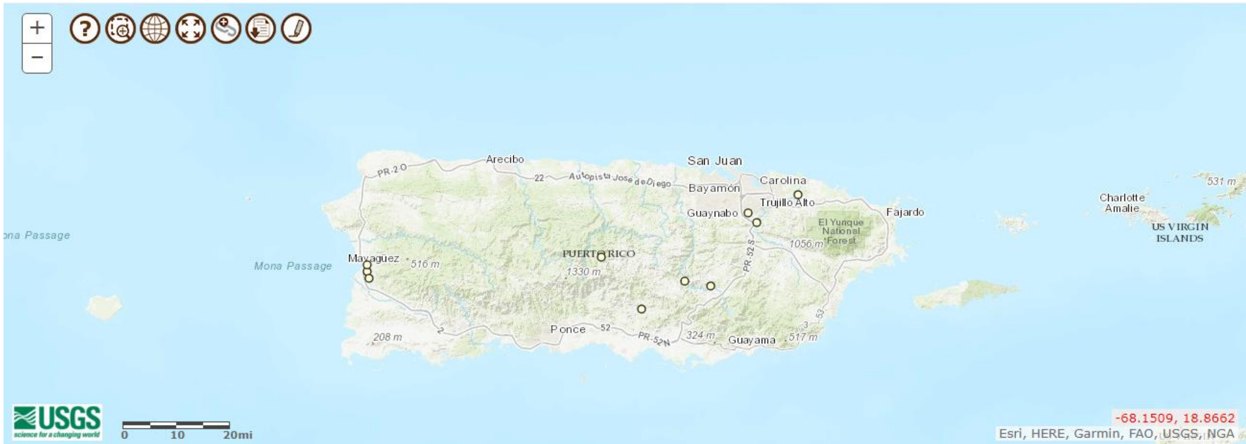

Figure 4. Known distribution of *Alternanthera philoxeroides* in the Puerto Rico, shown by yellow dots. Map from Thayer and Pfingsten (2018).

