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This PRA document was modified in 2021 to clarify the phytosanitary measures recommended

Pest Risk Analysis for

Alternanthera philoxeroides

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This risk assessment follows the EPPO Standard PM PM 5/5(1) *Decision-Support Scheme for an Express Pest Risk Analysis* (available at http://archives.eppo.int/EPPOStandards/pra.htm) and uses the terminology defined in ISPM 5 *Glossary of Phytosanitary Terms* (available at https://www.ippc.int/index.php).
This document was first elaborated by an Expert Working Group and then reviewed by the Panel on Invasive Alien Plants and if relevant other EPPO bodies.

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Photo: *Alternanthera philoxeroides stands in the Arno river*. CourtesyLorrenzo Cecchi (IT)

Pest Risk Analysis for *Alternanthera philoxeroides* (Mart.) Griseb.

This PRA follows EPPO Standard PM 5/5 *Decision-Support Scheme for an Express Pest Risk Analysis*.

PRA area: EPPO region
Prepared by: EWG on *Alternanthera philoxeroides* and *Myriophyllum heterophyllum*
Date: 2015-04-20/24

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Summary of the Express Pest Risk Analysis for *Alternanthera philoxeroides* (Mart.) Griseb.

PRA area: EPPO region

Describe the endangered area:

The warmer climatic regions, especially countries within the Mediterranean area. Countries most at prone to risk of invasion include: Portugal, Spain, France, Italy, Greece, Turkey, Morocco, Algeria, Tunisia, Monaco and Israel.

Habitats within the endangered area include; riparian systems (slow moving rivers, canals, irrigation canals, lakes, coastal areas etc.), semi aquatic systems, agricultural land, especially floodplains. These regions are predicted and described in section 9. *A. philoxeroides* also has the potential to become established in countries that have thermal water bodies, for example Germany, Hungary, Slovenia, Slovakia and Poland.

Main conclusions

Alternanthera philoxeroides presents a high phytosanitary risk for the EPPO region with a low uncertainty rating. *A. philoxeroides* is already present in the EPPO region in France and Italy. Further spread within and between EPPO countries is considered likely. The overall likelihood of *A. philoxeroides* continuing to enter the EPPO region is medium. It is not clear how this species entered the EPPO region and there are no clear pathways of further introduction, as the species is not widely traded as an aquarium plant or as any other type of living plant material. There may be confusion with *A. sessilis*, or other *Alternanthera* species traded for aquarium, ornamental or food purposes. The risk of the species establishing in other EPPO countries is considered high as movement through irrigation and river systems may act to connect countries, facilitating spread regionally, especially through high energy unstable river systems that may encourage fragmentation. Spread may be significantly accelerated by water based recreational activities. The potential high impact of the species within the EPPO region should be considered similar to that seen in other countries where the species has invaded and become established; i.e. Australia and the southern states of North America. Impacts are likely to be more pronounced in countries and regions where the climate most suited to population, establishment, growth and spread.

Entry and establishment

The species is already present and well established within the PRA area- in France and Italy. The overall likelihood of *A. philoxeroides* entering into the EPPO region is **moderate.**

The pathways identified are:

- Plants for planting (either deliberately or as a result of misidentification)
- Contaminant of other plants
- Accidental contaminant of bird seed
- Import of *A. sessilis* as a vegetable
- Shipping

Recently the species has shown increased invasiveness in existing sites in Italy and at a new site in the south east of France. In terms of habitats, it is possible for *A. philoxeroides* to establish throughout climatically suitable aquatic and riparian habitats within the EPPO region. *A. philoxeroides* also has the potential to establish within terrestrial agricultural systems within the EPPO region, but in particular in irrigated rice crops. There is the additional potential for the species to establish in various kinds of terrestrial habitats. *A. philoxeroides* is tolerant of a wide range of environmental aquatic conditions. Cold temperatures are likely to limit the northern distribution of this species. Climate change is likely to increase the likelihood of establishment in more areas of the EPPO region.

Potential impacts in the PRA area

Alternanthera philoxeroides has been shown to have significant environmental and economic impacts within the invaded range (excluding the EPPO region). There is no evidence to suggest that the impacts observed will be different in the EPPO region. The potential economic impact of *A. philoxeroides* in the EPPO region could be highly significant if the species spreads and establishes in further areas; especially when consideration is given to the loss of earnings and costs associated with management for other aquatic species in Europe. There are no host specific natural enemies in the EPPO region to regulate the pest species, and in many EPPO countries herbicide application in or around water bodies is highly regulated or not permitted. Climate change, especially rises in temperature may increase the total area this species is able to invade. Although we assume that impacts have occurred where the plant forms dense populations in the EPPO region. There has been no research conducted yet on the impact on native plant species or communities. The habitat potentially invaded by the species is vulnerable and provides important ecosystem services.

Phytosanitary measures:

The result of this PRA shows that *A. philoxeroides* poses an unacceptable risk in the EPPO region. It is recommended that *A. philoxeroides* is included on the list of quarantine pests.

The main pathways being consider are:
(1) Plants for planting (either as an intentional import as a case of misidentification).
(2) Contaminant of plants for planting
(3) Bird seed contamination

International measures:
(1) Prohibition of import into and within the EPPO region and within the countries of plants labeled as *A. philoxeroides* and all other synonyms and misapplied names in use, as well as subspecies.
(2) Certification scheme for pest free production from country of origin. All the measures or combination of measures identified as being appropriate for each pathway or for the commodity can be considered for inclusion in phytosanitary regulations in order to offer a choice of different measures to trading partners. Data requirements for surveillance and monitoring to be provided by the exporting country should be specified. In addition to the measure(s) selected to be applied by the exporting country, a phytosanitary certificate (PC) may be required for certain commodities. The PC is an attestation by the exporting country that the requirements of the importing country have been fulfilled. In certain circumstances, an additional declaration on the PC may be needed (see EPPO Standard PM 1/1(2) Use of phytosanitary certificates).
(3) Similar to that of number 2, with the addition of cleaning the product prior to export.
National measures:
Prohibition of selling, planting, holding, moving, and causing to grow in the wild of the plant in the EPPO region is necessary. Moreover, the plant has to be surveyed and eradicated or contained or controlled where it occurs. In addition, public awareness campaigns to prevent spread from existing populations in countries at high risk are necessary. If these measures are not implemented by all countries, they will not be effective since the species could spread from one country to another. National measures have to be combined with international measures, and international coordination of management of the species between countries is necessary.
Certification scheme for pest free production from country of origin. Inspection at points of entry. Awareness raising and training of boarder staff on the species with identification guides at point of entry. The national measures do not include measures on the contamination of bird seed with *A. philoxeroides*.
The combination of measures are:
At the international level: prohibition of import of the species, with the listing of the species as a quarantine pest.
At the national level:
Prohibition of selling, planting, holding, movement, and causing to grow in the wild of the plant, combined with management plans for early warning; obligation to report findings; eradication and containment plans; public awareness campaigns.
Prohibition of the import, selling, planting, movement, causing to grow in the wild
Considering the high costs to control the plant, the prohibition of the import, selling, planting, movement, and causing to grow in the wild is very cost-effective.
Prohibition of holding of the species
When the species has spread to unintended habitats, the prohibition of holding will result in an obligation to destroy the population, and contain or control the species.
Containment and control of the species in unintended habitats
Eradication measures should be promoted where feasible with a planned strategy to include surveillance, containment, treatment and follow-up measures to assess the success of such actions. As highlighted by EPPO (2014), regional cooperation is essential to promote phytosanitary measures and information exchange in identification and management methods. Eradication may only be feasible in the initial stages of infestation. This may be possible with the current level of occurrence the species has in the EPPO region. Coordination of all stakeholders is required and should be easy to achieve, especially since the distribution is limited.

General considerations should be taken into account for all pathways, where, as detailed in EPPO (2014), these measures should involve awareness raising, monitoring, containment and eradication measures. NPPO's should facilitate collaboration with all sectors to enable early identification including education measures to promote citizen science and linking with universities, land managers and government departments. The funding of awareness campaigns, targeting specific sectors of society, i.e. anglers, and the water based leisure trade will facilitate targeting groups most prone to spread *A. philoxeroides*. **Import for (aquatic) plant trade:** Prohibition of the import, selling, planting, holding and movement of the plant in the EPPO region. **Unintended release into the wild:** The species should be placed on NPPO's alert lists and a pro-active ban from sale should be recommended in countries most prone to invasion. Trade of the plant should be prohibited within the EPPO region. Management measures would be recommended to include an integrated management plan to control existing populations. Monitoring and surveillance including early detection for countries most prone to risk. Report any findings in the wider EPPO region, in particular the Mediterranean area. **Transportation through recreational activities** (method of spread within the EPPO region): Raise awareness on the species, including publicity regarding its identification and its impacts to the sector in question. **Intentional release into the wild:** Prohibition on planting the species or allowing the plant to grow in the wild. **Natural spread** (method of spread within the EPPO region): Increase surveillance in protected areas where there is a high risk the species may invade. NPPO's to provide land managers and stakeholders with identification guides and facilitate regional cooperation, including information on site specific studies of the plant, control techniques and management. **Transportation through machinery:** Raise awareness on the species, including publicity regarding its identification and its impacts to the sector in question.			
Phytosanitary risk for the *endangered area* (*Individual ratings for likelihood of entry and establishment, and for magnitude of spread and impact are provided in the document***)**	High ☒	Moderate ☐	Low ☐
Level of uncertainty of assessment (Overall, to the right) Pathways for entry – Moderate Likelihood of establishment outdoors in the PRA area – Low Likelihood of establishment in protected conditions in the PRA area – Moderate Spread in the PRA area – Low Impact in the current area of distribution – Low Potential impact in the PRA area – Low	High ☐	Moderate ☐	Low ☒
Other recommendations: • ***Inform EPPO or IPPC or EU*** Inform NPPO's, that surveys are needed to confirm the distribution of the plant, in particular in the area where the plant is present on the priority to eradicate the species from the invaded area. Inform DG Environment on the eligibility of the species for inclusion on the list of IAS of EU concern. • ***Inform industry, other stakeholders*** On the potential contamination in *Alternanthera sessilis* shipments • ***State whether a detailed PRA is needed to reduce level of uncertainty (if so, state which parts of the PRA should be focused on)*** Uncertain to how the plant arrived within the EPPO region. However, a detailed PRA will not establish this and thus the answer is no • ***Specify if surveys are recommended to confirm the pest status*** Surveys should be conducted to confirm the current distribution of the species within the EPPO region. • ***State what additional work/research could help making a decision.*** Pathway analysis and impacts on native species and communities where present.			

Express Pest Risk Analysis: *Alternanthera philoxeroides*

Stage 1. Initiation

Reason for performing the PRA:
The occurrence, impact and spread of *Alternanthera philoxeroides* (Mart.) Griseb in other regions of the world warrants an evaluation of potential impacts the species may have in the EPPO region. The high plasticity the species shows throughout its' invasive and native range, coupled with increasing suitable habitat as a result of climate change, highlights the need for performing a PRA in the EPPO region. *A. philoxeroides* currently has a limited distribution in the EPPO region. The species is present in France and Italy. Populations found in the Mediterranean region of France (Sorgues) in 2013 have been shown to be exhibiting more invasive behaviour than the other populations in France (http://www.gt-ibma) following a similar trend as that observed in Italy. *A. philoxeroides* was evaluated through the EPPO prioritisation Scheme in 2012 and as a result was considered to have a high priority for PRA. This high rating was justification for placing *A. philoxeroides* on the EPPO List of Alien Invasive Plants EPPO 2012).

PRA area: The EPPO region (map at www.eppo.org).

Stage 2. Pest risk assessment

1. Taxonomy:

Alternanthera philoxeroides (Mart.) Griseb. (Kingdom: Plantae; Class: Dicotyledoneae; Order: Caryophyllales; Family: Amaranthaceae, Genus: *Alternanthera*).

EPPO Code: ALRPO

Syn: *Achyranthes philoxeroides* (Mart.) Standl.; *Achyranthes paludosa* Bunbury; *Alternanthera philoxerina* Suess.; *Bucholzia philoxeroides* Mart.; *Telanthera philoxeroides* (Mart.) Moq. (Q Bank, 2015).

Common name: Global accepted common name: Alligator weed, Other: pig weed. Sri Lanka: Kimbul wenna, Mukunuwenna.

Plant type: Emergent aquatic perennial herb, amphibious or terrestrial

Related species in the EPPO region:

Native: None

Non-native: *Alternanthera caracasana* (L.) Sw., *Alternanthera nodiflora* R.Br., *Alternanthera peploides* (Humb. & Bonpl.) Urb., *Alternanthera pungens* Kunth, *Alternanthera repens* auct. (Royal Botanic Garden Edinburgh, 2001) *Alternanthera sessilis* (L.), *Alternanthera sessilis* var. *rubra* (Brunel, 2009).

Additional species used within the aquatic plant trade are: *Alternanthera aquatica* (Parodi) Chodat, *Alternanthera bettzichiana* (Regel) Voss, *Alternanthera cardinalis* Forssk., *Alternanthera lehmanii*, *Alternanthera reineckii* Forssk *Alternanthera Rosanervig*, *Alternanthera sessilis* var. *rubra*, *Alternanthera reineckii 'lilacina'*.

