Information on measures and related costs in relation to species included on the Union list

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This technical note provides information on the effectiveness of measures, alongside the required effort and resources, used to prevent the introduction, and to undertake early detection, rapid eradication, and management for the invasive alien species under review. Each table represents a separate measure.

Species (scientific name)	*Alternanthera philoxeroides* (Mart.) Griseb.
Species (common name)	Alligator Weed
Author(s)	Jonathan Newman, Waterland Management Ltd Vines Farm, UK Manuel A. Duenas, NERC Centre for Ecology & Hydrology, Wallingford, UK
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Reviewer	Lalith Gunasekera, Department of Agriculture and Fisheries Queensland, Australia

Summary

Highlight of measures that provide the most cost-effective options to prevent the introduction, achieve early detection, rapidly eradicate and manage the species, **including** significant gaps in information or knowledge to identify cost-effective measures.

Alligator weed (*Alternanthera philoxeroides)* is considered to be one of the worst aquatic weeds in the world. It presents a serious risk for MS with a Mediterranean climatic condition and *A. philoxeroides* is already present in France and Italy. Further spread within and between MS with a Mediterranean climate is considered likely. The most effective method of control is prevention of introduction to new areas which may be achieved by a ban on keeping, importing, selling, breeding and growing of the plant as required under Article 7 of the IAS Regulation, combined with frequent surveys and rapid eradication or, containment (quarantine the area if found) or, control where it occurs (EPPO, 2015). In addition, public awareness and education campaigns to enable early detection by enabling identification and preventing spread in countries at high risk are recommended. It is not clear how this species entered into the EU and there are no clear pathways of further introduction, as the species is not widely traded as an aquarium plant, does not produce viable seeds or as any other type of living plant material. There may be confusion with *A. sessilis*, (a food plant in Sri Lanka, known as ponnanganni (in Tamil), Mukunuwenna (in Sinhalese), sessile joyweed and dwarf copperleaf) or other *Alternanthera* species traded for aquarium, ornamental or food purposes. Alligator weed was discovered being mistakenly grown, shared and sold as a green leafy vegetable (belief as *A. sessilis*) by the local Sri Lankan community in all Australian states (Gunasekera and Bonila, 2001).

Early detection is best achieved by using a well-coordinated citizen science programme in MS at most risk.

Rapid eradication of small infestations (<100m^2) is possible using manual removal of aquatic vegetation, but terrestrial vegetation requires significant excavation of soil up to 1.8m deep. Chemical control using glyphosate is possible using repeated high dose applications for a period of between 3-5 years. This is not recommended because the risk of spread in those 3-5 years is very high, leading to additional populations that will require control.

Management is difficult, labour intensive and requires significant capital investment in equipment and ongoing monitoring up to 10 years. Disposal costs of harvested vegetation will also be high as the risk of regrowth from fragments is high, requiring secure transport equipment.

One significant gap in our knowledge relates to the effectiveness of known biological control agents in MS. However, there are few gaps in our knowledge of this species relating to prevention and management, and published information concludes that the risk of entry of this species is high (especially as it is already present in two MS); that early detection is difficult, and therefore early eradication is nearly always impossible, with management of larger populations being required as an ongoing cost for a period of at least 5 years.

Prevention – measures for preventing the species being introduced, intentionally and unintentionally. This section assumes that the species is not currently present in a Member State, or part of a Member State's territory. **This table is repeated for each of the prevention measures identified.**

Measure description Provide a description of the measure	**A ban on keeping, importing, selling, breeding and growing plants** labeled as A. philoxeroides as required under Article 7 of the IAS Regulation and all other synonyms and misapplied names in use, as well as subspecies.