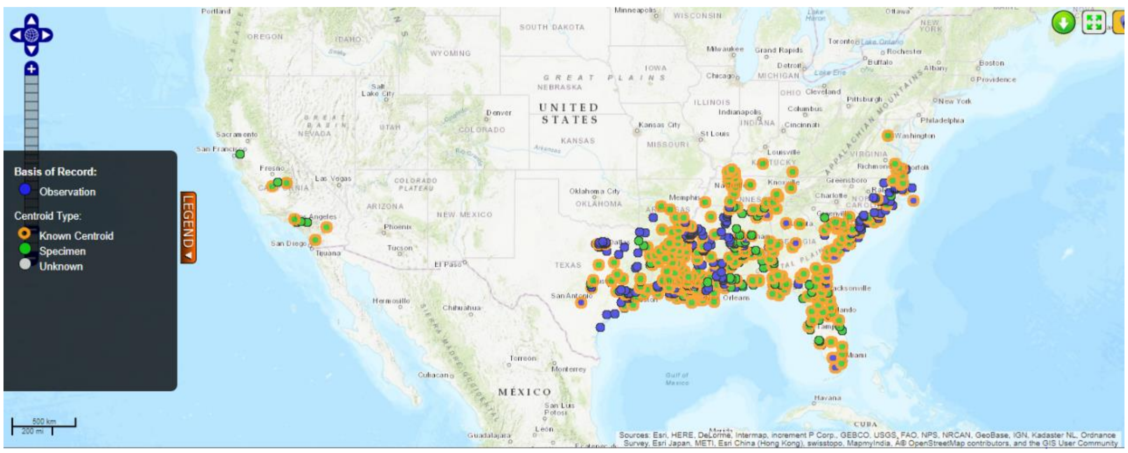

Figure 5. Known distribution of *Alternanthera philoxeroides* in the contiguous United States. Map from BISION (2018).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Alternanthera philoxeroides* is high in the southern and eastern contiguous United States, except for parts of northern New York and New England. It is also high in the Southwest and in small pockets in the Northwest. Many of the areas with a high climate match already have established populations of *A. philoxeroides*. The climate match is low in areas of northern New York and New England, the northern Midwest, the mid to northern Great Plains, and small pockets of the Pacific Northwest, and *A. philoxeroides* has not established there. The climate match was medium everywhere else. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous United States was 0.431, high. The following States had individually high climate matches: Alabama, Arizona, Arkansas, California, Connecticut, Delaware, Florida, Georgia, Illinois, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Nevada, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Vermont, Virginia, Washington, and West Virginia.

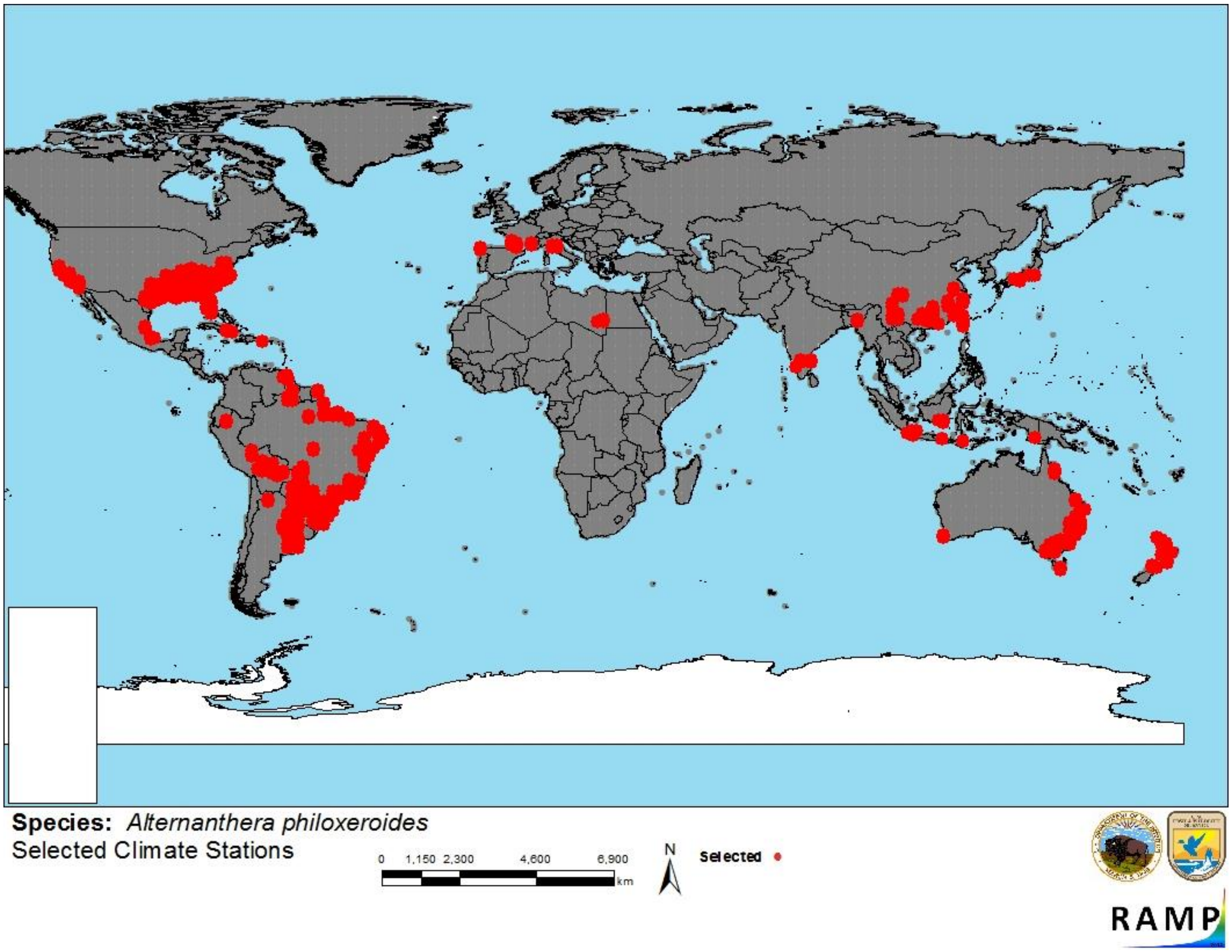

Figure 6. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Alternanthera philoxeroides* climate matching. Source locations from BISON (2018), GBIF Secretariat (2018), and IBP (No date).