2. Pest overview

Introduction

Alternanthera philoxeroides is an emergent aquatic perennial herb found growing in both aquatic and terrestrial habitats throughout its native and invasive range (Global Invasive Species Database, 2005). Native to the Paranà river basin (Brazil, Argentina Paraguay) in South America (Sosa *et al.*, 2004; Sosa *et al*., 2008) , *A. philoxeroides* is recorded from 37 countries (Q-Bank, 2015) (see section 6) where one of the earliest records outside its' native range was from the USA around 1890 (McGilvrey & Steenis, 1965;

Kay & Haller, 1982). In the EPPO region, *A. philoxeroides* is recorded from France and Italy only, though there are suitable habitats and climates for this species throughout Europe, in particular the Mediterranean region (Julien *et al*., 1995).

Environmental requirements

Optimum shoot emergence and growth is at a constant of 30°C. Growth is supressed at temperatures below 7 °C, however, the species can tolerate mean annual temperatures between 10 and 20 °C (Shen *et al.*, 2005). No shoot emergence was observed at a constant below 5°C (Shen *et al.*, 2005). Liu-qing *et al*. (2007) showed *A. philoxeroides* can be propagated following stratification of the stolon at 4°C for up to 72 hours. Photosynthetic optimum of the species was 30-37 °C and light saturation at 1000 μmol photons m^{-2} s^{-1} (Pers. Comm. Hussner, 2015). The species can tolerate a pH of between 4.8 and 7.7 in water (van Oosterhout, 2007). Frost and ice kill exposed stems and leaves – though protected stems enable the species to persist to the next season. *A. philoxeroides* persists and grows well in copper contaminated waters (Wei & Zheng-Hua, 2012). There have been numerous studies to show that *A. philoxeroides* can change the chemical composition and alter nutrient cycling of water bodies (Bassett, *et al*., 2010; Bassett *et al*., 2012). *A. philoxeroides* can tolerate relatively high levels of salinity for a freshwater plant (10 -30% of sea water) (Global Invasive Species Database, 2005) and can adapt to low light conditions (up to 12% of full light) (Weber, 2003).

Habitats

Although more suited to aquatic and riparian habitats, where the species forms dense mats in shallow slow-moving water bodies, *A. philoxeroides* is also a vigorous coloniser of terrestrial habitats where the extensive (up to 2m) deep rhizome system can sustain the population throughout extended dry periods (Government of South Australia, 2010). Often, *A. philoxeroides* grows at the interface between the aquatic and terrestrial environment (Julien & Bourne, 1988). Spread is predominantly vegetatively, from axillary buds at each node in the warm summer months. Julien and Borne (1988) lists a number of habitats which will sustain populations of the species, including, but not exclusive too, freshwater habitats, coastal areas, managed terrestrial habitats including cultivated/agricultural land, disturbed areas and urban habitats. In addition, natural and semi-natural habitats are prone to invasion including natural forests, riverbanks and wetlands.

Identification

Alternanthera philoxeroides is an emergent stoloniferous perennial herb. The leaves are dark green elliptic glabrous and opposite, 3.5 -7.1 cm in length and 0.5-2cm wide (Flora of North America Editorial Committee, 1993+). Mature aquatic plants have hollow stems up to 10 m long that form thick interwoven mats throughout the water body and emerge up to 20 cm out of the water when the plant flowers. Inflorescences are white, terminal and axillary, 1.4-1.7cm in diameter, on a short stalk (Flora of North America Editorial Committee, 1993+) (Appendix 1, Fig. 1). In the native range the species is known to set seed (Vogt, 1973). In much of the invasive range seed production is not observed (van Oosterhout, 2007). However, the species has been recorded to set seed in China. Lui-qing *et al*. (2007) cite Zhang *et al*. (2004) (in Chinese) that details *A. philoxeroides* showing a 6.5 % seed set in Zhengzhou City, Henan Province. Contamination of Bonsai plant soil sourced from China and detected in The Netherlands (pers. comm van Valkenburg, 2015) indicates that viable seed must be produced in China. In North America, *A. philoxeroides* flowers around early spring and into the summer months, whereas in Australia, the species flowers around mid-summer (Flora of North America Editorial Committee 1993+; Queensland Government, 2015). *A. philoxeroides* can be confused with a number of semi-aquatic species within the EPPO region; in particular the closely related congeners (see section 1).

Two biotypes of the species are present in Florida where each has a different morphology - (1) broad and (2) narrow stemmed leaved forms (Kay and Haller, 1982), probably similar to *A. philoxeroides* f. *philoxeroides* and *A. philoxeroides* f. *angustifolia* identified in the native range in Argentina (Sosa *et al.* 2004). Additionally, the two biotypes present in Argentina differ in the number of chromosomes (Parsons & Cuthbertson, 1992), and so must be different taxa. There is no information regarding different biotypes within the EPPO region.

Symptoms

Throughout the invaded region *A. philoxeroides* blocks waterways where it outcompetes native plant species and alters the nutrient composition of invaded sites (Buckingham, 1996). The plant can form very dense stands between the aquatic and terrestrial interface (see Appendix 1, Fig. 2). When growing in an aquatic environment the species reduces the amount of light entering the water-body which in turn has a detrimental impact on native flora (Chatterjee & Dewanji, 2014) and fauna (Bassett *et al*., 2012); and resultant plant decomposition rates (Buckingham, 1996; Bassett *et al*., 2006; Bassett *et al*., 2010; Bassett *et al.*, 2011). Low oxygen levels have been recorded below mats of the species (Quimby & Kay, 1976). Flood risk can be increased when the species invades as it has the tendency to increase sedimentation and block drainage ditches (Global Invasive Species Database, 2005). Indirectly, *A. philoxeroides* can act as a vector for diseases by increasing breeding grounds for mosquitoes – which in turn can have implications for both livestock and human health (Spencer & Coulson, 1976; Julien and Broadbent 1980; Schooler, 2012).

3. Is the pest a vector? No

Although not a direct vector of organisms, indirectly *A. philoxeroides* can create suitable habitats for pest species. For example, *A. philoxeroides* has been shown to increase breeding grounds for mosquitoes (Spencer & Coulson, 1976; Julien and Broadbent 1980; Schooler, 2012).

4. Is a vector needed for pest entry or spread? No

No. A vector is not needed for the entry of this weed species into the PRA area.

5. Regulatory status of the pest

Europe: In several EU countries the release of non-native plants into the wild is illegal (for example; GB under the Wildlife and Countryside Act 1981). EPPO does not regulate species within the region, but rather makes recommendations, through expert Panels. In Europe *A. philoxeroides* was added to the EPPO alert list in 2007 and transferred to the List of Invasive Alien Plants in 2012 (EPPO, 2012). In Portugal, under the Decreto Lei 565/99 legislation, it is prohibited to sell, exchange, transport, cultivate or keep *A. philoxeroides*. In Spain, the species is included in the list of the prohibited species of the Real Decreto 630/2013 http://www.boe.es/boe/dias/2013/08/03/pdfs/BOE-A-2013-8565.pdf .

USA: In the USA, *A. philoxeroides* has varying classifications at a federal, government or state level. In Alabama: Class C – noxious weed, Arizona: a prohibited noxious weed, California: A list (noxious weed), Florida: Prohibited aquatic plant- Class1, South Carolina: invasive aquatic plant (Plant pest) and Texas: a Noxious plant (USDA, 2008).

Australia: In Australia *A. philoxeroides* is a Weed of National Significance and a declared noxious weed in all States (Australian Government, 2003). In all states and territories, Government Departments are obliged by law to control and/or eradicate the species. In Victoria *A. philoxeroides* is a prohibited plant under the Catchment and Land Protection Act (1994). In New South Wales (NSW) the species is either categorised under the NSW Noxious Weeds Act 1003 as Class 2 (regionally prohibited weed) or Class 3 (regionally controlled weed) (New South Wales Government, 2013). Most territories in Australia restrict the plants importation (Natural Hertitage Trust, 2003). In Queensland *A. philoxeroides* is a Class 1 species, meaning the plant should be eradicated from all States.

In New Zealand, *A. philoxeroides* is listed as an unwanted organism under the Biosecurity Act (1993). The plant is included on the National Pest Plant Accord List. This bans the sale, propagation and distribution of *A. philoxeroides* throughout New Zealand. *A. philoxeroides* is classified as an Eradication Plant Pest by the Waikato Regional Council; with the Council undertaking eradication work with the goal of zero density by the year 2017 (Bassett, 2008).

Sri Lanka: In Sri Lanka, *A. philoxeroides* has been banned from cultivation following the devastating impact the species has caused to waterways (Jayasinghe, 2008). *A. philoxeroides* was grown by local communities as a food crop in a case of mistaken identity–the actual species used by locals is the close congener *A. sessilis* (L.) DC. *A. philoxeroides* has been suggested for inclusion in the national weed list, however, as of yet this has not happened (Pers. comm., Gunasekera, 2015).

6. Distribution

Continent	*Distribution*	*Comments*	*Reference*
North America	(1) Present in USA: Alabama, California, Florida, Georgia, Illinois, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia (2) Present in Mexico	(1) North America (restricted Southern distribution, **introduced**) (2) Mexico (widespread, **introduced**)	USDA, 2008
Central and South America	(1) Present in Honduras, Puerto Rico Trinidad and Tobago. (2) Present in Argentina, Brazil, Paraguay (3) Present Bolivia, Colombia, French Guiana, Guyana, Peru, Suriname, Venezuela, Uruguay	(1) Widespread and **introduced** in Central America (2) Widespread and **native** in South America (3) Introduced	Julien *et al*., 1995; Sosa *et al*., 2004; Sosa *et al*., 2008
Asia	(1) Present throughout Asia – to include Bangladesh, China (central and southern Provinces), India, India (Kashmir), Indonesia (Java, West Papua), Japan, Laos, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Singapore, Taiwan, Thailand, Vietnam	(1) Widespread throughout Asia (introduced)	CABI, 2015; Dugdale & Champion, 2012; Holm *et al*., 1999; Masoodi & Khan 2012; Tanveer *et al*., 2013; Waterhouse, 1993; Yamamoto & Kusumoto 2008; Zhou, *et al*., 2008
Europe	(1) Present in France and Italy	(1) Restricted distribution (introduced)	Fried *et al*., 2014; Garbari & Pedullà, 2001; Georges 2004; Iamonico & Iberite 2014; Iamonico *et al*., 2010; Iamonico & Pino, 2015.
Oceania	(1) Australia (all States and Territories) (2) New Zealand (North Island-Bay of Plenty and the Waikato area Auckland, Northland area)	(1) Widespread (introduced) though eradicated from the Northern Territory, South Australia and Tasmania (2) Widespread (introduced) Eradicated from the South Island	(Julien *et al*.,1995; Julien, 1999; Bassett *et al*., 2010; Bassett *et al*., 2011)

Introduction:

A. philoxeroides is found in the USA, Australia, New Zealand, much of Asia and more recently Europe (see Appendix 2, Fig. 3). The centre of origin of *A. philoxeroides* is reported to be the Argentinian Paraná river region in South America (Julien *et al*., 1995) where over 30 species of *Alternanthera* occur (Telesnicki *et al*., 2011). Sosa *et al*. (2008) include Paraguay, Uruguay and Brazil as the plants native range. The species has spread to other regions in South America (see Appendix 2, Fig. 4).

Asia:
A. philoxeroides is found in Asia where it is widespread and problematic in some regions (see appendix 2 Fig. 5). In the hotter tropical regions; including Indonesia and Thailand, the plant does not grow with the vigour seen in more temperate regions (Julien *et al*., 1995). In Sri Lanka *A. philoxeroides* was identified in the western and southern provinces of the country in 1999 (Jayasinghe, 2008). The plant has also been recorded as present in central provinces in Sri Lanka at high altitudes (above 2500 m asl.) in 2004 (personal communication L. Gunasekera, 2015). *A. philoxeroides* is found throughout India including Assam, Bihar, West Bengal, Tripura, Manipur, Andhra Pradesh, Karnataka, Maharashtra, Delhi and the state of Punjab (Pramod *et al*., 2008). More recently, the plant has been recorded from Wular Lake (Kashmir) at an altitude of 1580 m asl. (Masoodi & Khan, 2012). Here populations are expanding (Masoodi *et al.*, 2013).

USA:
In the USA, *A. philoxeroides* has been recorded as present since 1897 (Zeigler, 1967; Kay and Haller, 1982). *A. philoxeroides* has been a significant weed in the USA since the 1960's and onwards (Spencer & Coulson, 1976; Buckingham, 1996). The plant is introduced to 15 southern States (USDA, 2008) (Appendix 2, Fig 6).

Oceania:
In Australia *A. philoxeroides* was first observed in 1940s near Newcastle, New South Wales (Hockley, 1974; Julien & Bourne 1988). It has been observed in every state in Australia, but has now been eradicated from the Northern Territory and South Australia, due to early monitoring and observation (van Oosterhout, 2007). It is still present in NSW, where very dense monospecific stands occur (van Oosterhout, 2007). It is currently present in other states where it occurs mixed with other species (Appendix 2, Fig. 7).

