Information on measures and related costs in relation to species considered for inclusion 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.

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Comments which could support improvement of this document are welcome. Please send your comments by e-mail to *ENV-IAS@ec.europa.eu*

Species (scientific name)	*Cardiospermum grandiflorum* Sw., Prodr. Veg. Ind. Occ. 64 (1788)
Species (common name)	European common names • English: balloon vine, heart seed vine, heartseed, showy balloon vine, grand balloon vine, heart pea • Italian: Cardiospermo a fiori grandi • Spanish: amor en bolsa, farolillo, globillo, tronadora • Portuguese: balãozinho, cipó-timbó-miudo Additional common names • Australia: large balloon creeper • Cook Islands: kopūpū takaviri (Maori) • Jamaica: heart pea, wild supple jack

	• South Africa: blaasklimop, opblaasboontjie (Afrikaans), heart seed, intandela, uzipho (Zulu) (Pasiecznik, 2014; EPPO, 2016)
Author(s)	Nicola Schoenenberger, Innovabridge Foundation, Contrada al Lago 19, 6987 Caslano Switzerland.
Date Completed	15/10/2017
Reviewer	Giuseppe Brundu, Department of Agriculture, University of Sassari, Viale Italia 39, 07100 Sassari, Italy

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.

Cardiospermum grandiflorum Sw. (Sapindaceae) is an herbaceous, perennial, seed propagated climber plant (vine). The species also spreads vegetatively by suckering and root fragments (Pasiecznik, 2014). Its wide Neotropical native range spreads from southern Mexico to the Caribbean (type specimen from Jamaica) and Brazil (Carrol *et al.*, 2005). It's nativeness to tropical Africa has been questioned and remains to be confirmed (Gildenhuys *et al*., 2013; EPPO, 2016). The species is invasive in South Africa, Australia, Cook Islands, Fiji, French Polynesia, New Zealand and Malta; it is introduced to Sri Lanka, naturalized in the USA and its casual presence has been recorded in France (Landes and Alpes-Maritimes) and Italy (Sicily); non-native records exist for the Canary Islands (Spain) and Madeira (Portugal), with unknown invasion status (EPPO, 2016).

C. grandiflorum is invasive in riparian habitats, along forest margins, and is also found in rocky habitats, disturbed sites such as urban areas, transport infrastructure and agricultural fields (EPPO, 2017). *C. grandiflorum* performs best in subtropical climates with mean annual temperature between 15 °C and 25 °C (Pasiecznik, 2014), the only extensive invasion reported in a Mediterranean climate refers to Malta (Ameen, 2013).

C. grandiflorum is principally introduced through ornamental trade (Henderson, 2001; Pasiecznik, 2014), although it is infrequently listed in online nursery catalogues. Moreover, its seed-carrying inflated capsules of can float for extensive periods in watercourses (e.g., along rivers and across the sea) and thus can cover substantial distances over short time scales (Gildenhuys, 2015a). A trade ban, combined with awareness campaigns aimed *inter alia* at collectors exchanging seeds non-commercially (e.g. botanical gardens), early detection and rapid eradication measures, would prevent spread and negative impacts in balloon vine-free areas.

Mechanical, often combined with chemical control has proven to be efficient to eradicate *C. grandiflorum*, especially at initial stages of the infestation (BRAIN, 1997; Biosecurity Queensland, 2013; PIER, 2013; Weedbusters, 2017), also considering its relatively short lived seed bank. Biological control by the seed-feeding weevil *Cissoanthonomus tuberculipennis* is being implemented in South Africa since 2013, and first results indicate efficient

establishment and spread of the agent and a significant decrease in seed production by *C. grandiflorum*.