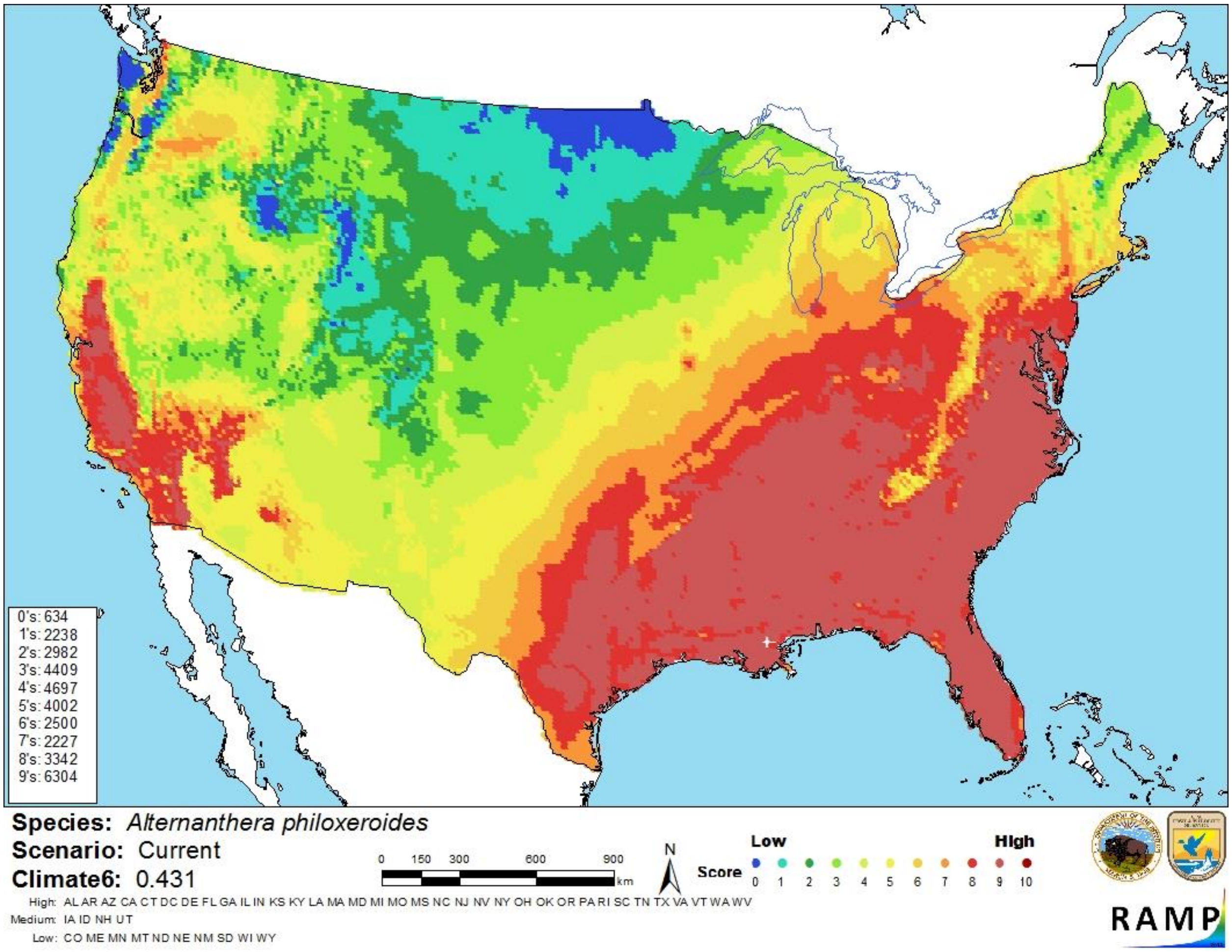

Figure 7. Map of RAMP (Sanders et al. 2014) climate matches for *Alternanthera philoxeroides* in the contiguous United States based on source locations reported by BISON (2018), GBIF Secretariat (2018), and IBP (No date). 0 = Lowest match, 10 = Highest match. Counts of climate match scores are tabulated on the left.

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≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

Certainty of this assessment is high. Good quality, scientifically defensible information on the biology, invasion history and impacts of this species is available. Reliable information on introductions and documented impacts is available.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Alligator weed *Alternanthera philoxeroides*) is a wetland plant that is native to South America. It has been transported around the world as an aquarium and ornamental plant and as contaminate of other materials and ballast. The history of invasiveness for *A. philoxeroides* is high. This aquatic plant has been established in the southeast United States since the early 1900s (Swearingen and Bargeron 2014). *A. philoxeroides* grows in dense mats clogging waterways and outcompeting native shoreline plants. The terrestrial form can create dense canopies and smother most other herbaceous plants. It is a weed in agricultural fields and pastures. Once established, control of *A. philoxeroides* is expensive and difficult. The climate match is high. The climate match results indicate that there is suitable climatic conditions for continued spread to the majority of the eastern United States as well as much of the Southwest. The certainty of assessment is high. 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** There have been established populations with significant negative effects in the contiguous United States since the late 1800s.
- **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.

BISON. 2018. Biodiversity Information Serving Our Nation (BISON). U.S. Geological Survey. Available: https://bison.usgs.gov. (January 2018).