In New Zealand it was first recorded 1906 by Cheeseman (Flora of New Zealand) (Roberts & Sutherland, 1989) and recorded as *Telanthera philoxeroides*. It is recorded now from Northland, north of Auckland, and the Waikato Region and Bay of Plenty and has been eradicated from four sites on the South Island (pers. comm. P. Champion) (Bassett *et al*., 2011; Bassett *et al*., 2012) (Appendix 2, Fig. 8). New sites keep being discovered on the North Island (pers. comm. P. Champion).

EPPO region:
In the EPPO region, *A. philoxeroides* is only present in Italy and France (see Appendix 2, Fig. 9). The first record of *A. philoxeroides* in Europe was from France in 1971 (Dupont, 1984; Dupont, 1989). The species was long confined in the SW France between the middle of the Gironde Estuary and the middle course of the River Garonne (Appendix 2, Fig. 10). New populations were found in the same region on the Tarn river in the 2000s (Fried *et al*., 2014). Frequently observed in this area, *A. philoxeroides* never forms dense populations and is not considered as invasive in this Atlantic region (Georges, 2004). In 2013, a new location was found near Sorgues (Provence) on the Ouvèze River, a tributary of the River Rhone in the Mediterranean region (Fried *et al.,* 2014). In just one year, the plant expanded from 10 m^2 to over 1500-2000 m^2 (a stand of 3-4 m width over 500 m long) at the interface between the river and the banks. The species is now considered as an invasive species in the French Mediterranean region.

In Italy it was discovered in 2001 near Pisa, Tuscany (Garbari & Pedullà, 2001) where sizable populations have been recorded from a canal close to Fosso Oncinetto, Madonna dell'Acqua. The plant is also recorded from Tuscany along the Arno river from Signa to Florence as invasive (Iamonico *et al*., 2010; Iamonico & del-Pino, 2015) and in Lazio in Rome along the Tevere river and in the national Park of Circeo in Borgo Grappa as a casual (Ceschin *et al*., 2006). In Lazio the status of *A. philoxeroides* has been updated and it is now considered invasive (Iamonico & Iberite, 2014).

7. Habitats and their distribution in the PRA area

Habitats	**EUNIS** **http://eunis.eea.europa.eu/**	**Presence in PRA area (Yes/No)**	**Comments**	***Reference***
Freshwater bodies including canals, rivers (slow moving), ponds, irrigation channels, estuaries and lakes	C1 : Surface standing waters C2 : Surface running waters	Yes	Major habitat(s) within the PRA area and the habitat(s) at the highest risk of invasion	Bassett *et al*., 2010; Bassett *et al*., 2011; EPPO, 2012; CABI, 2015; Julien & Bourne 1988; van Oosterhout, 2007
Coastal areas	C2 : Surface running waters	Yes	Major habitat especially around the Mediterranean where the species has been predicted to be able to colonise due to the favourable climatic conditions.	Julien *et al*., 1995; Julien & Bourne 1988; van Oosterhout, 2007
Riverbanks	C3 : Littoral zone of inland surface waterbodies	Yes	Major habitat within the PRA area.	Global Invasive Species Database, 2005; Julien & Bourne 1988; van Oosterhout, 2007
Wetlands	C3 : Littoral zone of inland surface waterbodies	Yes	Major habitats within the PRA area.	Julien & Bourne 1988; van Oosterhout, 2007; EPPO, 2012;
Terrestrial – managed including agricultural habitats (poorly drained),	I1 : Arable land and market gardens I2 : Cultivated areas of gardens and parks	Yes	Major habitats within the PRA area though freshwater and riparian systems more prone to invasion due to the spread through these systems.	Clements *et al*., 2014; Julien & Bourne 1988; van Oosterhout, 2007
Terrestrial - natural	E3 : Seasonally wet and wet grasslands	Yes	Major habitats throughout the PRA area though less prone to invasion than riparian systems – water courses.	Julien & Bourne 1988; van Oosterhout, 2007; Bassett *et al*., 2012
Urban - managed	J : Constructed, industrial and other artificial habitats	Yes	Major habitats within the PRA area and highly prone to invasion if riparian systems facilitate spread	Julien *et al*., 1995; Milvain, 1995; Julien & Bourne 1988; van Oosterhout, 2007

8. Pathways for entry

Possible pathways	**Short description explaining why it is considered as a pathway**	Existing legislation?	Pest already intercepted on the pathway? Yes/No
Plants for planting (either as an intentional import as a case of misidentification).	Import of plant material through the aquatic plant trade.	Yes	Australia, **Yes** (Julien and Bourne 1988) Sri Lanka – imported from Australia (personal communication L. Gunasekera, 2015) EPPO region **No**, however see (Brunel, 2009; EPPO, 2012).
Contaminant of plants for planting	Contaminant of import of bonsai plant material	Yes (in part)	(Personal communication van Valkenburg, 2015)
Bird seed	Contaminant from outside the EU		(Personal communication van Valkenburg, 2015; Verbrugge *et al.*, 2014)
Food commodity	Food commodity through misidentification (confusion with *A. sessilis*)		(Personal communication L. Gunasekera, 2015)
Shipping	Transportation via shipping	Yes, but not fully ratified	USA (McCann *et al.*, 1996), and Australia , New Zealand (Hofstra & Champion, 2010). **Yes** EPPO region, No.

In a pathway analysis for aquatic plants entering the EPPO region, Brunel (2009) highlights that *A. philoxeroides* was not reported as an imported species. The author goes on to suggest that this might be because the species is already present, and being propagated within the EPPO region. It is interesting to note that four species from the family Amaranthaceae were imported into the EPPO region between 2006 and 2007. However, this does not exclude the species from being introduced as an ornamental plant in previous years and it is suggested that this pathway is origin of the species in France (EPPO, 2012).

The aquabase web site (www.aquabase.org) lists six species of *Alternanthera* in their database, which gives an indication of the species being present in the aquarium trade. These species are; *A. aquatica, A. bettzickiana, A. cardinalis, A. philoxeroides, A. reineckii, A. sessilis var. rubra*. For *A. philoxeroides* a description is included on its size (60 x 60cm), temperature requirements (18 to 25 ºC), pH (6.60 to 7.00) substrate type (sand) and light intensity (intensive), most of which are incorrect. *A. philoxeroides* is listed in some ornamental books (Cheers (1999) cited in Georges (1998)) or more specifically in aquariology books (Tervers (1995) cited in Georges (2004)) but the authors warn about the potential invasive behaviour of the species. *A. philoxeroides* does not feature in the PPP index, and it is also lacking from other horticultural plant lists. There is little evidence that the species is used as an ornamental/aquarium plant, however, some online forums do highlight that the species is traded/exchanged by private sellers (see http://www.acquariforum.com/forum/showthread.php?t=22206). The species is not recorded in the catalogue of major producers of aquarium plants of South East Asia. In online aquarium fora the plant is highlighted as being a poor species to grow (see http://www.aquaticplantcentral.com/). *A. philoxeroides* is not recorded as being kept in many botanical gardens within the EPPO region.

There is potential that *A. philoxeroides* is being misidentified and imported into the EPPO region under another name. Similar confusion of closely related species has been noted in Sri Lanka by Jayasinghe (2008). Alligator weed has a very similar appearance to another plant native to South America in the same family Amaranthaceae named as mukunuwenna or sessile Joyweed (*A. sessilis*). It is a leafy vegetable and very popular in Sri Lankan diet. There was some confusion among the Sri Lankan community over this leafy vegetable and the alligator weed growing in Australia and Sri Lanka. Sri Lankan communities in Australia were cultivating and unknowingly using alligator weed as a vegetable for over 25 - 30 years until it was located several back gardens in all Australian States and Territories (pers. Comm. Gunasekera, 2015). As a result of the massive public awareness campaign and providing a replacement vegetable plant (*Alternanthera denticulata*), the majority of Sri Lankans in Australia now recognize the difference between their real vegetable - mukunuwenna plant and alligator weed. Alligator weed was first discovered in Sri Lanka in 1999 in Southern Province and suspect that someone from Australia brought the weed into Sri Lanka having mistaken it for Mukunuwenna - Sessile Joyweed (Gunasekera & Bonila, 2001).

Alternanthera philoxeroides seed has been found as a contaminant of bird seed originating from outside the EU (Van Denderen *et al*., 2009).

During a 2014 survey of contaminants from Bonsai plants from China, seedlings of *A. philoxeroides* were found at 2 different importers (pers. comm. van Valkenburg, 2015).

Alternanthera philoxeroides has been recorded entering Australia, New Zealand (Hockley, 1974) and the USA (Carley & Brown, 2006) via ship ballast water. However, it is more probable that the species entered Australia from ship cargo (Julien and Bourne, 1988).

Rating of the likelihood of entry	*Low* ☐	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ☐

9. Likelihood of establishment outdoors in the PRA area

Climatic suitability risk mapping decision support scheme.

Based on the area of potential establishment already identified, how similar are the climatic conditions that would affect pest establishment to those in the current area of distribution?

Answer: **largely similar**, Level of uncertainty: **Low**

Stage 1: Is it appropriate to map climatic suitability?

1.1 Based on the response to the above, is there low uncertainty that the climate in the area suitable for establishment is completely or largely similar to the climate where the pest is currently present?

Yes – The present occurrence and stable habitats of *A. philoxeroides* within the PRA area confirm that the climate is largely similar to that of the current area of distribution.

1.3 Does the species spend a large part of its life cycle experiencing climatic conditions significantly different to those measured at weather stations?

Yes- The species is an emergent aquatic perennial herb

It is not appropriate to use climatic mapping for this species in the EPPO region.

The native range of *A. philoxeroides* is within the Köppen Climate Zone Cfa, the humid subtropical climate (Kottek *et al*., 2006). This climate is characterised by hot muggy summers and frequent thunderstorms. Winters are mild and precipitation during this season comes from mid-latitude cyclones. This climate type is quite common on the east coasts of continents. Average temperature of the warmest month is above 22°C (72°F). Average temperature of the coldest month is below 18°C (64°F) but above -3°C (27°F). Rainfall is equally spread out through the year. Weather is dominated by mid-latitude cyclones in winter. Summers are dominated by frequent thunderstorms because of the presence of Maritime Tropical air masses and intense surface heating. High humidity occurs in summer months. Summer climate is much like humid tropics. Frost can occasionally occur with the presence of Continental Polar air masses in winter. Precipitation varies from 650 to 2500 mm (26 and 98 in.). Invaded regions tend to have climate zones of Cfb, which is only slightly different to Cfa in that the mean temperature of the coldest months are all at least above 10 ºC. There is also a coastal influence in South America of zone Aw, characterised by climates having a pronounced dry season, with the driest month having precipitation less than 60 mm and less than 1/25 of the total annual precipitation. Aw climates are found at the outer margins of the tropical zone, but occasionally at an inner-tropical location.

The species occurs in clearly defined climatic zones, Cfa, Cfb, Csa and Aw (based on the Geiger climate zones (Fig. 11 & 12, Appendix 3).

Rating of the likelihood of establishment outdoors	*Low* ☐	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ☐

10. Likelihood of establishment in protected conditions in the PRA area

Protected conditions could provide suitable habitats for the establishment and persistence of *A. philoxeroides* especially if the conditions contain humidity coupled with aquatic habitats within. However, this scenario should not be considered a relevant situation for this plant species.

Rating of the likelihood of establishment in protected conditions	*Low* ☐	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ☐

11. Spread in the PRA area

Records along the Garonne river (Figure 10) where new populations are regularly found upstream (probably due to human assisted spread) can be used as a very rough estimate of the rate of spread. Between the first record in La Réole in 1971 (Dupont, 1984, 1989) and the most distant sites found upstream (Finhan in 2002), there are about 150 km, that correspond to a mean spread of ~ 5km/year. At a local scale, the population found on the Ouvère river (near Sorgues in Provence) showed that in just one year, the plant expanded from 10 m^2 to over 1500-2000 m^2 (a stand of 3-4 m wide on a 500 m reach) at the interface between the river and the banks.

Natural spread: The likelihood of natural spread within and between EPPO countries is high due to the connectivity of international waterways. The natural spread of *A. philoxeroides* is predominantly by vegetative growth and fragmentation in the field. It is unlikely that seeds are produced in the PRA area. However, in China despite low viability seeds are produced (Zhang *et al*. 2004). This means that spread is more likely by fragmentation. However, we do not have any information on fragmentation rates in the PRA.

Autofragmentation is probably low, but allo-fragmentation in disturbed habitats may be significant. This may contribute greatly to the invasiveness of alligator weed and also make it very adaptable to habitats with heavy disturbance and/or highly heterogeneous resource supply (Wang *et al*., 2009), such as the Ouvèze River. Spread is typically dependent on the aquatic habitat structure and water flow, with lower rates occurring in stable environments and more rapid spread in disturbed habitats with higher flow rates. In contrast, the spread of any terrestrial form is likely to be very slow. Spread to new areas may also be facilitated by water fowl as shown by other invasive species in other aquatic systems around the world (Australian Government, 2003).