Prevention – measures for preventing the species being introduced, intentionally and unintentionally. **This table is repeated for each of the prevention measures identified.**	
Measure description Provide a description of the measure	**The risk of intentional introductions can be reduced by the implementation of a ban on keeping, importing, selling, breeding and growing the species.** Ornamental trade is the main pathway of introduction of *C. grandiflorum* around the world (Henderson, 2001; Pasiecznik, 2014). Avoidance of new introductions or further spread through the promulgation of trade bans is thus considered the most efficient and cost-effective prevention measure. In online nursery catalogues**,** *C. grandiflorum* is relatively infrequently listed, whereas the congeneric *C. halicacabum* is more readily available. In South Africa and the Australian states of New South Wales and Queensland, *C. grandiflorum* is currently listed as a noxious weed, and in New Zealand as an 'Unwanted Organism' under state legislation. Listing implies the obligation to contain or control populations according to specified management plans issued by the authorities (Australia), the execution of a government sponsored management programme (South Africa), or the possible eradication following extensive management efforts. Moreover, regulation prohibits ownership, import, sale, propagation, distribution and dumping into the environment (EPPO, 2016). Risk assessments classifying *C. grandiflorum* as a 'High Risk' species have been conducted for the USA (USDA, 2013), and for Hawaii and other Pacific Islands (PIER, 2013). In the EPPO region, the likelihood of establishment and the potential impact were assessed as being moderate, with a moderate to high uncertainty. However, it was added to the EPPO Alert List in 2012 and transferred to the List of Invasive Alien Plants in 2013. In the framework of the LIFE project IAP-RISK, EPPO has prepared a full PRA (Pest Risk Analysis) and scored *C. grandiflorum* as a 'High Risk' species under future climatic scenarios and therefore recommended it for regulation as a quarantine pest (EPPO, 2016).
Effectiveness of measure e.g. has the measure previously worked, failed	The promulgation of trade bans and listings generally occurred decades after introduction and invasion, limiting the effectiveness of the measure. In Australia, first records *C. grandiflorum* date back to 1923 (Carroll *et al.*, 2005a) but regulation was put into force in 1999 (Environment Protection and Biodiversity Conservation Act). In South Africa, the species was introduced around

	100 years ago (Simelane *et al.*, 2011) and became listed in 1982 (under Conservation of Agricultural Resources (CARA) Act 43), long after its rapid spread to several of the country's provinces (Henderson, 2001; Simelane *et al.*, 2011). In New Zealand, it was listed in 1999 under the country's Biosecurity Act, and following extensive management efforts, is now rare or even possibly eradicated from the country (EPPO, 2016). This was also possible thanks to public awareness and educational campaigns (e.g. http://www.weedbusters.org.nz). If trade bans are introduced *a priori*, i.e. before invasive spread of the species, they can be expected to be effective measures against invasion. However, given the species' desirable characteristics as an ornamental, it could be likely moved around non-commercially. Therefore, the potential for further human-assisted spread cannot be ruled out (EPPO, 2016). If the measure is not implemented by all European countries (i.e. only in countries most prone to invasion), it may not be effective since the species could be moved from one country to another, either intentionally or unintentionally.
Effort required e.g. period of time over which measure need to be applied to have results	To be effective, trade bans must be enforced indefinitely. This is particularly true for European countries where the species' potential range is expected to expand significantly under future climate change scenarios (EPPO, 2016). Moreover, accompanying measures to avoid intentional release into the wild or export prohibition (e.g. if a trade ban is implemented only in a subset of European countries), may have to be put in place to render trade bans efficient.
Resources required [1] e.g. cost, staff, equipment etc.	Evaluations of the costs associated with the implementation of trading bans of *C. grandiflorum* are not available. However, it is generally recognised that prevention is better than cure, with eradication of introduced species typically becoming less feasible as spread progresses (e.g. Thuiller *et al.*, 2005). In countries effectively enforcing the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), with roughly 5,000 species of animals and 29,000 species of plants whose international trade is regulated (CITES, 2017), the implementation, at least in respect of border controls, relative to one quite easily identifiable additional species may cause no or very little additional cost. However, guidance tools for proper identifications of the traded commodity are required.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	The promulgation of a trading ban would generally increase the awareness of the risks associated with invasive alien plants and the control measures in place to hinder their introduction.

Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	The economic impact on the ornamental plant industry is considered low, as only small volumes of the species are traded. An online search (3.11.2017) with the terms “buy / for sale Cardiospermum grandiflorum” on Google, first 20 hits analysed, restricted to websites from Europe, in Spanish (comprar / en venta Cardiospermum grandiflorum), Italian (acquistare / in vendita Cardiospermum grandiflorum), French (acheter / en vente Cardiospermum grandiflorum), German (Cardiospermum grandiflorum kaufen / zum Verkauf) and English, resulted in the following hits: - English: one nursery offering Cardiospermum spp. (several offering C. halicacabum). - Spanish: one botanical garden (Real Jardín Botánico Juan Carlos I Universidad de Alcalá, Catálogo de especies 2011, Spain) offering C. grandiflorum seeds. - Italian: one living C. grandiflorum plant for sale on ebay. - French: no record. German: one botanical garden (University Duisburg Essen, Germanx, Index Seminum 2016) offering C. grandiflorum seeds from natural habitats non-commercially and two websites selling C. grandiflorum seeds commercially (http://www.sunshine-seeds.de/Cardiospermum-grandiflorum-45722p.html / https://www.exot-nutz-zier.de/Samenliste/Samen_Ranker_Kletterpflanzen_C/Cardiospermum_grandiflorum/ProductDetails8848.aspx?Category=1&SubCategory=67&ProductDetailsTemplate=). Nursery professionals are generally highly aware of invasive plants, accept responsibility for horticultural introductions and are willing to engage in preventive measures both in terms of voluntary codes of conduct (e.g. Burt *et al.*, 2007) and mandatory trade regulations (e.g. Humair *et al.*, 2014). On the other hand, in some countries like e.g. France, there is an increasing movement of collectors and garden lovers that decry the “unjustified fear” that leads to the interdiction of selling and cultivating invasive alien ornamental plants (e.g. Clément & Lapouge-Déjean, 2014).
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 exact costs of a trading ban for the Member States are unknown. It is widely accepted that prevention is highly cost effective, being much cheaper than early detection, rapid eradication or management measures (cost of inaction). Nurseries and seed producers will suffer only very moderate economic losses as *C. grandiflorum* is only very limitedly traded, and a substitutive species looking very similar (*C. halicacabum*) is already in trade.

Level of confidence [2] See guidance section	**High.** Information comes from published material, or current practices based on expert experience applied in third countries with similar environmental, economic and social conditions. Moreover, a thorough PRA was recently performed for the EPPO region (which includes the EU). Note however that collectors may continue exchanging seeds non-commercially and extreme (i.e. inter-continental) long-distance dispersal may occasionally occur.

Prevention – measures for preventing the species being introduced, intentionally and unintentionally. **This table is repeated for each of the prevention measures identified.**	
Measure description Provide a description of the measure	**Awareness campaigns targeted at key stakeholder groups to reduce the risk of unintentional introductions and spread.** They may be set up to prevent mislabelling, dumping of garden waste, carrying around of *C. grandiflorum* curious seeds in countries at high risk, and to avoid soil movements from infested sites. Unintentional introductions may occur through extreme long-distance dispersal (i.e. intercontinental) which is possible also naturally, thanks to its inflated fruits that remain buoyant over long periods of time (Gildenhuys *et al.*, 2015a; Carthey *et al.*, 2016; see also Early Detection section below); as a consequence of mislabelling of nursery material, e.g. In online nursery catalogues, confusion between *Cardiospermum spp.* occur as traded *C. halicacabum* is frequently mislabelled as *C. grandiflorum* (presumably because of its more evocative specific epithet); dumping of garden waste (in South Africa *C. grandiflorum* is commonly observed in disturbed habitats such as abandoned agricultural fields, urban environments, and areas outside domestic gardens; EPPO, 2016); or through moving of contaminated soil by earthmoving equipment, cars etc. (Port Macquarie Landcare group, 2012).
Effectiveness of measure e.g. has the measure previously worked, failed	It is difficult to assess the effectiveness of awareness campaigns against unintended introductions. Moreover, the identification of *C. grandiflorum* may be difficult when it is traded as seed, and misidentifications or mislabelling specially with *C. halicacabum* may occur. However, at generic level, the traded specimens are readily identifiable, being it in the form of seeds/fruits or of live plants (Cullen *et al.*, 2011).
Effort required e.g. period of time over which measure need to be applied to have results	To be successful, awareness campaigns need to be repeated over time, and additional information readily provided upon request by the public, i.e. identification tools, indications for correct transport and disposal, lists of composting plants and incinerators that accept invasive alien

	species, including eventual fees. Campaigns may have to be directed to specific stakeholder groups such as the garden industry or the construction industry (in areas where construction land is infested a cadastre of seed-contaminated soil, to be consulted prior to soil excavations may be implemented).
Resources required [1] e.g. cost, staff, equipment etc.	No information available.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	General increase of the awareness of the risks associated with invasive alien plants, and the possible actions that can be taken.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	In general awareness campaigns are received positively.
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 exact costs are unknown.
Level of confidence [2] See guidance section	**Medium**: due to the difficulty to assess the effectiveness of awareness campaigns against unintended introductions.