Effectiveness of measure e.g. has the measure previously worked, failed	The plant was already banned in some MS (import banned in ES and IE; trade banned in PT), and this measure was suggested as best practice for MS with a Mediterranean climate by the EPPO Pest Risk Assessment (EPPO, 2015). The majority of imports of aquatic plants come in to the EU through the Netherlands, although France and Italy may also receive significant volumes (Brunel, 2009). It is probably too early in the process to determine the long term effectiveness of this measure. However, similar bans on aquatic invasive species have been implemented in the UK (Defra, 2013) and in the Netherlands (Verbrugge, 2014) have been successful in the short term in reducing new occurrences of species in the wild, and have also lead to increased awareness of the problem by the horticultural trade.
Effort required e.g. period of time over which measure need to be applied to have results	The effectiveness of import bans requires training in plant identification of border and customs staff. It is likely that the origin of plants is likely to be South East Asia, so inspections need to focus on imports from these countries, but also from Australia where the plant is widespread and available to trade. Considerable effort is required to train border and customs inspectors in plant identification.
Resources required [1] e.g. cost, staff, equipment etc.	It may be an appropriate first step to concentrate expenditure and resources in the Netherlands in order to demonstrate the effectiveness of such an inspection scheme. In addition, there is a big Sri Lankan community in Italy and it may be wise to check imports from Sri Lanka into Italy. This is an ongoing requirement and is estimated (by the author) at circa €100,000 per MS per annum.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	None Known
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	The horticultural trade tends to resist absolute bans on trade in species, unless clear evidence can be presented to demonstrate environmental impact. It is clear from the EPPO PRA (EPPO, 2015) that where this species occurs in MS, that impacts on native species biodiversity, ecosystem services, agriculture, and human activities, with related economic impacts, and any restriction in trade should be acceptable.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction	Additional costs for MS would include the costs of monitoring, database management, reporting and further assessment of management requirements. These can usually be included within the normal activities of regulatory bodies or nature conservation organisations.

- the cost-effectiveness - the socio-economic aspects	
Level of confidence [2] See guidance section	**High** The plant has already been banned in some MS (import banned in ES and IE; trade banned in PT).

Prevention – measures for preventing the species being introduced, intentionally and unintentionally. This section assumes that the species is not currently present in a Member State, or part of a Member State's territory. **This table is repeated for each of the prevention measures identified.**	
Measure description Provide a description of the measure	**Unintentional introductions** Human-assisted spread is a high risk for this species, especially if *A. philoxeroides* is present 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 (Schooler, 2012), e.g., in boating, fishing and water-sports equipment (Caffrey, 1993; Caffrey *et al*., 2010). This species can also be unintentionally introduced by contaminant of plants for planting (EPPO, 2015). Public awareness campaigns are needed to prevent spread from existing populations in countries at high risk. There are already public information campaigns and inspections of boats and fishing equipment, as per the "Check, Clean and Dry" Campaign in the UK (GB Non-Native Species Secretariat, 2017).
Effectiveness of measure e.g. has the measure previously worked, failed	Public awareness campaigns to prevent the spread from existing populations in countries at high risk are necessary. However, if these measures are not implemented by all countries, they will not be effective since the species could spread from one country to another (EPPO, 2015).
Effort required e.g. period of time over which measure need to be applied to have results	The campaigns will need to be run in the long term.
Resources required [1] e.g. cost, staff, equipment etc.	There is no information available about the cost of public campaigns. Given the ease of spread of this plant and the costs linked to its management once established, prevention would be the cheapest course of action.

Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	None known.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	The suggested measures could have a related impact on recreational water activities, but this impact is low compared to the potential impact of the species. Therefore, any restriction of this measure should be acceptable.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	There is no information available about the cost of public campaigns, but the cost of inaction should be greater than the cost of implementing prevention methods, due to the difficulty of eradicating this species once it is established.
Level of confidence [2] See guidance section	**High** Public awareness campaigns have been run in a number of countries, including within the EU and are important tools to stop the human-mediated spread of invasive aquatic plants with positive results in the countries in which they have been implemented.

Early detection - Measures to achieve early detection and run an effective surveillance system for achieving an early detection of a new occurrence (cf. Article 16 of the IAS Regulation). This section assumes that the species is not currently present in a Member State, or part of a Member State's territory. **This table is repeated for each of the early detection measures identified.**	
Measure description Provide a description of the surveillance method	**Citizen Science** in collaboration with a coordinating national body (Maistrello, 2016). Citizen science can broadly be defined as the involvement of volunteers in science. Over the past decade there has been a rapid increase in the number of citizen science initiatives. The breadth of environmental-based citizen science is immense. Citizen scientists have surveyed for and monitored a broad range of taxa, and also contributed data on weather and habitats reflecting an increase in engagement with a diverse range of observational science. Citizen science has taken many varied approaches from citizen-led (co-created) projects with local community groups to, more commonly, scientist-led mass participation initiatives that are open to all sectors of society. Citizen science provides an indispensable means of combining environmental research with