Human assisted spread: Human assisted spread is a high risk for this species especially if *A. philoxeroides* becomes more prominent in lakes and rivers where water based recreational or commercial activities take place (Caffrey, 1993). The species can enter dormancy without light and survive desiccation for prolonged periods which would enable the survival of the species on recreational equipment (Schooler, 2012). Such activities may include leisure boating, fishing and water-sports (Caffrey, 1993; Caffrey *et al*., 2010). Water based leisure activities have been shown to facilitate the spread of invasive species in many regions, in particular invasive aquatic weeds (Rothlisberger *et al.*, 2008).

Intentional and unintentional release into the wild can facilitate spread within the PRA area. Intentional release may come from human assisted planting such as a case of mistaken identity that occurred in Sri Lanka (Jayasinghe, 2008). Brunel (2009) has highlighted that *A. sessilis* is traded within the EPPO from plant material from outside the EPPO region. Unintentional releases may occur within and between EPPO countries such as dumping of aquarium material or unintentional releases where the plant is a contaminant.

Human assisted spread may occur within and between EPPO countries though we consider that this is very unlikely at present. However, this pathway for spread has been shown to occur in Australia (van Oosterhout, 2007). Additionally Coventry *et al.* (2002) details that *A. philoxeroides* can also be transported as a contaminant in plant mulching material, although the EWG considers this an unlikely mode of transport in the PRA area.

Rating of the magnitude of spread	*Low* ☐	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ☐

12. Impacts in the current area of distribution

Impacts on biodiversity

In China *A. philoxeroides* has been shown to decrease the stability of the plant community and, over time, permanently displace native species (Guo & Wang, 2009). In India Chatterjee & Dewanji (2014) showed that *A. philoxeroides* reduced macrophyte species richness by up to 30% when the infestation was high. In New Zealand (Bassett, 2008; Bassett *et al*., 2012a) showed that an increasing cover of *A. philoxeroides* decreased native plant species cover which resulted in loss of native species in the long-term. Throughout the plants invasive range, studies have shown that *A. philoxeroides* alters the native plant community composition (Schooler, 2012; Bassett *et al*., 2012a). The latter study also questions the possible effect of biotic resistance with the presence of some species that would be particularly effective competitor against alligator weed and would therefore reduce its impact.

A philoxeroides has been shown to alter the invertebrate and insect community structure in areas that it invades. In New Zealand, the species has been shown to displace specialist invertebrate species compared to native sedges (Cyperaceae) – reducing abundance and species richness (Bassett *et al*., 2012b). In China *A. philoxeroides* infested plots showed lower abundance of native insects compared to uninvaded plots (Pan *et al*. 2010). Possible loss of inanga spawning sites in estuarine situations has also been reported by Timmins and Mackenzie (1995).

Impacts on ecosystem services

A. philoxeroides has been shown to alter macrophyte decomposition rates in north New Zealand lakes (Bassett *et al.*, 2006). *A. philoxeroides* decomposed significantly faster compared to native plant species – which may potentially act to alter the ecosystem processes of the invaded community – aiding the colonisation of additional invasive plant species (Bassett *et al.*, 2006), or perpetuating conditions suitable for *A. philoxeroides*. Dense populations can result in decreased dissolved oxygen below the plant canopy (Quimby and Kay 1976). Cultural services can be degraded by the infestation of *A. philoxeroides* into scenic waterbodies. In China the plant has had serious impacts in famous scenic areas (Commonwealth of Australia, 2012).

Impacts on agriculture

Where *A. philoxeroides* invades agricultural land, the species has been shown to reduce yields for a number of crop species including rice (45%), wheat (36%), sweet potato (63%) lettuce (47%) and corn (19%) (Shen *et al*. 2005; van Oosterhout, 2007). Impacts on agriculture have been recorded throughout the invasive range including USA, North Carolina – where *A. philoxeroides* was infesting over 4000 ha of agriculture land (van Oosterhout, 2007). Additionally the species is reported to invade orchards, tea plantations and berry fields and cause losses of soybean, cotton and peanuts (Commonwealth of Australia, 2012). The species also presents a risk for the vegetable industry valued at $150 million annually in the Hawkesbury–Nepean catchment (http://weeds.dpi.nsw.gov.au/Weeds/Details/7#TOC). In Sri Lanka *A. philoxeroides* competed with the vegetable industry in particularly carrots in 2004 (pers. comm. Gunasekera, 2015).

Impacts on livestock and pasture

Cattle and horses will graze *A. philoxeroides* in terrestrial pasture land though photosensitivity and skin lesions have been associated with feeding on this species – resulting in the death of cattle (van Oosterhout, 2007). In Australia, *A. philoxeroides* successfully outcompetes pasture species like clover (*Trifolium* spp.) and *Pennisetum clandestinum* Hochst. Ex Chiov., degrading pasture lands in terrestrial habitats (Julien&Bourne, 1988). *A. philoxeroides* has been shown to increase breeding grounds for snails and mosquitoes in Asia which can have impacts on livestock, food production and human health (Global Invasive Species Database, 2005; EPPO, 2012).

Economic impacts

Economic impacts have been recorded throughout the invaded range. In just six years, the New South Wales Government spent AUS-$3- million controlling the weed in one irrigation region (van Oosterhout, 2007). During 2008/2009, the NSW spent $800,000 to control alligator weed. If they included additional costs such as public awareness campaigns as well as planning, coordination and inspection, the total expenses would be approximately $1,300,000. In China annual control costs are estimated at US$72 million (Liu & Diamond, 2005).

In Florida, USA, in the 1940s, the economic loss attributed to the invasion of *A.* philoxeroides and *Eichhornia crassipes* (Mart.) Solms., was estimated at over US $20-million per year (Rockwell, 2003). In 2002, the USA control costs are approximately $170 to $370/ha with the herbicides glyphosate and fluoridone (Van Driesche *et al*., 2002). The last three years the total acreage treated was 62 with a total cost of $9,000 – due to the effectiveness of biological control agents under the specific climatic conditions in Florida (Pers. comm. Schardt, 2015).

In Australia, the invasion by the species currently threatens the viability of the turf industry in the Hawkesbury basin, which is valued at over $50million each year (Australian Weeds Committee, 2012). The dense vegetation also has an impact on hydro-electric power production and waterway infrastructure (Csurhes & Markula, 2010).

Impacts on human activities

Aquatic invasive plant species can impact on recreational activities including boating, angling, swimming and other leisure pursuits (Caffrey, 1993; Caffrey *et al*., 2010). Mats of *A. philoxeroides* can choke water bodies reducing access and movement in catchment areas (Julien *et al*., 1992). In developing countries, aquatic plant species can have significant impacts on the livelihoods of poor rural communities who are dependent on the natural resource base to earn a living. Invasive aquatic plants can have negative impacts on communities that depend on fishing to sustain an income (Aloo *et al*., 2013). *A. philoxeroides* increases breeding grounds for mosquitos (Spencer & Coulson, 1976; Julien and Broadbent 1980; Schooler, 2012). The species is also known to produce calcium oxalates which can present a problem if the species is consumed (Bates *et al.,* 1976).

Control methods

In the introduced range, *A. philoxeroides* is managed using both conventional – manual, mechanical and chemical control – and biological control (Sainty *et al.,* 1998; Clements *et al*., 2014). Manual control, i.e. the physical removal of the plant is both time consuming and expensive. All fragments of the plant need to be removed to avoid any regeneration of the population. Further complications can arise for manual control in terrestrial habitats as the species has been recorded as having 10 times more biomass belowground compared to aboveground. Schooler *et al*. (2008) recorded a dry root biomass of 7.3 kg m^{-2} when the population had been established for over 20 years.

Physical control is an approach where chemical control is not deemed feasible –due to the sensitivity of the habitat (Clements *et al.,* 2014). In a study to evaluate the effectiveness of chemical and physical control methods on an early stage infestation, Clements (2014) showed that 75% of the population could be removed using physical removal with minimal follow up treatments required to address any re-growth. Chemical application, specifically Glyphosate (applied at 3 times the manufacturer's recommendations) and metsulfuron-methyl were effective at controlling populations after two years. The effectiveness of herbicides for management of alligator weed have been reviewed by Dugdale and Champion (2012).

Integration of control methods has also been shown to be effective against *A. philoxeroides.* A combination of chemical application, complemented by physical removal during follow up surveys showed success in controlling *A. philoxeroides* in the Coolabah Reserve, New South Wales Australia (van Oosterhout, 2007).

In Asia, (Bangladesh, China, Indonesia, Japan, Myanmar, Nepal, Sri Lanka and Vietnam) *A. philoxeroides* is regarded as a highly invasive weed that causes significant environmental damage to the areas it invades. Management methods may have restricted its occurrence and vigour in some areas, however, the weed is still a prolific invader and a permanent feature in many slow moving water bodies throughout the region (PAN, 2007; Masoodi *et al.*, 2013).

Biological control using natural enemies from the plants native range (classical biological control) has been effective in controlling the species in some countries. The leaf beetle, *Agasicles hygrophila* Selman & Vogt. has been used successfully in Australia (aquatic habitats), New Zealand, the USA and Thailand (CABI, 2015). In Florida, *A. philoxeroides* has been supressed below an ecological and economic threshold and although the species is still present in 80% of public waters – the low levels do not warrant additional control practices (University of Florida, 2015). In Australia, biological control has proved effective in reducing the spread of aquatic populations in regions with mild to warm winters – however, the control of terrestrial populations using biocontrol methods has not been successful.

Rating of the magnitude of impact in the current area of distribution	*Low* ☐	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ☐

Ecosystem services

Ecosystem service	**Does the IAS impact on this Ecosystem service?** Yes/No	**Short description of impact**	**Reference**
Provisioning	Yes	Impacts on agricultural production; degrades pasture land	(van Oosterhout, 2007; Julien & Bourne, 1988)
Regulating	Yes	Degrades biological diversity; alters decomposition rates	Guo & Wang, 2009; Chatterjee & Dewanji, 2014; Bassett *et al.*, 2006)
Supporting	Yes	Alters decomposition rates and adds to habitat instability with the influx of additional IAPs	(Bassett *et al.*, 2006)
Cultural	Yes	Invades scenic areas; restricts access for recreation and tourism	(Commonwealth of Australia, 2000; Julien *et al.*, 1992)

13. Potential impact in the PRA area

Introduction

Alternanthera philoxeroides has been shown to have significant impacts both environmental and economic within the invaded range (excluding the EPPO region) (see section 12). There is no evidence to suggest that the impacts observed will be different in the EPPO region. There are no host specific natural enemies in the EPPO region to regulate the pest species and in many EPPO countries herbicide application in or around water bodies is not permitted. Climate may increase the total area this species is able to invade increasing the impact to the EPPO Region.

Habitats of high conservation value and rare species are present in the potential habitats where the species may occur (including exposed riverine sediments, wetlands, wet grasslands and littoral zones of rivers) .

Impacts on protected sites and endangered habitats within the EPPO region

The EPPO region contains numerous protected sites and endangered habitats throughout. The interface between the freshwater and terrestrial systems, where *A. philoxeroides* could invade, harbours a number of significant habitats that are rare and infrequent in both space and time. Exposed river sediments, for example, are habitats that harbour a number of rare and endangered Diptera and Coleoptera species (O'Callaghan *et al.*, 2013) within the EPPO region; and could potentially be under threat from the occurrence of *A. philoxeroides.* The presence of *A. philoxeroides* in rivers and lakes in the EU can act to degrade such habitats reducing the ecological status of water bodies and therefore degrading habitats.

Impacts on native species within the EPPO region

To-date, there is no research on the impact of *A. philoxeroides* on individual native plant species or native plant communities, or impacts on higher trophic levels in the EPPO region. Where studies have been conducted, with other aquatic weeds forming similar dense stands, for example (Stiers *et al*., 2011; reviewed in Schultz and Dibble 2012), a negative impact on abundance of both plants and macroinvertebrates has been shown.

Human health impacts

A. philoxeroides increases breeding grounds for mosquitoes (Spencer & Coulson, 1976; Julien and Broadbent 1980; Schooler, 2012). The species is also known to produce calcium oxalates which can present a problem if the species is consumed (Bates *et al.,* 1976).

Economic impacts within the EPPO region

The potential economic impact of *A. philoxeroides* in the EPPO region could be significant if the species spreads and establishes in further areas; especially when consideration is given to the loss of earnings and costs associated with management for other aquatic species in Europe. Based on a national survey in France, the cost of water primrose (*Ludwigia* spp.) and waterweed (Elodea spp.) were estimated at nearly 8 million euros a year (low estimate) (Chas & Wittmann, 2015). The annual cost of just one such species, *Hydrocotyle ranunculoides* L., to the British economy alone was estimated at €33-million (Williams *et al*., 2010). The economic impact is expected to be higher for this species as it invades terrestrial and irrigated agricultural areas.

Will impacts be largely the same as in the current area of distribution? Yes /No

If No

Rating of the magnitude of impact in the area of potential establishment	*Low* ☐	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ☐

14. Identification of the endangered area

The **endangered area**

The warmer climatic regions, especially countries within the Mediterranean area Julien *et al*. (1995). Countries most at prone to risk of invasion include: Portugal, Spain, France, Italy, Greece, Turkey, Morocco, Algeria, Tunisia, Monaco and Israel.