Early detection - Measures to 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	**Monitoring of sentinel sites.** Early Detection and Rapid Eradication (EDRE) is key to prevent ecological harm and excessive management costs of new infestations (Davis, 2009). An Early Detection system for the species should involve both the active monitoring of sentinel (high risk) sites by experts (discussed in this table), alongside the citizen science (discussed in the following Early Detection table) Monitoring of sentinel sites involves active surveillance in areas where there is a high risk the species may invade such as forest margins, along watercourses, and in disturbed urban open areas in subtropical climates (Carroll, 2005a; Gildenhuys *et al.*, 2013). In Europe, due to its scare presence, such surveillance may concentrate on areas suitable for establishment at present or under future climatic scenarios (EPPO, 2016), and particularly in the vicinity of already established populations (Malta, Sicily and southern France), of parks and botanical gardens, composting facilities where garden waste is processed, landfill sites of excavated soil and along the maritime coast lines (extreme long-distance dispersal). Modelling approaches to identify invasion hot spots may be a prerequisite (Ibáñez *et al*., 2009). This measure can be supported by remote sensing**.** Woody climber species can be mapped by hyperspectral remote sensing and digital image processing techniques (Cheng *et al*., 2007). However, no data is available for *Cardiospermum* spp.
Effectiveness of the surveillance e.g. has the surveillance previously worked, failed	The effectiveness of monitoring sentinel sites as an early detection measure has the potential to be high. Although the introduction of *C. grandiflorum* to the Cook Islands after a hurricane is interpreted as trans-oceanic dispersal (Meyer, 2004), surveillance along ocean coasts to detect extremely long-distance dispersal is most probably ineffective the event being too rare. Dispersal towards mainland Europe would imply propagule spread from the closest infested coastal areas that is the Canary Islands and Malta. The surface oceanic currents, however, are directed away from the European continent, from the Canary Islands (Canary Current) southwards along the north west African coast (Mittelstaedt, 1991) and from Malta (Mid Mediterranean Jet) south-eastwards (Incarbona *et al*., 2011).
Effort required e.g. required intensity of surveillance (in time and space) to be sufficiently rapid to allow rapid eradication	Monitoring of sentinel sites presuppose mapping and modelling efforts to define potential hot-spots of invasion.

Resources required [1] e.g. cost, staff, equipment etc.	The measure requires trained people to undertake the monitoring, and associated transport costs. Monitoring of water courses may be burdensome and involve the need of boats, personal floatation devices, etc. However, this becomes more feasible if more than one species is monitored.
Side effects (incl. potential) i.e. positive or negative side effects of the method on public health, environment, non-targeted species, etc.	The total cost of monitoring of Invasive Alien Plant species can be reduced as several species can be monitored jointly. This is true for observational monitoring and for remote sensing.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	There may be issues around gaining access to private land to undertake monitoring.
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 exact costs are unknown. It is a widely accepted that EDRR is cost effective, being cheaper than management measures, which have to be continued indefinitely (cost of inaction) (Clout & Williams, 2009).
Level of confidence [2] See guidance section	**High** Monitoring of risk based hot-spots (sentinel sites) has proven to be highly effective to detect early introductions of invasive plants. Information comes from current practices based on expert experience (however, not on *C. grandiflorum*).