	environmental education, extension and wildlife recording (Roy, *et al.*, 2012).
Effectiveness of the surveillance e.g. has the surveillance previously worked, failed	Delaney *et al*. (2008) successfully used the data collected by citizen scientists to create a large-scale standardized database of the distribution and abundance of native and invasive crabs along the rocky intertidal zone in Massachusetts, USA. An assessment of the accuracy of data collected by citizen scientists showed that, depending on experience, between 80 and 95% accuracy in identification was achieved (Delaney *et al.*, 2008).
Effort required e.g. required intensity of surveillance (in time and space) to be sufficiently rapid to allow rapid eradication	Roy *et al.* (2012) state that "Environmental monitoring relies on long-term support in terms of volunteer liaison, data handling, quality assurance, publication and statistical support for measuring trends, requiring the involvement of a professional scientific organisation. The use of volunteers in Citizen science is critical for the success and is supported at a European-level through the SEBI (Streamlining European 2010 Biodiversity Indicators) "public awareness indicator" which reported that over two-thirds of EU citizens report personally making efforts to help preserve nature. The Pan-European SEBI initiative was launched in 2005. SEBI aims to develop a European set of biodiversity indicators to assess and inform European and global biodiversity targets. SEBI links the global framework, set by the Convention on Biological Diversity (CBD), with regional and national indicator initiatives. Many of the headline indicators rely entirely on the availability of monitoring data and particularly datasets on biodiversity developed by volunteer naturalists (Levrel *et al.*, 2010). The participation of volunteers in the development of these monitoring schemes is not only beneficial in collating large-scale and long-term datasets but also results in other advantages including improvement of the public's knowledge of biodiversity (Cooper *et al.*, 2007), support of public debates and reduction in the costs of biodiversity monitoring (Levrel *et al.*, 2010)."
Resources required [1] e.g. cost, staff, equipment etc.	Integration of accurate citizen science requires a coordinating scientific or government body. Normally the work would be funded by research grant funding, or by direct funding of scientific organisations by MS Governments. Annual costs for running citizen science projects in 2007 – 2008 were estimated at between €80,000 and €170,000 (Roy *et al*., 2012).
Side effects (incl. potential) i.e. positive or negative side effects of the method on public health, environment, non-targeted species, etc.	Positive side effects included greater awareness of environmental problems by the public and trade bodies. The active involvement of volunteers is also likely to provide feedback on potential new problems. Concerns over the quality of data are common, but data quality issues are not unique to citizen science and large sample sizes can increase precision (Hochachka *et al.*, 2012).
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Generally, this technique is accepted by stakeholders, and involvement with research and the scientific community tends to increase acceptance of public funding of such bodies.
Additional cost information [1]	There is a very large cost benefit ratio for citizen science which effectively leverages scientific

When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	effort. Volunteer observers for biodiversity surveillance in the UK were estimated to contribute time in-kind worth more than £20 million during 2007–08 (http://www.jncc.gov.uk/page-3721).
Level of confidence [2] See guidance section	**High** Citizen science has been shown to provide significant leverage in observation power, accurate data (depending on experience and training) and should be encouraged as a valuable tool in the early detection of *Alternanthera philoxeroides* in the EU.