CABI. 2018. *Alternanthera philoxeroides* (alligator weed) [original text by J. Rojas-Sandoval]. *In* Invasive Species Compendium. CAB International, Wallingford, U.K. Available: http://www.cabi.org/isc/datasheet/4403. (January 2018).

Commonwealth of Australia. 2015. Weeds of Australia: Alligator weed *Alternanthera philoxeroides*. Australian Government, Department of the Environment and Energy, Canberra, Australia. Available: http://keyserver.lucidcentral.org/weeds/data/080c0106-040c-4508-8300-0b0a06060e01/media/Html/Alternanthera_philoxeroides.htm. (June 2015).

EDDMapS. 2018. Early Detection & Distribution Mapping System. University of Georgia, Center for Invasive Species and Ecosystem Health, Tifton, Georgia. Available: http://www.eddmaps.org/distribution/usstate.cfm?sub=2779. (January 2018).

GBIF Secretariat. 2018. GBIF backbone taxonomy: *Alternanthera philoxeroides* (Mart.) Griseb. Global Biodiversity Information Facility, Copenhagen. Available: https://www.gbif.org/species/3084923. (January 2018).

GISD (Global Invasive Species Database). 2018. Species profile: *Alternanthera philoxeroides*. Invasive Species Specialist Group, Gland, Switzerland. Available: http://www.iucngisd.org/gisd/species.php?sc=763. (January 2018).

IBP (India Biodiversity Portal). No date. *Alternanthera philoxeroides* (Mart.) Griseb. India Biodiversity Portal, species page. Available: http://indiabiodiversity.org/species/show/228681. (January 2018).

ITIS (Integrated Taxonomic Information System). 2014. *Alternanthera philoxeroides* (Mart.) Griseb. Integrated Taxonomic Information System, Reston, Virginia. Available: http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=20770. (August 2014).

NIES (National Institute for Environmental Studies). 2018. *Alternanthera philoxeroides*. *In* Invasive species of Japan. National Research and Development Agency, National Institute for Environmental Studies, Tsukuba, Japan. Available: http://www.nies.go.jp/biodiversity/invasive/DB/detail/81140e.html. (January 2018).