Early detection - Measures to 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.** An Early Detection system for the species should involve both the active monitoring of sentinel (high risk) sites by experts (discussed in the above Early Detection table), alongside the citizen

	science (discussed in this table) For an eye-catching and easily identifiable species as *C. grandiflorum*, using citizen science involving of the public can be an effective approach for early detection. Such programs for invasive *Cardiospermum spp.* are being implemented e.g. in the USA (EDDMapS, 2017) or South Africa (Cape Town Invasive Species Unit, 2017). They typically imply public awareness campaigns, fact sheets and identification keys, the use of social media, apps for mobile devices or online field-books to report geo-located sites of infested areas, and competitions for new reports implying some sort of reward (prizes or citation of the finder's name on a website or publication, e.g. "Cape Town's Invasive Species Unit has launched a competition with great prizes for anyone spotting any of the 28 targeted invasive species in the City", see http://www.invasives.org.za/news-previews/item/1350-spot-invaders-and-win). For Citizen Science projects involving IAS in Europe see https://easin.jrc.ec.europa.eu/CitizenScienceProjects.
Effectiveness of the surveillance e.g. has the surveillance previously worked, failed	The effectiveness of surveillance has the potential to be **high**. **Citizen Science** approaches seem to be successful in South Africa (http://www.capetowninvasives.org.za) and New Zealand (http://www.weedbusters.org.nz), where, after being listed as an 'Unwanted Organism' and following extensive management efforts, *C. grandiflorum* is now rare or even possibly eradicated from the country (EPPO, 2016). However, without an established institution able to respond rapidly and appropriately (Rapid Eradication), early warnings remain purposeless (Clout & Williams, 2009). For example, in Malta, the relatively early detection of invasive stands of *C. grandiflorum* have not induced control measures (Ameen, 2013). In Switzerland, an app for mobile devices and an online field-book to report early findings of invasive alien plants, was well accepted by the public, the number of annual reports amounting to approximately 3'500-5'000 findings in the first two years after launching of the tool (Michael Jutzi. Pers. Comm.). There are a number of citizen science activities focused on invasive species in Europe, including an invasive species reporting mobile app developed by the JRC European Alien Species Information Network (EASIN) (https://easin.jrc.ec.europa.eu/); and the UKs Plant Tracker app which focuses on public reporting of non-native plants, though not *Cardiospermum* (http://www.planttracker.org.uk).
Effort required e.g. required intensity of surveillance (in time and	**Citizen Science** programs need to integrate easily available technical tools for disseminating information, good communication concepts, systems for data validation, well-designed and

space) to be sufficiently rapid to allow rapid eradication	standardized methods of data collection, feedback to volunteers on their contribution as a reward for participation (Silvertown, 2009).
Resources required [1] e.g. cost, staff, equipment etc.	In Switzerland, an app for mobile devices (running on both Android and Mac) to report geo-located findings of invasive alien plants, and later on for all flora, was developed since 2015. Costs are estimated as following (Sibyl Rometsch & Christophe Bornand, Pers. Comm.). Development: 153,000 CHF (ca. 130,000 EUR); running costs including updates: 20,000 CHF/year (ca. 17,500 EUR).
Side effects (incl. potential) i.e. positive or negative side effects of the method on public health, environment, non-targeted species, etc.	The total cost of monitoring of Invasive Alien Plant species can be reduced as several species can be monitored jointly. This is true for observational monitoring and for remote sensing.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Citizen Science can be rewarding for the individuals practising it, as it conveys a feeling of usefulness and strengthens civil society participation.
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 exact costs are unknown. It is a widely accepted that EDRR is cost effective, being cheaper than management measures, which have to be continued indefinitely (cost of inaction) (Clout & Williams, 2009).
Level of confidence [2] See guidance section	**High** as shown by New Zealand's example.