Rapid eradication - Measures to achieve rapid eradication after an early detection of a new occurrence (cf. Article 17). This section assumes that the species is not currently present in a Member State, or part of a Member State's territory. **This table is repeated for each of the eradication measures identified.**	
Measure description Provide a description of the measure	**Physical control** (mechanical or manual) are appropriate for small and isolated situations and are useful in removing initial invaders of a catchment if they can be located early enough. All above and below ground plant material must be removed. Care must be exercised during removal to ensure that broken plant sections are not dispersed on equipment or in downstream flow (Julies and Stanley, 1999). Physical removal of small patches. Excavation of the whole area back to bare soil in terrestrial situations. It is important to prevent any fragments leaving the infested area. Prevention of spread of fragments on machinery by cleaning on site and not leaving any fragments behind is critical.
Effectiveness of measure e.g. has the measure previously worked, failed	Attempts to remove infestations in Australia have not proved successful due to the creation of fragments which spread and caused new populations (CRC, 2003).
Effort required e.g. period of time over which measure need to be applied to achieve rapid eradication	In small infestations, manual removal of floating aquatic plants is relatively easily achieved. Where the population is greater than 100m2, mechanical cutting and harvesting equipment is required, which incurs significant cost in terms of purchase a, transport, labour and maintenance. In addition, unless followed up by careful hand picking of fragments, any machine cutting will inevitably lead to fragmentation and spread. Significant effort is required to ensure that fragments are collected, and that monitoring of the surrounding areas is carried out for at least 3 years after treatment.

	In terrestrial situations, deep excavation of the area is required, with deep disposal (more than 10 m), or incineration on site. This plant forms a very large underground rhizomatous root system that is difficult to control completely. Any fragments not removed from the soil will regrow. When growing in terrestrial conditions, this species can survive without any water for several months (Gunasekera and Adair, 2000). The risk of spread associated with physical removal techniques come from the movement of fragments on machinery and movement of fragments in contaminated soil that is transported away from an infestation. Any machinery involved in the physical removal of alligator weed must be washed down according to strict hygiene protocols to prevent the risk of spreading fragments.
Resources required [1] e.g. cost, staff, equipment etc.	These are dependent on the scale of the problem, but to remove areas of less than 100m^2 should take no more than 1 day, with at least three people. The cost of machinery (mechanical excavator) and disposal of waste material should also be included. An approximate cost for this would be in the order of €4000.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	Mechanical control can damage the bank and surrounding areas, especially considering the depth of excavation required for terrestrial plants (1.8m). Large volumes of decomposing plant material left on river banks is also unacceptable. Environmental impact is limited when the infestation is small, but large populations will cause significant long term damage to riparian habitats. Mechanical control is mostly non-selective and therefore non-target plants will inevitably be damaged.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Mechanical control of aquatic and riparian weeds is generally accepted by stakeholders, unless considerable damage is seen to be done without any effort to reinstate the area. Issues that tend to cause problems are disposal of waste along the banks (not advisable with this species), or leaving piles of rotting material on the banks, which are unsightly, can smell as they rot down and tend to attract flies.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	Once removed it is very likely that regrowth from fragments will occur, despite careful biosecurity arrangements. Therefore, additional monitoring of the managed site and downstream of the site will be required on a regular basis for up to 5 years after removal. Immediate action should be taken is other populations are discovered, with a follow up period of 5 years after every occurrence. The cost of inaction will be very high. Infestations will occur stretching up the bank and across narrow waterways, completely blocking flow or navigation.
Level of confidence [2] See guidance section	**High** Considerable research into the physical management of this species has been undertaken and published.

Management - Measures to achieve management (cf. Article 19). This section assumes that the species is already established in a Member State, or part of a Member State's territory. **This table is repeated for each of the management measures identified.**	
Measure description Provide a description of the measure	**Manual control**, i.e. the physical removal or uprooting 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 in aquatic situations. Further complications can arise for manual control in terrestrial habitats as the species has very deep roots and has been recorded as having 10 times more biomass belowground than aboveground. Schooler *et al*. (2007) recorded a dry root biomass of 7.3 kg m^{-2} when the population had been established for over 20 years. Mechanical or manual control is usually used in sensitive habitats, where damage to non-target plants is unacceptable, e.g. Clements *et al.*, (2014). However, mechanical or manual control provides an immediate control result and should be used at early stages of infestation and on discovery of very new populations, ensuring all fragments are collected and disposed of.
Effectiveness of measure e.g. has the measure previously worked, failed	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. The level of control achieved is probably not sufficient to achieve long term control, and should either be increased in frequency or intensity; or, combined with a frequently repeated mechanical and chemical treatment to control any remaining fragments.
Effort required e.g. period of time over which measure need to be applied to have results	In small infestations, manual removal of floating aquatic plants is relatively easily achieved. Where the population is greater than $100m^2$, mechanical cutting and harvesting equipment is required, which incurs significant cost in terms of purchase a, transport, labour and maintenance. In addition, unless followed up by careful hand picking of fragments, any machine cutting will inevitably lead to fragmentation and spread. Significant effort is required to ensure that fragments are collected, and that monitoring of the surrounding areas is carried out for at least 3 years after treatment. In terrestrial situations, deep excavation of the area is required, with deep disposal (more than 10 m), or incineration on site. This plant forms a very large underground rhizomatous root system that is difficult to control completely. Any fragments not removed from the soil will regrow. When growing in terrestrial conditions, this species can survive without any water for several months (Gunasekera and Adair, 2000).