Habitats within the endangered area include; riparian systems (slow moving rivers, canals, irrigation canals, lakes, coastal areas etc.), semi aquatic systems, agricultural land, especially floodplains. These regions are predicted and described in section 9. *A. philoxeroides* also has the potential to become established in countries that have thermal water bodies, for example Germany, Hungary, Slovenia, Slovakia and Poland (Hutorowicz 2006; Eliáš *et al*., 2009).

15. Climate change

Climate projection: **2050**

Which component of climate change do you think is most relevant for this organism?

Temperature ***Precipitation*** ***$C0_2$ levels*** ***Sea level rise*** ***Salinity***

*Are the **introduction pathways** likely to change due to climate change and will the overall risk and uncertainly score change due to climate change? (If yes provide new score)*	**Reference**
The introduction pathways are unlikely to change as a result of climate change as the species is mainly thought to enter the EPPO region as a result of the horticultural trade or a contaminant of plants for planting and bird seed. The overall rating for introduction will not change.	(Ensbey & van Oosterhout, 2012) (Brunel, 2009; EPPO, 2012).
*Is the **risk of establishment** likely to change due to climate change and will the overall risk and uncertainly score change due to climate change? (If yes provide new score)*	**Reference**
The risk of establishment will potentially increase with temperature increases. Those areas which are currently unsuitable for the occurrence of *A. philoxeroides* may become more suitable with increased number of day degrees. Extreme weather events, flooding etc., will increase the occurrence and potential areas of establishment for the plant. Of importance, *A. philoxeroides* is highly tolerant to submergence – even though growth is supressed survival rates remain high. *A. philoxeroides* can tolerate high levels of seas-water salinity (10 -30%). The overall rating for establishment will not change.	(Fan *et al*., 2015 ; Global Invasive Species Database, 2015 ; Julien et al., 1995)
*Is the **risk of spread** likely to change due to climate change and will the overall risk and uncertainly score change due to climate change? (If yes provide new score)*	**Reference**
The risk of spread is likely to increase within the EPPO region as established populations build and become more invasive. An increase in extreme natural events, such as increased flooding may act to facilitate movement of the species between areas. At present the population of *A. philoxeroides* in France does not exhibit the invasive tendencies seen in other regions of its invasive range. Increased nitrogen levels have been shown to increase the expansion and invasion capacity of *A. philoxeroides* in China. *A. philoxeroides* has been shown to increase in growth and vigour at elevated C02 levels. The overall rating for the risk of spread will not change.	(Ding and Zhang, 2014; Julien *et al*., 1995; Wang *et al*., 2014; Xu *et al*., 2009)
***Will impacts change** due to climate change and will the overall risk and uncertainly score change due to climate change? (If yes provide new score)*	**Reference**
With increased temperature, C02 levels and nitrogen deposition the impacts of *A. philoxeroides* may be more profound within native plant communities. *A. philoxeroides* has high phenotypic plasticity which will enable the species to persist and outcompete species with restricted habitat requirements. The overall rating for the risk of spread will not change.	Ding and Zhang, 2014

16. Overall assessment of risk

Alternanthera philoxeroides is already present in the EPPO region (and currently spreading in France and Italy) and further spread within and between EPPO countries is considered likely. It is not clear how this species entered the EPPO region and there are no clear pathways of further introduction, as the species is not widely traded as an aquarium plant or as any other type of living plant material. There may be confusion with *A. sessilis*, or other *Alternanthera* species traded for aquarium or ornamental or food purposes, but the EWG was unsure of the volume of traded species via these pathways.

The risk of the species establishing in other EPPO countries is considered high as movement through irrigation and river systems may act to connect countries, facilitating spread regionally, especially through high energy unstable river systems that may encourage fragmentation. Spread via seeds is considered unlikely. Spread will be significantly accelerated by water based recreational activities.

The potentially severe impact of the species within the EPPO region should be considered similar to that seen in other countries where the species has invaded and become established; i.e. Australia and the southern states of North America. Impacts are likely to be more pronounced in countries and regions where the climate is conducive to facilitate stable population growth and spread.

No effects have been reported within endangered areas within the EPPO region (Georges, 2004). However, recently the species has shown increased invasiveness in the areas it occurs (Iamonico & Pino, 2015; Fried *et al*., 2014; Iamonico & Iberite 2014).

Pathways for entry:

Rating of the likelihood of entry	*Low* ☐	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ☐

Likelihood of establishment outdoors in the PRA area

Rating of the likelihood of establishment outdoors	*Low* ☐	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ☐

Spread in the PRA area

Rating of the magnitude of spread	*Low* ☐	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ☐

Impact in the current area of distribution

Rating of the magnitude of impact in the current area of distribution	*Low* ☐	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ☐

Potential impact in the PRA area

Rating of the magnitude of impact	*Low* ☐	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ☐

The risk posed by this species in the potential pathways detailed, plus the spread and impact in the PRA area is an unacceptable risk

17. Stage 3. Pest risk management

The pathways being consider are:
(1) Plants for planting (either as an intentional import as a case of misidentification).

(2) Contaminant of plants for planting

(3) Bird seed contamination

Possible pathways *(in order of importance)*	**Measures identified**
Plants for planting (either as an intentional import as a case of misidentification).	Prohibition of import into and within the EPPO region and within the countries of plants labeled as *Alternanthera philoxeroides* and all other synonyms and misapplied names in use, as well as subspecies.
Contaminant of plants for planting	PC AND Plants have been produced in a pest free area (PFA) Or Plants for planting have been produced in a pest free place of production/production site (official inspections + monitoring and control methods)
Bird seed contamination*	Grain has been produced in a pest-free area (PRA) Or Pest-free place of production/production site (official inspections + monitoring and control methods) Or Cleaning and treatment of grain lot to remove *Alternanthera philoxeroides* seeds,

* Bird seed contaminant refers to grain

Recommendations within countries:
Prohibition of selling, planting, holding, moving, and causing to grow in the wild of the plant in the EPPO region is necessary. Moreover, the plant has to be surveyed and eradicated or contained or controlled where it occurs. In addition, public awareness campaigns to prevent spread from existing populations or from botanic gardens in countries at high risk are necessary. If these measures are not implemented by all countries, they will not be effective since the species could spread from one country to another. National measures have to be combined with international measures, and international coordination of management of the species between countries is necessary.

Certification scheme for pest free production from country of origin. Inspection at points of entry. Awareness raising and training of boarder staff on the species with identification guides at point of entry.

The national measures do not include measures on the contamination of bird seed with *A. philoxeroides*/

The combination of measures are:
At the international level: prohibition of import of the species, with the listing of the species as a quarantine pest.

At the national level:
Prohibition of selling, planting, holding, movement, and causing to grow in the wild of the plant, combined with management plans for early warning; obligation to report findings; eradication and containment plans; public awareness campaigns.

Prohibition of the import, selling, planting, movement, causing to grow in the wild
Considering the high costs to control the plant, the prohibition of the import, selling, planting, movement,

and causing to grow in the wild is very cost-effective.

Prohibition of holding of the species
When the species has spread to unintended habitats, the prohibition of holding will result in an obligation to destroy the holding, contain or control the species.

Containment and control of the species in unintended habitats
Eradication measures should be promoted where feasible with a planned strategy to include surveillance, containment, treatment and follow-up measures to assess the success of such actions. As highlighted by EPPO (2014), regional cooperation is essential to promote phytosanitary measures and information exchange in identification and management methods. Eradication may only be feasible in the initial stages of infestation. This is possible with the current level of occurrence the species has in the EPPO region. Coordination of all stakeholders is required and should be easy to achieve, especially since the distribution is limited.

Decontaminate machinery that has come into contact with populations of the plant.

General considerations should be taken into account for all pathways, where, as detailed in EPPO (2014), these measures should involve awareness raising, monitoring, containment and eradication measures. NPPO's should facilitate collaboration with all sectors to enable early identification including education measures to promote citizen science and linking with universities, land managers and government departments. The funding of awareness campaigns, targeting specific sectors of society, i.e. anglers, and the water based leisure trade will facilitate targeting groups most prone to spread *A. philoxeroides*.

Import for (aquatic) plant trade: Prohibition of the import, selling, planting, holding and movement of the plant in the EPPO region.

Unintended release into the wild: The species should be placed on NPPO's alert lists and a ban from sale would be recommended in countries most prone to invasion. Export of the plant should be prohibited within the EPPO region. Management measure would be recommended to include an integrated management plan to control existing populations. Monitoring and surveillance including early detection for countries most prone to risk. Report any finding in the whole EPPO region in particular the Mediterranean area.

Transportation through recreational activities (method of spread within the EPPO region): Raise awareness on the species, including publicity regarding its identification and its impacts to the sector in question.

Intentional release into the wild: Prohibition on planting the species or allowing the plant to grow in the wild.

Natural spread (method of spread within the EPPO region): Increase surveillance in protected areas where there is a high risk the species may invade. NPPO's to provide land managers and stakeholders with identification guides and facilitate regional cooperation, including information on site specific studies of the plant, control techniques and management.

Transportation through machinery: Raise awareness on the species, including publicity regarding its identification and its impacts to the sector in question.

See Standard PM3/67 'Guidelines for the management of invasive alien plants or potentially invasive alien plants which are intended for import or have been intentionally imported' (EPPO, 2006).

See Standard PM9/19 (1) 'Invasive alien aquatic plants' (EPPO, 2014).

See Standard PP 3/74(1) 'EPPO guidelines on the development of a code of conduct on horticulture and invasive alien plants' (EPPO, 2009).

18. Uncertainty

Pathways for entry – Moderate
Justification for uncertainty score: The fact that *A. philoxeroides* is already present in two countries within the EPPO region highlights that potential pathways for the entry of this species are already present. Pathways for the entry of the species exist (as detailed in section 8) but the number of interceptions has so far been low (see section 8).

Likelihood of establishment outdoors in the PRA area – Low
Justification for uncertainty score: The presence and establishment of the plant in France and Italy justify the low uncertainty score for this category.

Likelihood of establishment in protected conditions in the PRA area – Moderate
Justification for uncertainty score:
Protected conditions could provide suitable habitats for the establishment and persistence of *A. philoxeroides* especially if the conditions contain humidity coupled with aquatic habitats within. However, this scenario should not be considered a relevant situation for this plant species.

Spread in the PRA area – Low
Justification for uncertainty score: The localised distribution of *A. philoxeroides* in France, coupled with the observations that the species does not exhibit the same invasive tendency as it does elsewhere in the invasive range, contrasted with the invasive behaviour of the plant in Italy tend to give some degree of uncertainty to how the species will spread throughout the EPPO region. However, the ability of the plant to produce viable fragments resistant to desiccation and hypoxia suggest the species could be easily spread within the EPPO region.

Impact in the current area of distribution – Low
Justification for uncertainty score: The impacts of *A. philoxeroides* have been fully evaluated within the invasive range. These studies have been conducted scientifically through replication, thus, the low level of uncertainly here is justified.

Potential impact in the PRA area – Low
Justification for uncertainty score: How a weed behaves in one region, under one climatic condition and its associated impacts may be different to that of another region. Because of the similarity of climate, ecological conditions, habitats and the plants amphibious growth habit in the PRA area, compared to the invaded area, similar impacts can be expected. Therefore, even without any scientific studies conducted on this species in the EPPO region, the level of uncertainty is low.

20. Remarks
Inform EPPO or IPPC or EU
Inform NPPO’s, that surveys are needed to confirm the distribution of the plant, in particular in the area where the plant is present on the priority to eradicate the species from the invaded area.

Inform DG Environment on the eligibility of the species for inclusion on the list of IAS of EU concern.