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	**Manual removal by pulling out the plant and its taproots** is recommended for small infestations. Seedlings can be successfully hand pulled all year round. Plants can also be cut at the base, the root dug out, and the top growth brought down using a brush hook or similar tool, or left to die off. In case of dense curtain infestations, stems can be cut at waist height, leaving the top growth dying off and eventually falling out of the canopy (BRAIN, 1997; Biosecurity Queensland, 2013; PIER, 2013; Weedbusters, 2017). A combination of manual and chemical control is generally advised as regrowth is common (Biosecurity Queensland, 2013), involving cutting and painting the stump with herbicides (plant protection products) or cutting and leaving the stems to re-sprout then spray the foliage with herbicides (Weedbusters, 2017), or cutting or scraping and painting very large plants (BRAIN, 1997). See chemical control Rapid Eradication table below for more information.
Effectiveness of measure e.g. has the measure previously worked, failed	There are conflicting statements regarding the effectiveness of the measure. Simelane (2014) indicates that "mechanical control of balloon vine is extremely difficult and costly", and Pasiecznik (2014) states that control has proven difficult. Others indicate that *C. grandiflorum* is not difficult to control and large infestations can be cleared in a fairly short time with concentrated efforts, using both chemical and manual weeding methods (BRAIN, 1997). In fact, eradication of invasive alien plant infestations smaller than one hectare is usually possible, and early detection can make the difference between successful eradication, and the necessity for infinite management measures and financial commitment (Rejmánek & Pitcairn, 2002). The European and Mediterranean Plant Protection Organisation (EPPO, 2016), advises that "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" and highlights the importance of regional cooperation to promote information exchange in identification and management methods. EPPO's Expert Working Group considers that eradication of *C. grandiflorum* is feasible at the current level of occurrence of the species in the EPPO region (EPPO, 2016). For follow-up management seed longevity, which is estimated to last around two years (Vivian-Smith & Panetta, 2002) must be taken into consideration. However, the exact plant and seed longevity is yet to be confirmed (Global Invasive Species Database, 2017), and some websites report a much longer persistence of *C. grandiflorum* in the soil seed bank (e.g. http://www.sown.com.au reports up to 11 years of persistence, without any reference cited).

Effort required e.g. period of time over which measure need to be applied to achieve rapid eradication	As with any invasive plant species there is a need for follow-up maintenance to avoid recolonization. Spot weeding is needed to control newly germinated plants until depletion of the often relatively large soil seed bank, as seeds start to sprout responding strongly to the availability of light (BRAIN, 1997; FloraBase, 2012). Follow-up is considered critical for the first 18 months after application of the measure and correlated disturbance (CHAH, 2011), and should be dealt with quarterly check-ups (Global Invasive Species Database, 2017). Considering the uncertainty about seed longevity, efforts to guarantee permanent eradications may have to be ensured over a longer period of time.
Resources required [1] e.g. cost, staff, equipment etc.	Manpower and simple tools for cutting and digging. However, in the worst cases, hand pulling can cost as much as 10.00-14.00 euro/m2 when plants are well developed, there are difficulties in site accessibility and if additional cost are included in the estimate, such as filling the gap with new soil, collecting and providing the disposal for all the removed plant material, safety costs. Very rarely can this cost be lower than 1.00-1.50 euro per square meter (Giuseppe Brundu, Pers. Comm.)
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	Pulling of the aerial parts of the vines from the canopy can damage the native plants they are climbing on as well as disrupting a potential habitat for various species (BRAIN, 1997; Global Invasive Species Database, 2017). After management, seeds will often mass germinate when a disturbance creates a clearing in the vegetation (Muyt, 2001; Vivian-Smith & Panetta 2002). Densely invaded riparian systems are subject to erosion after clearing, and improved understanding of how to manage ecosystem recovery is needed (Richardson & van Wilgen, 2004).
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Public perception of manual management is generally positive, see also chemical control Management table below. EU/national/local legislation on the use of plant protection products and biocides needs to be respected.
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	Cost of inaction and consequent invasive spread of *C. grandiflorum* is presumably high, as illustrated by the example from Malta (Ameen, 2013), where the plant is smothering native Mediterranean vegetation.

Level of confidence [2] See guidance section	**High.** All sources recommend manual control. 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.