	If machinery is to be used for physical removal, or if earthmoving is to be done in and around alligator weed infested areas, precautions must be taken to ensure that machinery and soil movement from infested areas to clean areas is limited and that proper wash down and disposal procedures are carried out.
Resources required [1] e.g. cost, staff, equipment etc.	The costs of equipment, staff, fuel, wash down facilities, disposal, transport and monitoring and surveillance are anticipated to be very high when compared to the costs of treating other noxious aquatic weeds.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	The use of herbicides on aquatic populations is not permitted in most MS, therefore manual and mechanical control is normally required. Mechanical control can damage the bank and surrounding areas, especially considering the depth of excavation required for terrestrial plants (1.8m). Large volumes of decomposing plant material left on river banks is also unacceptable. Environmental impact is limited when the infestation is small, but large populations will cause significant long term damage to riparian habitats. Mechanical control is mostly non-selective and therefore non-target plants will inevitably be damaged. Public health can be adversely affected if control is not undertaken, as mosquito control programs can be inhibited by the presence of *Alternanthera* (CABI, 2017).
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Mechanical control of aquatic and riparian weeds is generally accepted by stakeholders, unless considerable damage is seen to be done without any effort to reinstate the area. Issues that tend to cause problems are disposal of waste along the banks (not advisable with this species), or leaving piles of rotting material on the banks, which are unsightly, can smell as they rot down and tend to attract flies.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	Once removed it is very likely that regrowth from fragments will occur, despite careful biosecurity arrangements of the area. Therefore, additional monitoring of the managed site and downstream of the site including the stream banks will be required on a regular basis for up to 5 years after removal. Immediate action should be taken is other populations are discovered, with a follow up period of 5 years after every occurrence. The cost of inaction will be very high. Infestations will occur stretching up the bank and across narrow waterways, completely blocking flow or navigation.
Level of confidence [2] See guidance section	**High** Considerable research into the physical management of this species has been undertaken and published.

Management - Measures to achieve management (cf. Article 19). This section assumes that the species is already established in a Member State, or part of a Member State's territory. **This table is repeated for each of the management measures identified.**	
Measure description Provide a description of the measure	**Chemical application**, specifically glyphosate, dichlobenil and metsulfuron-methyl effectively controlled populations after two years (Clements *et al*., 2014). The effectiveness of herbicides for management of alligator weed has been reviewed by Dugdale and Champion (2012). EU/national/local legislation on the use of plant protection products and biocides needs to be respected.
Effectiveness of measure e.g. has the measure previously worked, failed	Dugdale and Champion (2012) state "Although several herbicides achieved good to excellent control (80–89% and 90–100%, respectively) in the short- and medium-term, good to excellent long-term control was not as common and usually required repeated herbicide applications. For example, good to excellent long-term control was reported on eight occasions where herbicide was applied more than once: glyphosate three or four times within 12 months (Schooler *et al*., 2007); imazapyr once per year for two years (Langeland, 1986) and twice in 10 months (Hofstra and Champion, 2010); metsulfuron-methyl, three or four times within 12 months (Schooler *et al*. 2008), five times over two years (Schooler *et al*., 2010) and twice in 10 months (Hofstra and Champion 2010); and triclopyr, three or four times within 12 months (Schooler *et al*., 2008) and twice in 10 months (Hofstra and Champion, 2010). Where herbicide was only applied once, good to excellent long-term control was only achieved on five occasions, twice with imazapyr (Allen *et al*., 2007, Hofstra and Champion, 2010) and once each with dichlobenil, karbutilate (Blackburn and Durden, 1974), and metsulfuron-methyl (Hofstra and Champion, 2010). However, only a single application of metsulfuron-methyl and imazapyr to young plants (3-months old) resulted in excellent control, with older plants being less effected (Hofstra and Champion, 2010). For established plants, Allen *et al*. (2007) reported that imazapyr was applied once to alligator weed in the spring and autumn, and only the autumn application resulted in effective long-term control. They suggested that this was because of better downward translocation of the herbicide at this time of year. The marshes that they did the experiment in were inundated after herbicide application, which offers an alternative explanation for the effective control after a single application because inundation after herbicide application has been observed anecdotally to improve control with herbicides (Steenis and McGilvery, 1961; Langeland, 1986). Although the mechanism for this improved control is not known, it seems likely that alligator weed under water will be stressed through reduced gas exchange capacity and reduced light availability.