Pallewatta, N., J. K. Reaser, and A. T. Gutierrez, editors. 2003. Invasive alien species in South-Southeast Asia: national reports and directory of resources. Global Invasive Species Programme, Cape Town, South Africa.

Poelen, J. H., J. D. Simons, and C. J. Mungall. 2014. Global Biotic Interactions: an open infrastructure to share and analyze species-interaction datasets. Ecological Informatics 24:148–159.

Sainty, G., G. McCorkelle, and M. Julien. 1998. Control and spread of Alligator Weed *Alternanthera philoxeroides* (Mart.) Griseb. in Australia: lessons for other regions. Wetlands Ecology and Management 5:195–201.

Sanders, S., C. Castiglione, and M. Hoff. 2014. Risk assessment mapping program: RAMP. U.S. Fish and Wildlife Service.

Swearingen, J., and C. Bargeron. 2014. Invasive Plant Atlas of the United States. University of Georgia Center for Invasive Species and Ecosystem Health. Available: http://www.invasiveplantatlas.org/subject.html?sub=2779#maps. (August 2014).

Thayer, D. D., and I. A. Pfingsten. 2018. *Alternanthera philoxeroides* (Mart.) Griseb. U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, Florida. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=227. (January 2018).

USDA, NRCS. 2018. *Alternanthera philoxeroides* (Mart.) Griseb. The PLANTS database. National Plant Data Team, Greensboro, North Carolina. Available: https://plants.usda.gov/core/profile?symbol=ALPH. (January 2018).

10 References Quoted But Not Accessed

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.

Anderson, L. C. 2009. Herbarium specimen voucher data. Florida State University Herbarium. Florida State University, Tallahassee.

Aurand, D. 1982. Nuisance aquatic plants and aquatic plant management programs in the United States. Volume 2, Southeast. The MITRE Corporation, McLean, Virginia.

Bassett, I., Q. Paynter, R. Hankin, and J. R. Beggs. 2012. Characterising alligator weed (*Alternanthera philoxeroides*; Amaranthaceae) invasion at a northern New Zealand lake. New Zealand Journal of Ecology 36(2):216–222.

Buckingham, G. R. 1996. Biological control of alligatorweed, *Alternanthera philoxeroides*, the world's first aquatic weed success story. Castanea 61:232–243.

Calflora. 2015. The Calflora Database. Available: http://www.calflora.org/. (December 2015).

Carter, R. 1999. Herbarium specimen voucher data, Valdosta State University Herbarium. Valdosta State University, Valdosta, Georgia.

Center, T. D., and J. Balciunas. 1975. The effects of water quality on the distribution of alligator weed and water hyacinth. United States Army Engineers Waterways Experimental Station Technical Report 10:B3–B13.

Center for Invasive Species and Ecosystem Health. 2015. EDDMapS: Early detection and distribution mapping system. The University of Georgia, Tifton. Available: http://www.eddmaps.org.

Chester, E. W. 1988. Alligatorweed, *Alternanthera philoxeroides* (Mart.) Griseb. in Kentucky. Transactions of the Kentucky Academy of Science 49(3/4):140–142.

Chester, E. W., B. E. Wofford, and R. Kral. 1997. Atlas of Tennessee vascular plants, volume 2. Angiosperms: Dicots. Center for Field Biology, Austin University, Clarksville, Tennessee.

Commonwealth of Australia. 2000. Alligator weed (*Alternanthera philoxeroides*) strategic plan. National Weeds Strategy Executive Committee, Australia.

Coulson, J. R. 1977. Biological control of alligatorweed, 1959–1972. A review and evaluation. Agricultural Research Service, United States Department of Agriculture, Technical Bulletin 1547.

Coventry, R., M. Julien, and J. Wilson. 2002. Report of the 1st CRC for Australian Weed Management Alligator Weed Research Workshop. Department of Land and Water Conservation, Windsor, Australia.