Inform industry, other stakeholders
Inform on the need for correct identification and labelling of the species and on the risk the species present

State whether a detailed PRA is needed to reduce level of uncertainty (if so, state which parts of the PRA should be focused on)
No

Specify if surveys are recommended to confirm the pest status
No

State what additional work/research could help making a decision.
N/A

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Appendix 1. Relevant illustrative pictures (for information)

Figure 1: *Alternanthera philoxeroides* (Mart.) with flower Chris Evans, Illinois Wildlife Action Plan, Bugwood.org

Figure 2: *Alternanthera philoxeroides* (Mart.) invasion in the USA. Chris Evans, Illinois Wildlife Action Plan, Bugwood.org

Appendix 2. Distribution maps of *Alternanthera philoxeroides*

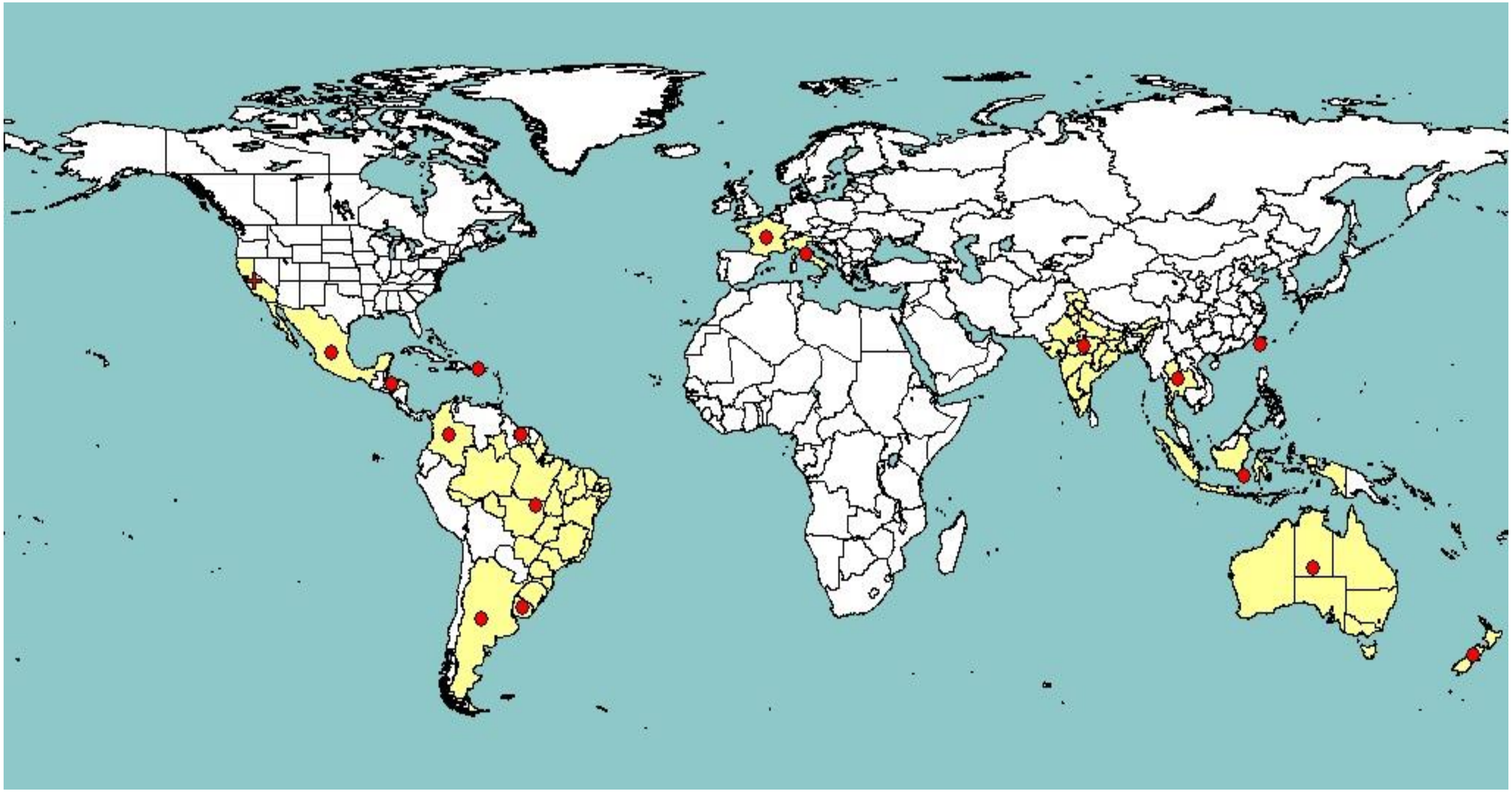

Figure 3: Global occurrence of *Alternanthera philoxeroides* (EPPO PQR)

Figure 4. Occurrence of *Alternanthera philoxeroides* in South America (Data taken from Gbif). Additional points added from scientific sources using Google maps, ggmap Library (R version 3.1.2 (2014-10-31).

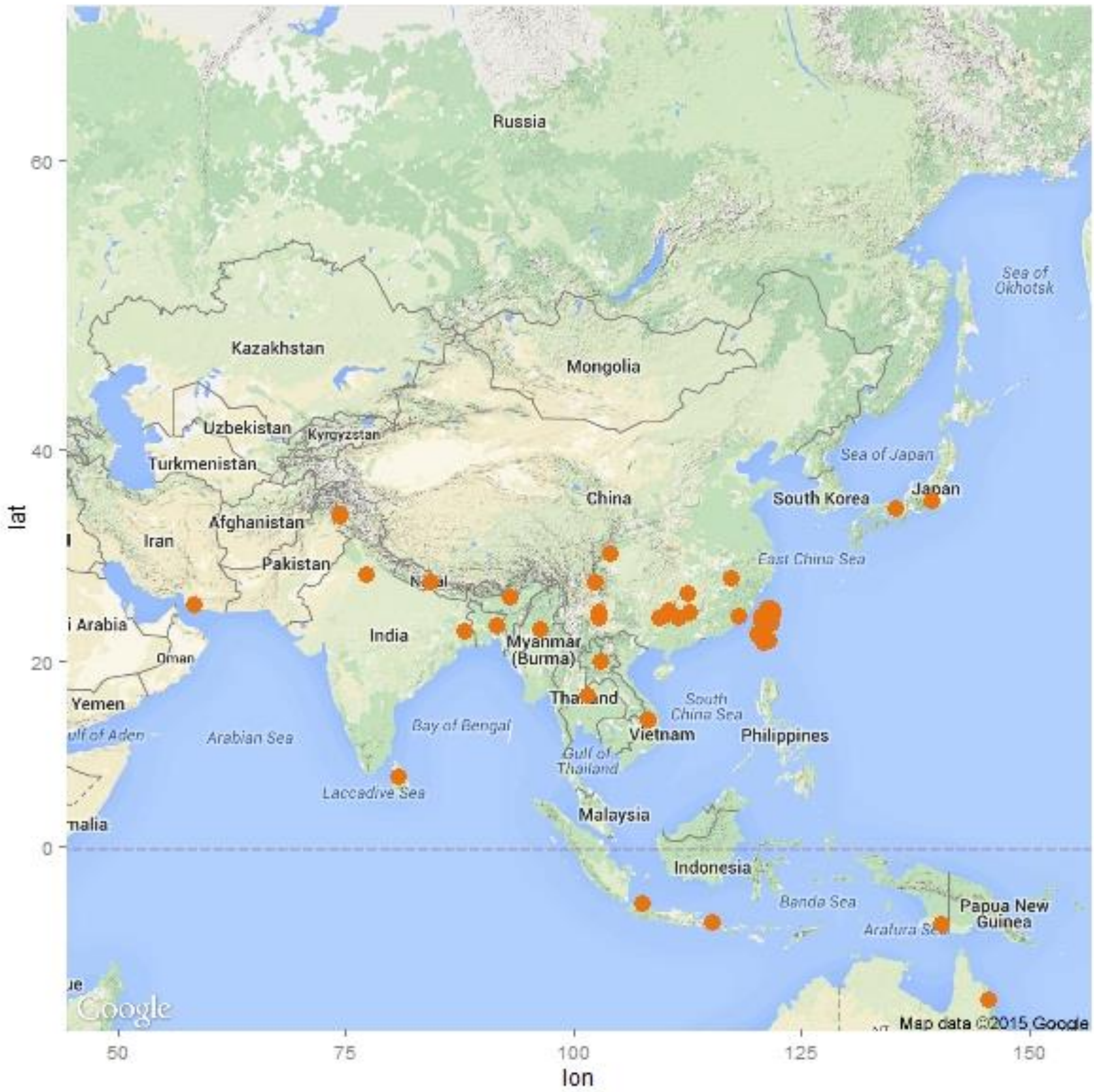

Figure 5. Occurrence of *Alternanthera philoxeroides* in Asia (Data taken from Gbif). Google maps using ggmap Library (R version 3.1.2 (2014-10-31).

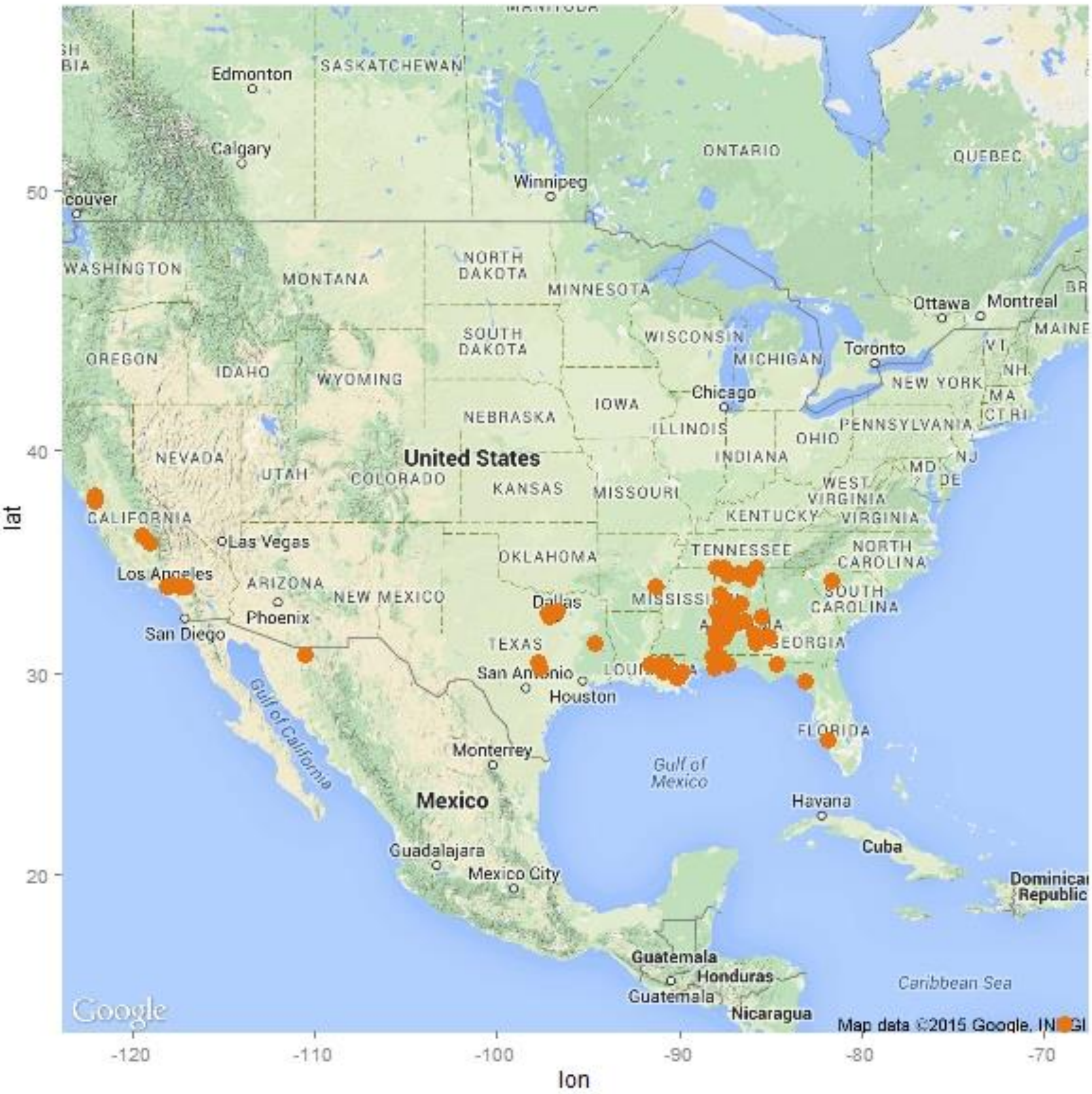

Figure 6. Occurrence of *Alternanthera philoxeroides* in North America (Data taken from Gbif). Google maps using ggmap Library (R version 3.1.2 (2014-10-31).