	The need for multiple herbicide applications was also demonstrated by Bowmer *et al*. (1991), who tested at least 100 combinations of herbicides in ten experiments in replicated damp terrestrial plots over three years in New South Wales, Australia. They found that no single herbicide application eradicated alligator weed; repeat applications were always necessary. The best treatment regimes were 1) a single application of dichlobenil followed by metsulfuron or glyphosate nine months later or 2) three applications of metsulfuron or metsulfuron + glyphosate over 18 months." In experiments conducted by Clements *et al.*, (2014), glyphosate treatments at 3 × label rate treatment provided the greatest level of control and were considerably more effective than 1 × label rate at 11 and 48 weeks after treatment (WAT). By 91 WAT abundance remained considerably less than controls. Dichlobenil provided excellent control, reducing alligator weed abundance by 100% for all rates up to 11 WAT, which was maintained at 48 and 91 WAT for 2 × label rate. Dichlobenil treatment at 2 × label rate was more effective than the 1 × and 0.5 × label rate treatments. Metsulfuron-methyl treatments reduced alligator weed abundance to near zero by 7 to 9 (WAT), however, by 48 WAT regrowth had occurred. By 91 WAT abundance remained considerably less than controls (Clements *et al.,* 2014). The addition of a surfactant to metsulfuron-methyl treatments had no effect on control efficacy. The relative effectiveness of herbicides that achieved good to excellent control has been examined. Imazapyr, (dichlobenil) and metsulfuron-methyl provide the best and most consistent control of alligator weed while triclopyr triethylamine and glyphosate are less effective (Dugdale & Champion, 2012). Increased effectiveness of foliar applied herbicides may be achieved by using selective approved adjuvants in aquatic situations (Dugdale & Champion, 2012). Most of these herbicides, except for some glyphosate formulations, are not approved for use in or near water in MS.
Effort required e.g. period of time over which measure need to be applied to have results	Herbicide treatments need to be applied at greater than the label rate to be effective, but only required application once per year (van Oosterhout, 2007).

Resources required [1] e.g. cost, staff, equipment etc.	Herbicide costs are relatively low (Glyphosate as Roundup pro Biactive 360 is ~ €60 for 5 litres), which at 3 times the label rate would treat and area up to 6000m^2, giving a cost per hectare of €96 for herbicide. Labour costs can be up to €250 per day per man, and given that two men can spray approximately 1-2 hectares per day the cost per day per hectare is likely to be €250. Equipment is also relatively simple and therefore cheap. Trained staff are required to undertake spraying operations in or near water and the costs of training is approximately €600 per man. These costs are dependent on ease of access to sites. Where access is difficult, costs may be double these quoted.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	Glyphosate is fully approved for use in aquatic and terrestrial habitats in some MS and has no long term environmental impact. Dichlobenil and metsulfuron-methyl are currently not approved for aquatic use in the EU and are unlikely to be used unless *A. philoxeroides* becomes widespread and abundant.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Herbicide application to water is always a controversial issue with stakeholders, but careful consultation and education can usually alleviate some of their concerns. Chemical control of *A. philoxeroides* is unlikely to have any impact on economic activities, or any effect on animal welfare, especially if using glyphosate.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	The cost of implementation for member states will be linked to the cost of surveying and monitoring, which are dependent on the effort applied. The cost of inaction by any member state where this species occurs is likely to be high, and if efforts to prevent spread are unsuccessful, then costs of eradication often become too high to justify, and prioritised control measures are usually implemented in the most sensitive sites. Herbicide control using glyphosate appears to be very cost effective, with the total per hectare cost approaching €350. Some difficulty is anticipated when using herbicides to treat weeds in water (use small boat), the cost of education and training of local stakeholders should be included as part of the treatment programme.
Level of confidence [2] See guidance section	**Medium** This assessment is based on similar herbicides used in a different part of the World. It may be that the species responds differently to the same herbicide in the EU.