Craft, B. R., and D. Kleinpeter. 1989. Vegetation and salinity changes following the installation of a fixed crest weir at Avery Island, LA. U.S. Fish and Wildlife Service and Louisiana Department of Natural Resources.

DAISIE. 2016. Delivering Alien Invasive Species Inventories for Europe. European Invasive Alien Species Gateway. Available: www.europe-aliens.org/default.do.

Flora of China Editorial Committee. 2016. Flora of China. Missouri Botanical Garden, St. Louis, Missouri, and Harvard University Herbaria, Cambridge, Massachusetts. Available: http://www.efloras.org/flora_page.aspx?flora_id=2.

Flora of Panama. 2016. Flora of Panama (WFO). Tropicos website. Missouri Botanical Garden, St. Louis, Missouri, and Harvard University Herbaria, Cambridge, Massachusetts. Available: http://www.tropicos.org/Project/FOPWFO.

Godfrey, R. K., and J. W. Wooten. 1981. Aquatic and wetland plants of the Southeastern United States, dicotyledons. University of Georgia, Athens.

Gunasekera, L. 1999. Alligator weed - an aquatic weed present in Australian backyards. Plant Protection Quarterly 14(2):77–78.

Gunasekera and Adair. 2000. [Source material did not give full citation for this reference.]

Guo, L. and T. Wang. 2009. Impact of invasion of exotic plant *Alternanthera philoxeroides* on interspecies association and stability of native plant community. Chinese Journal of Eco-Agriculture 17:851–856.

Helton, R. J., and L. H. Hartmann. 1996. Statewide aquatic vegetation survey summary, 1995 Report. Inland Fisheries Division, District 3-E, Jasper, Texas.

Hoagland, B. W., and N. A. McCarty. 1998. Noteworthy collections: Oklahoma. Castanea 63(2):194.

Hooker, K. L., and H. M. Westbury. 1991. Development of wetland plant communities in a new reservoir. Pages 45–60 *in* F. J. Webb, editor. Proceedings of the 18th Annual Conference on Wetlands Restoration and Creation. Hillsborough Community College. Tampa, Florida.

ISSG. 2016. Global Invasive Species Database (GISD). Invasive Species Specialist Group of the IUCN Species Survival Commission.

Jayasinghe, H. 2008. Please don't eat mallung leaf lookalike. Sunday Times, Sri Lanka.

Julien, M. H., and J. E. Broadbent. 1980. The biology of Australian weeds 3. *Alternanthera philoxeroides* (Mart.) Griseb. Journal of the Australian Institute of Agricultural Science 46(3):150–155

Julien, M. H., and R. R. Chan. 1992. Biological control of alligator weed: unsuccessful attempts to control terrestrial growth using the flea beetle *Disonycha argentinensis* (Col., Chrysomelidae). Entomophaga 37(2):215–221.

Julien, M. H., B. Skarratt, and G. F. Maywald. 1995. Potential geographical distribution of alligator weed and its biological control by *Agasicles hygrophila*. Journal of Aquatic Plant Management 33:55–60.

Kay, S. H., and W. T. Haller. 1982. Evidence for the existence of distinct alligtorweed biotypes. Journal of Aquatic Plant Management 20:37–41.

Kight, J. 1988. Tennessee-Tombigbee Waterway. Pages 324–329 *in* Proceedings of the 22th Annual Meeting on Aquatic Plant Control Research Programs. U.S. Army Corps of Engineers, Waterways Experiment Station. Vicksburg, Mississippi.

Langeland, K. A., H. M. Cherry, C. M. McCormick, and K. A. Craddock Burks. 2008. Identification and biology of non-native plants in Florida's natural areas. University of Florida IFAS Extension, Gainesville.

Long, R. W., and O. Lakela. 1971. A flora of tropical Florida. University of Miami Press, Coral Gables, Florida.