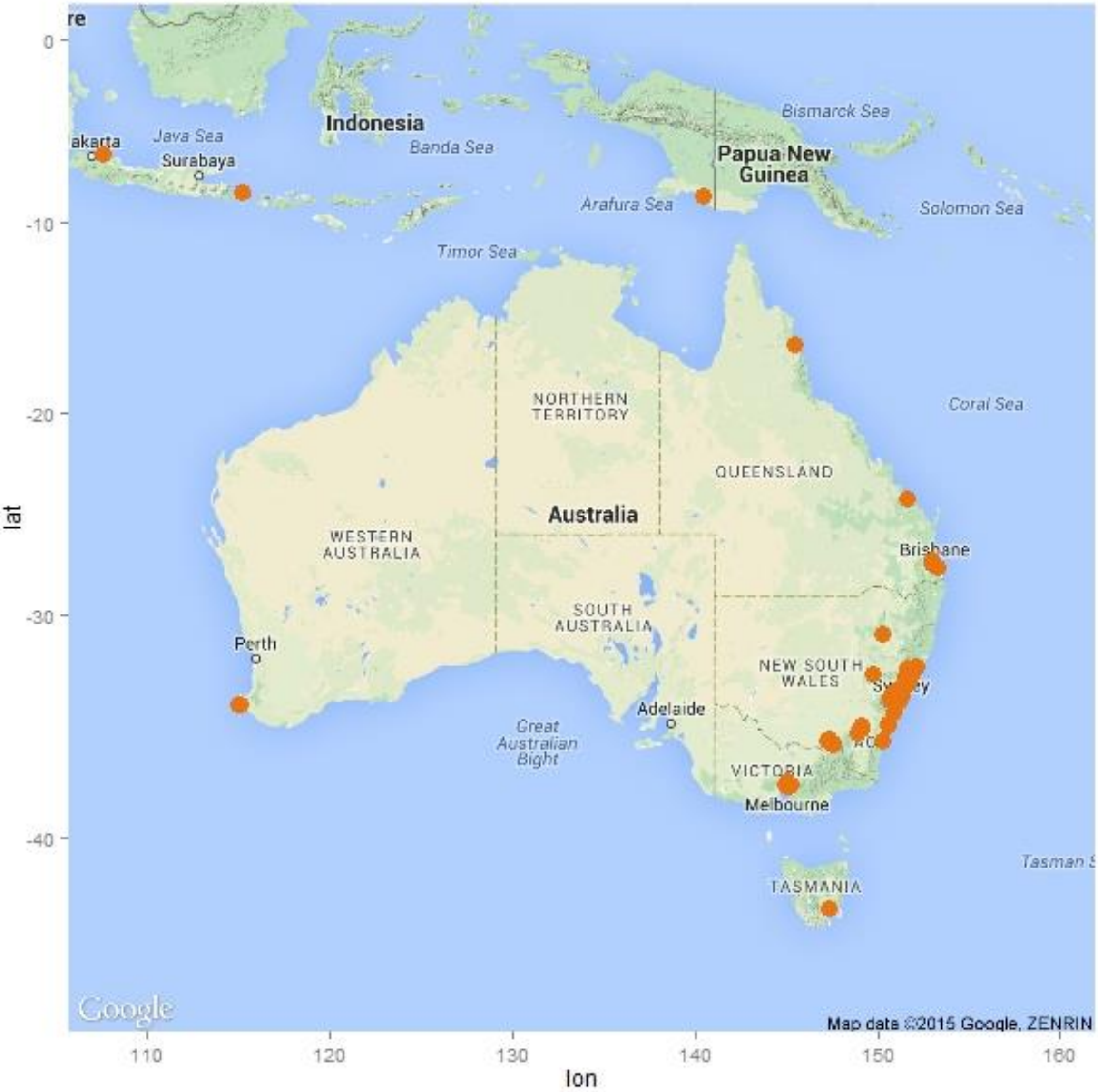

Figure 7. Occurrence of *Alternanthera philoxeroides* in Australia (Data taken from Gbif). Google maps using ggmap Library (R version 3.1.2 (2014-10-31).

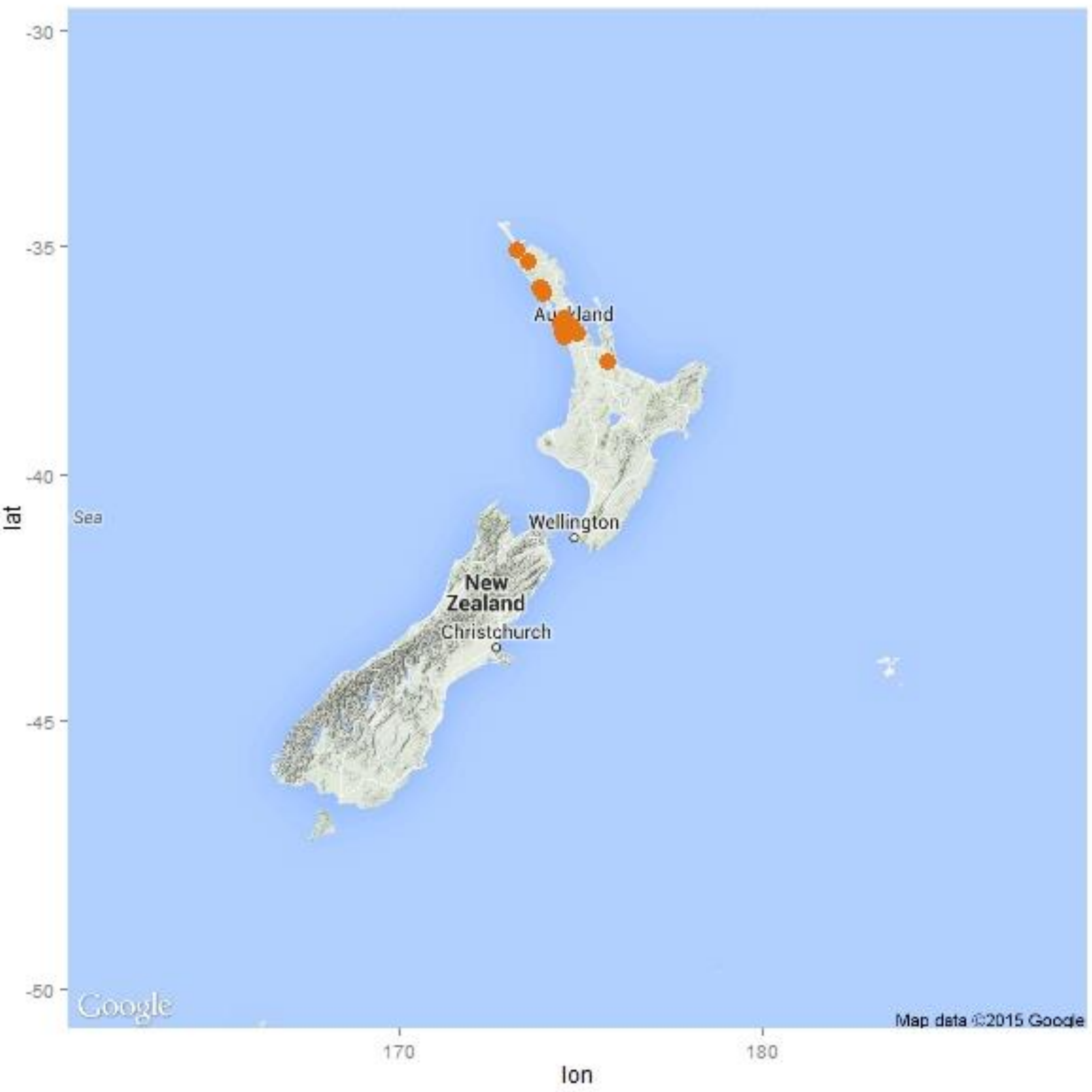

Figure 8. Occurrence of *Alternanthera philoxeroides* in New Zealand (Data taken from Gbif). Google maps using ggmap Library (R version 3.1.2 (2014-10-31).

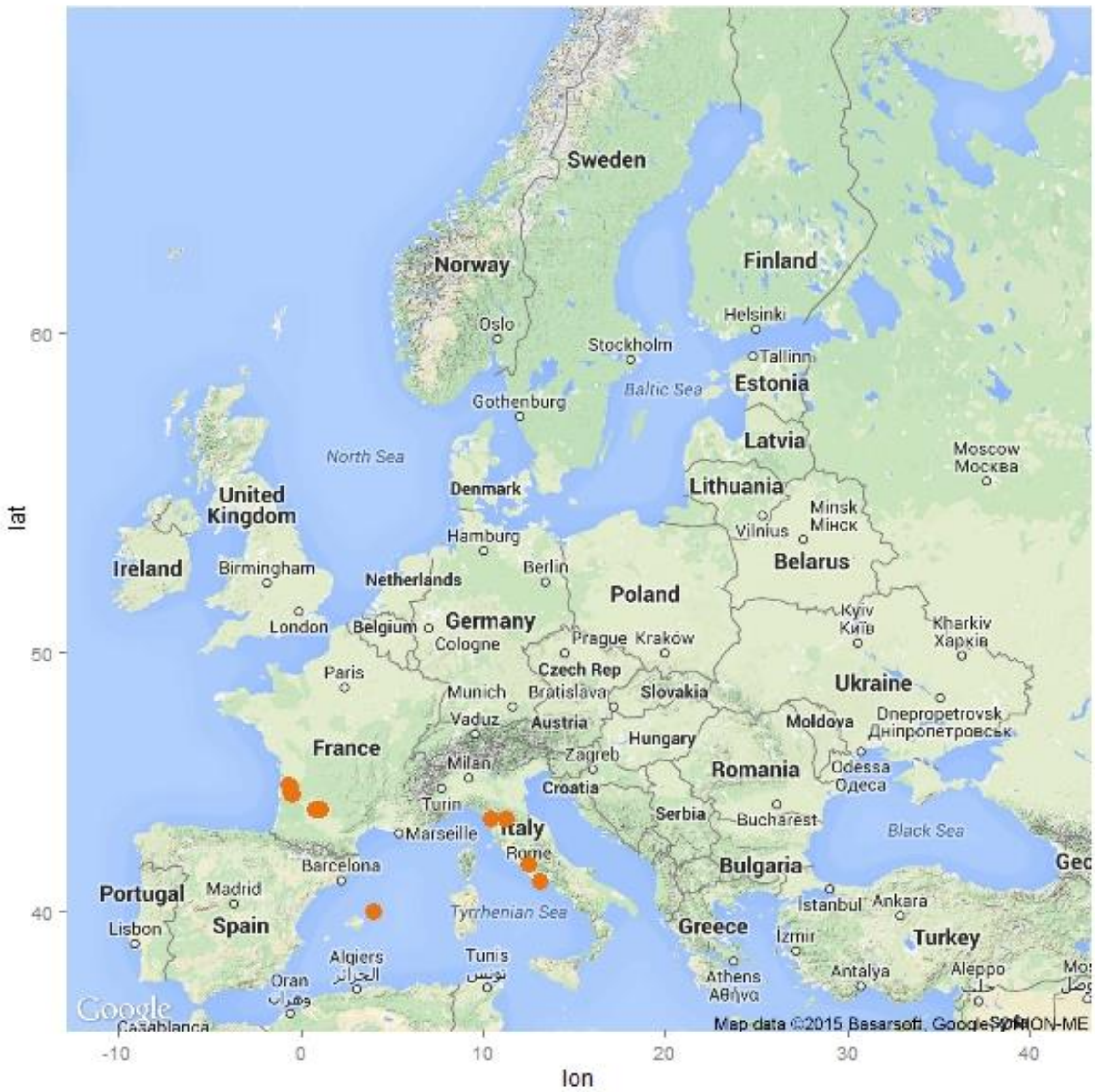

Figure 9. Present occurrence of *Alternanthera philoxeroides* in Europe (Data taken from Gbif). Google maps using ggmap Library (R version 3.1.2 (2014-10-31).