Management - Measures to achieve management (cf. Article 19). This section assumes that the species is already established in a Member State, or part of a Member State's territory. **This table is repeated for each of the management measures identified.**	
Measure description Provide a description of the measure	**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 the USA from the mid-1970s, control programs integrating herbicide (2,4-D or 2,4,5-T) with biological control (using flea beetles (*Agasicles hygrophila* Selman and Vogt), thrips (*Amynothrips andersoni* O'Neill) and moths (*Vogtia malloi* Pastrana)) had been established (Durden *et al*., 1975). Fortunately, good control of floating alligator weed was achieved with the flea beetle, particularly when integrated with herbicide programs (Durden *et al*. 1975, Gangstad, *et al*., 1975). It should be borne in mind that the release of macro-organisms as biological control agents is currently not regulated at EU level. Nevertheless national/regional laws are to be respected. Before any release of an alien species as a biological control agent an appropriate risk assessment should be made. In addition EU/national/local legislation on the use of plant protection products and biocides needs to be respected.
Effectiveness of measure e.g. has the measure previously worked, failed	The combined use of glyphosate and physical removal controlled the species in under 5 years (van Oosterhout, 2007). However, attempts to establish the alligator weed flea beetle have been unsuccessful in North Carolina due to cold sensitivity (Langeland, 1986). This means that floating aquatic alligator weed poses a much greater problem in these areas and herbicide control programs are required for the aquatic ecotype (Dugdale & Champion, 2012).
Effort required e.g. period of time over which measure need to be applied to have results	The period of time needed to ensure complete control is based on the requirement for follow up surveys. While all the weed will probably have been controlled in 3 years, surveys are necessary for at least 2-5 years after complete control has been demonstrated.
Resources required [1] e.g. cost, staff, equipment etc.	Labour costs are approximately €250 per day, for three people over five years, with three surveys per year this is a total cost of €3,750, per site, plus the costs of the initial control which are estimated at €600 per hectare. Equipment is relatively simple and therefore cheap. Disposal costs of physically removed material should be taken into consideration, with burying on site being the cheapest option.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	With careful application of the herbicide element of this treatment, effects on non-target species are very limited. Physical control usually has few side effects, except perhaps trampling of native vegetation and the costs of disposal. Public health is unlikely to be affected. The control measure has a short term effect on the local environment, but recovery of native species is rapid and normally within 1 year.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare	Herbicide application to water is always a controversial issue with stakeholders, but careful consultation and education can usually alleviate some of their concerns. Chemical control of *A.*

considerations, public perception, etc.	*philoxeroides* is unlikely to have any impact on economic activities, or any effect on animal welfare, especially if using glyphosate (bioactive?).
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	The cost of implementation for member states will be linked to the cost of ongoing public awareness, surveying and monitoring, which are dependent on the effort applied. The cost of inaction by any member state where this species occurs is likely to be high, and if efforts to prevent spread are unsuccessful, then costs of eradication often become too high to justify, and prioritised control measures are usually implemented in the most sensitive sites. Herbicide control using glyphosate appears to be very cost effective, with the total per hectare cost approaching €350. Some difficulty is anticipated when using herbicides to treat weeds in water, the cost of education and training of local stakeholders should be included as part of the treatment programme.
Level of confidence [2] See guidance section	**Medium** This assessment is based on similar herbicides used in a different part of the World. It may be that the species responds differently to the same herbicide in the EU.