Louisiana State University Herbarium. 2010. Louisiana State University Herbarium - vascular plants. Louisiana State University, Baton Rouge.

Lynch, J. J., J. E. King, T. K. Chamberlain, and A. L. Smith, Jr. 1950. Effects of aquatic weed infestations on the fish and wildlife of the Gulf States. US Department of the Interior, Fish and Wildlife Service, Special Scientific Report 39.

Madsen, J. D. 2010. Invasive plant atlas of the MidSouth. Geosystems Research Institute, Mississippi State University, Starkville. Available: http://www.gri.msstate.edu/ipams/.

Madsen, J. D., G. Ervin, V. Maddox, and C. Abbott. 2010. Invasive plant atlas of the MidSouth. Mississippi State University.

Masoodin, A., and F. A. Khan. 2012. Invasion of alligator weed (*Alternanthera philoxeroides*) in Wular Lake, Kashmir, India. Aquatic Invasions 7(1):143–146.

Mississippi River Basin ANS Regional Panel. 2006. Annual Report to the ANS Task Force (9/1/05 to 8/31/06). Mississippi River Basin ANS Regional Panel.

Missouri Botanical Garden. 2007. Missouri Botanical Garden. Missouri Botanical Garden, St. Louis.

Montz, G. N. 1979. Distribution of selected aquatic species in Louisiana. U.S. Army Corps of Engineers, New Orleans, Louisiana.

New York Botanical Garden. 2015. The New York Botanical Garden Herbarium (NY) - vascular plant collection. The New York Botanical Garden, New York.

Newman, M. J., and W. W. Thomaston. 1979. Aquatic weed control in Georgia. Proceedings of the Southern Weed Science Society 32:271–279.

North Carolina Division of Water Resources. 1996. Economical and environmental impacts of N.C. aquatic weed infestations. North Carolina Department of Environment, Health, and Natural Resources, Raleigh.

OEPP/EPPO. 2016. *Alternanthera philoxeroides* (Mart.) Griseb. European and Mediterranean Plant Protection Organization Bulletin 46(1):8–13.

Parsons, W. T., and E. G. Cuthbertson. 1992. Noxious weeds of Australia. Inkata Press, Melbourne, Australia.

Penfound, W. T., and T. T. Earle. 1948. The biology of water hyacinth. Ecological Monographs 18(4):447–472.

Pheloung, P. C. 1995. A report on the development of a weed risk assessment system commissioned by the Australian Weeds Committee and the Plant Industries Committee. Agriculture Protection Board, Western Australia.

Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the vascular flora of the Carolinas. University of North Carolina Press, Chapel Hill.

Regents of the University of California. 2015. Jepsen online interchange for California floristics. University and Jepson Herbaria, University of California, Berkeley.

Reimus, R. G., and W. B. Robertson, Jr. 1997. Plants of Dry Tortugas National Park: an annotated list and expanded checklist. Institute for Regional Conservation, Miami.

Rui-Yan, M., and W. Ren. 2004. Effect of morphological and physiological variations in the ecotypes of alligatorweed, *Alternanthera philoxeroides* on the pupation rate of its biocontrol agent *Agasicles hygrophila*. Zhiwu Shengtai Xuebao 28(1):24–30.

Sainty, G. R. 1973. Aquatic plant identification guide. Water Conservation and Irrigation Commission of New South Wales, North Sydney, Australia.

Schardt, J. D., and D. C. Schmitz. 1991. 1990 Florida aquatic plant survey. CGA Florida Department of Natural Resources, Bureau of Aquatic Plants, Technical Report 91, Tallahassee, Florida.

Sculthorpe, C. D. 1967. The biology of aquatic vascular plants. Edward Arnold, London.

Smith, E. B. 1988. An atlas and annotated list of the vascular plants of Arkansas, 2nd edition. University of Arkansas, Fayetteville.

Sosa, A. J., E. Greizerstein, M. V. Cardo, M. C. Telesnick, and M. H. Julien. 2008. The evolutionary history of an invasive species: alligator weed, *Alternanthera philoxeroides*. International Symposium on Biological Control of Weeds XII:435–442.