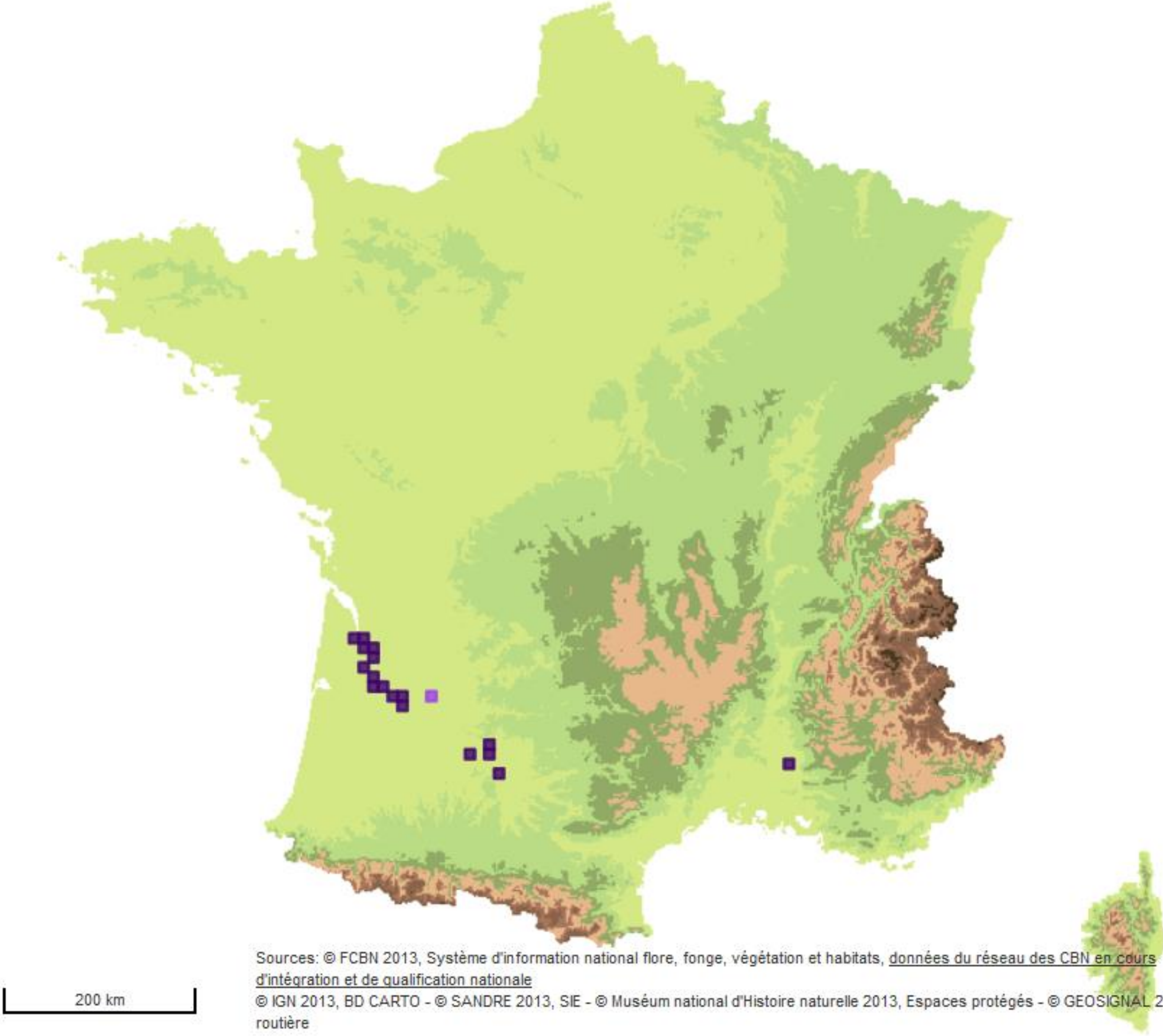

Figure 10. Occurrence of *Alternanthera philoxeroides* in France

Appendix 3. Geiger Climatic Zones

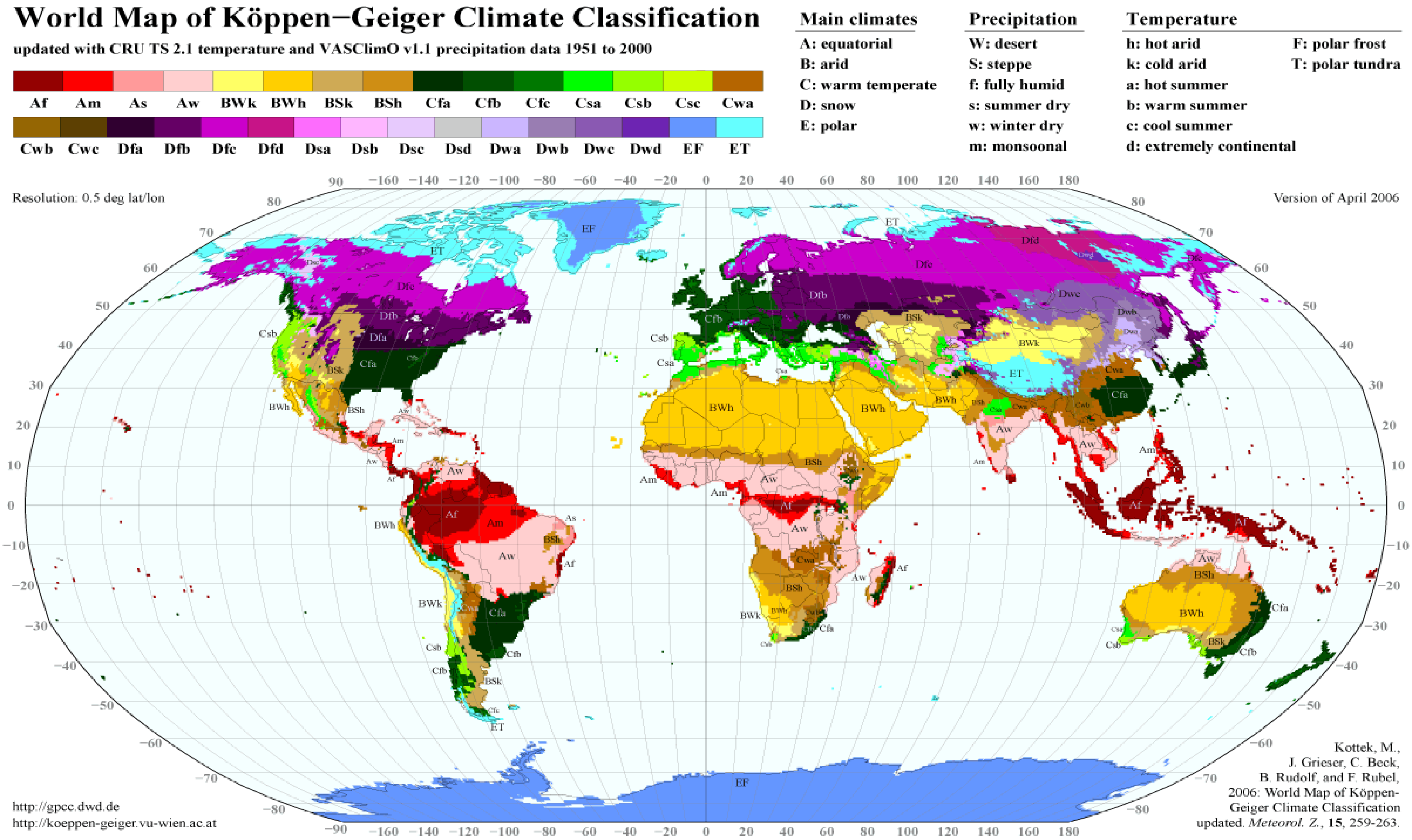

Figure 11. Geiger Climatic Zones

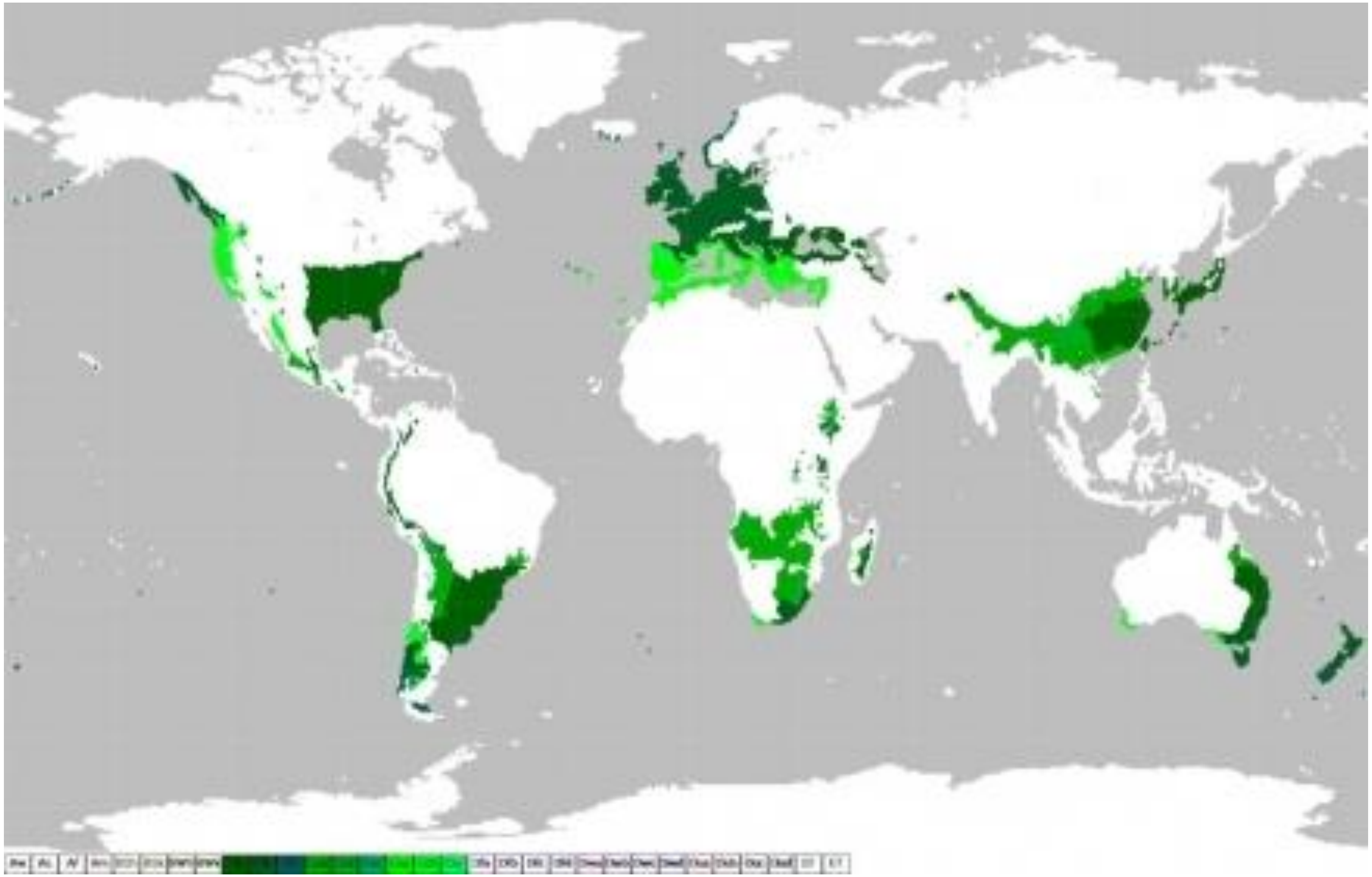

Figure 12. Geiger Climatic Zones - C

Appendix 4. Maps of predicted distribution of *Alternanthera philoxeroides* (Taken from Julien *et al.* 1995)

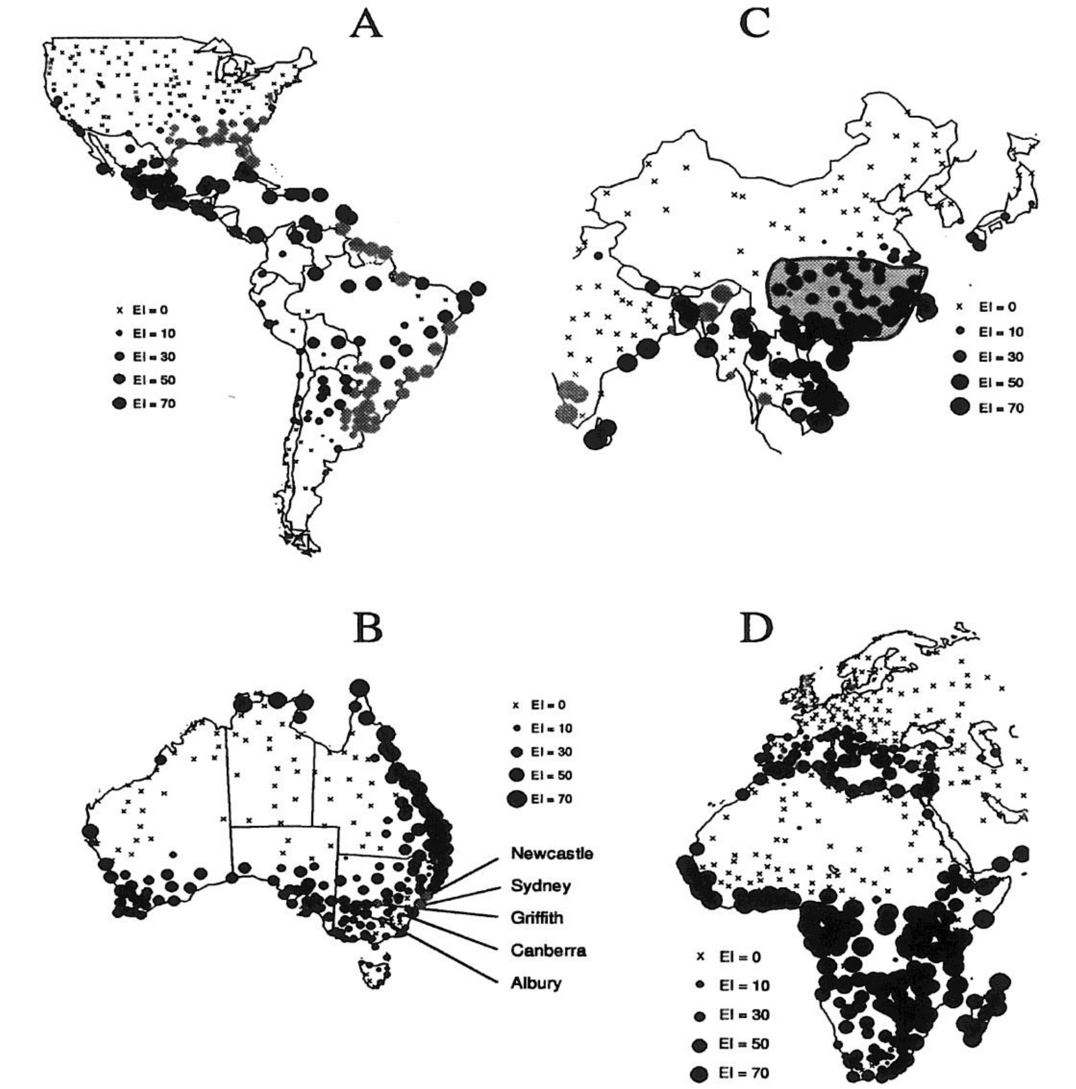

Figure 1. The predicted distributions of alligator weed in: A) The Americas, where locations that occur within the known distributions are hatched and the native range of the weed is considered to be around the Parana River system in north eastern Argentina; B) Australia, where Sydney, Newcastle, Albury and Griffith are hatched to indicate the current distribution; C) eastern Asia, where locations with alligator weed in India, Burma and Thailand are hatched while the southern region of China known to have alligator weed is hatched; and D) Africa and Europe. Crosses indicate unfavourable locations for growth and the areas of circles are proportional to the suitability of the location for the weed.

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Figure 13. Maps of predicted distribution of *Alternanthera philoxeroides* (Taken from Julien *et al.* 1995)