Management - Measures to achieve management (cf. Article 19). This section assumes that the species is already established in a Member State, or part of a Member State's territory. **This table is repeated for each of the management measures identified.**	
Measure description Provide a description of the measure	**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 provided good suppression in aquatic infestations in the Sydney region of Australia, successfully reducing large floating infestations on permanent water bodies back to edge infestations (Julien, 1981) and successfully in New Zealand, the USA and Thailand (CABI, 2017). It should be borne in mind that the release of macro-organisms as biological control agents is currently not regulated at EU level. Nevertheless national/regional laws are to be respected. Before any release of an alien species as a biological control agent an appropriate risk assessment should be made.
Effectiveness of measure e.g. has the measure previously worked, failed	*Agasicles hygrophila*, a biocontrol agent originally from Argentina, has been introduced into other countries. In Australia, it is established and successfully controls *A. philoxeroides* in aquatic habitats. In New Zealand, it destroys most foliage of the weed annually. In Thailand, it has spread around Bangkok and the lower central plain area producing excellent control of *A. philoxeroides*. In the USA, this biocontrol agent is generally successful in controlling the weed in Southern States (CABI, 2017).

	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 biological control methods has not been successful (CABI, 2017). Alligator weed flea beetle (*Agasicles hygrophila*) is limited to warm temperate and subtropical areas and the predicted range of alligator weed in Australia far exceeds the predicted range of the flea beetle (Julien, Skarratt and Maywald, 1995). Suppression by the flea beetle occurs where winters are mild and can take several seasons after the beetle is released. In cooler areas the insect may survive, but lower temperatures limit population increase and suppression does not occur. Populations of insects can't survive where frost or ice kills the tops of the alligator weed stems. New populations may recolonise each year from warmer areas but fail to increase to damaging levels before next winter (Coulson, 1977).
Effort required e.g. period of time over which measure need to be applied to have results	The initial period of host specificity testing would take approximately 3 years, after which the agent could be released. If survival over winter is achieved, the populations should be self-sustaining. Otherwise, in house rearing and re-release every year would be required in summer months.
Resources required [1] e.g. cost, staff, equipment etc.	Usually significant effort is required before release of a biological control agent, and this would be required for European non-target species. . However, most biological control agents have been identified, and the choice of agent would be straightforward.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	In a well-managed biological control program, there should be no side effects. Non-target plants will not be affected as they will have been included in the rigorous testing program. Effects on public health will be positive as mosquito breeding areas created by stagnant water amongst stands of *A. philoxeroides* will be removed
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	The cost of testing established biocontrol agents from other parts of the world in MS conditions would probably cost in the region of €300,000. This could be carried out in one MS and information used for others, so costs need not be repeated. The cost effectiveness (benefit : cost) of biological control programs of aquatic weeds range from 2.5 to 1 to 15:1 (McConnachie *et al.,* 2003) and up to 4000:1 (Culliney, 2005). Socio economic impacts are rare and often supportive if the problem and solution is explained fully. However, careful management of biological programs is usually necessary, despite the adverse impact of the target weed. The cost of inaction would be very high. There is no limit to the spread of this species in suitable

	habitats in Mediterranean climates. Even temporarily dry streams are susceptible.
Level of confidence [2] See guidance section	**High** Significant control has been achieved in Florida, and similar control levels are anticipated in MS with a Mediterranean climate. It is doubtful if effective biological control agents will survive in more northern MS.

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Notes

1. Costs information. The cost information depends on the information available.

2. Level of confidence provides an overall assessment of the confidence that can be applied to the information provided for this method.

- **High**: Information comes from published material, or current practices based on expert experience applied in one of the EU countries or third country with similar environmental, economic and social conditions.
- **Medium**: Information comes from published data or expert opinion, but it is not commonly applied, or it is applied in regions that may be too different from Europe (e.g. tropical regions) to guarantee that the results will be transposable.
- **Low**: data are not published in reliable information sources and methods are not commonly practiced or are based soley on opinion; This is for example the case of a novel situation where there is little evidence on which to base an assessment.

3. Citations and bibliography. The APA formatting style for citing references in the text and in the bibliography is used.
e.g. Peer review papers will be written as follows:
In text citation: (Author & Author, Year)
In bibliography: Author, A. A., & Author, B. B. (Publication Year). Article title. *Periodical Title*, Volume(Issue), pp.-pp.
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