Southeast Exotic Pest Plant Council. 2008. Early Detection & Distribution Mapping System. University of Georgia Center for Invasive Species and Ecosystem Health.

Texas Invasive Plant and Pest Council. 2015. Texas Invasives Database.

Thomas, R. D., and C. M. Allen. 1996. Atlas of the vascular flora of Louisiana volume II: Dicotyledons Acanthaceae - Euphorbiaceae. Bourque Printing, Baton Rouge, Louisiana.

University of Alabama Biodiversity and Systematics. 2007. Herbarium (UNA). University of Alabama, Tuscaloosa.

University of Connecticut. 2011. CONN. University of Connecticut, Storrs.

University of Florida Herbarium. 2016. Florida Museum of Natural History. University of Florida, Gainesville.

USDA-ARS. 2016. Germplasm Resources Information Network (GRIN). National Plant Germplasm System. National Germplasm Resources Laboratory, Beltsville, Maryland.

USDA-NRCS. 2016. The PLANTS Database. National Plant Data Center, Baton Rouge, Louisiana.

Valentine, J. M. 1976. Plant succession after saw-grass mortality in southwestern Louisiana. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies (1976):634–640.

Ved, D. K., S. T. Sureshchandra, V. Barve, V. Srinivas, S. Sangeetha, K. Ravikumar, R. Kartikeyan, V. Kulkarni, A. S. Kumar, S. N. Venugopal, B. S. Somashekhar, M.V. Sumanth, N. Begum, S. Rani, K. V. Surekha, and N. Desale. 2016. FRLHT's ENVIS Centre on Medicinal Plants, Bengaluru.

Vogt, G. B., P. C. Quimby, Jr., and S. H. Kay. 1992. Effects of weather on the biological control of alligatorweed in the Lower Mississippi Valley Region, 1973–83. U.S. Department of Agriculture Technical Bulletin 1766.

Ware, D. 1998. Herbarium specimen voucher data, Herbarium of the College of William & Mary (WILLI). College of William and Mary, Williamsburg, Virginia.

Waterhouse, D. F. 1993. The major arthropod pests and weeds of agriculture in Southeast Asia. Australian Centre for International Agricultural Research, Monograph 21, Canberra.

Weber, E. 2003. Invasive plant species of the world: a reference guide to environmental weeds. CAB International, Wallingford, UK.

Weeds of Australia. 2016. Weeds of Australia, Biosecurity Queensland Edition.

White, D. A. 1993. Vascular plant community development on mudflats in the Mississippi River Delta, Louisiana, USA. Aquatic Botany 45:171–194.

Wofford, B. E. 1977. State records and other recent noteworthy collections of Tennessee plants II. Castanea 42(3):190–193.

Woffard, B. E., and W. M. Dennis. 1976. State records and other recent noteworthy collections. Castanea 41(2):119–120.

Wu, H., J. Carrillo, and D. JianQing. 2016. Invasion by alligator weed, *Alternanthera philoxeroides*, is associated with decreased species diversity across the latitudinal gradient in China. Journal of Plant Ecology 9(3):311–319.

Xu, B., R. F. Weng, and M. Zhang. 1992. Chromosome numbers of Shanghai plants I. Investigatio et Studium Naturae, 12:48–65.

Zeiger, C. F. 1967. Biological control of alligatorweed with *Agasicles* n. sp. in Florida. Journal of Aquatic Plant Management 6:31–34.

Zeiger, C. F. 1976. Aquatic plant problems in Puerto Rico. Pages 24–25 *in* Proceedings, Research Planning Conference on the Aquatic Plant Control Program, 1975. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Zhang, Z., X. Li, and Z. XiaoMin. 2010. Effect on species diversity of plant communities caused by invasion of *Alternanthera philoxeroides* in different habitats. Acta Prataculturae Sinica 19(4):10–15.