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	**Chemical control methods** include: cutting in spring or summer and painting the stump with 33% glyphosate (PIER, 2013), 50% glyphosate (Biosecurity Queensland, 2013), or with undiluted (100%) glyphosate (BRAIN, 1997); cutting the base and treat the re-sprouted leaves with 1-2% Glyphosate (BRAIN, 1997; Weedbusters, 2017); scraping and painting large plants with glyphosate (BRAIN, 1997). Vine seedlings can be successfully foliar sprayed, and the mix should be adjusted according to observed results (BRAIN 1997). Single plants can be spot sprayed with 3-4% 2.4 D amine and 5% Fluroxypyr (Biosecurity Queensland, 2013). Other herbicides successfully used against larger plants of *Cardiospermum spp.* include paraquat (note that paraquat is not approved in the EU), glufosinate-ammonium, lactofen (not approved in the EU), carfentrazone-ethyl, or sulfentrazone (not approved in the EU) (Brighenti *et al.*, 2003). A combination chemical and manual control is generally advised (Biosecurity Queensland, 2013). It is important to note that 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	Both chemical and manual weeding methods can control *C. grandiflorum* (BRAIN, 1997). However, the application of herbicides may be impossible or illegal due to the frequent proximity to water of invaded stands.
Effort required e.g. period of time over which measure need to be applied to achieve rapid eradication	See manual removal table (Rapid Eradication).
Resources required [1] e.g. cost, staff, equipment etc.	To undertake chemical control measures trained operators, pesticides, and spraying equipment are needed. A project in Italy which developed a drone based pesticide distribution system on corn,

	cost ca. 100 Euro per hectare, including the cost of a technician to operate the drone.[1]
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	Herbicide treatments may negatively affect native species and pollute surface and groundwater (Simelane *et al.*, 2011; PIER, 2015), cause non-target effects in soil microbiota, or constitute health hazards for the workers employed in managing *C. grandiflorum*. See also manual removal table (Rapid Eradication).
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	The use of pesticides in the environment may be perceived very negatively by the public.
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	See manual removal table (Rapid Eradication).
Level of confidence [2] See guidance section	**High.** All sources concur on the usefulness of chemical management methods, in particular when combined with (after) mechanical methods. 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.

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	**Mechanical management** – See also manual removal table (Rapid Eradication). To date, managing *C. grandiflorum* invasions has mostly involved physical removal or burning (EPPO, 2016), although infestations appear daunting, they can be effectively controlled (CHAH,

[1] http://www.ambienteterritorio.coldiretti.it/TEMATICHE/Agricoltura-Biologica/Pagine/Arrivaildronecontrolapiralidedelmais.aspx (Italian)

	2011)
Effectiveness of measure e.g. has the measure previously worked, failed	See manual removal table (Rapid Eradication). An integrated approach including both manual and chemical weeding can be effective to control large infestations (BRAIN, 1997) For Europe, there is very little information. Only MEPA (2013) provides guidelines for managing *C. grandiflorum* and restoring native plant communities in terrestrial settings in the Maltese Islands**.**
Effort required e.g. period of time over which measure need to be applied to have results	See manual removal table (Rapid Eradication). To prevent spread and re-colonization along waterways, a catchment wide approach can be beneficial when controlling *C. grandiflorum* (CHAH, 2011). Moreover, national measures should be combined with international measures, and international coordination of management of the species between countries is recommended (EPPO, 2016).
Resources required [1] e.g. cost, staff, equipment etc.	See manual removal table (Rapid Eradication). Once established and widespread, mechanical control of *C. grandiflorum*, would potentially incur the largest costs, also because of the dead plant material which has to be removed (and disposed) to restore exposure of the understory to sunlight (Simelane, 2014). However, it is problematic to define the amount of time and money spent on an individual species as generally a number of species are managed simultaneously (David Simelane*,* Pers. Comm.).
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	The removal of the dried-out vegetation from the canopy may be difficult due to the height of the infestation and herbicide spray may be an option when used with the correct equipment (CHAH, 2011). Moreover, the species' preference for sensitive riparian areas and need for multiple control treatments may make treatment expensive and ecologically damaging (USDA, 2013). In addition, thorough disposal is critical (to avoid further dispersal), if the seeds and taproots need to be removed from sites (Global Invasive Species Database, 2017).
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	See manual removal table (Rapid Eradication).
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction	Cost of inaction and consequent invasive spread of *C. grandiflorum* is presumably high, as illustrated by the example from Malta (Ameen, 2013), where the plant is smothering native Mediterranean vegetation.

- the cost-effectiveness - the socio-economic aspects	
Level of confidence [2] See guidance section	**Moderate.** There is little information about control of large areas invaded by *C. grandiflorum*.

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 management** – See chemical control table (Rapid Eradication). Large curtain infestations with dense stands of hundreds of stems growing together can be cut at waist height and the leaves re-sprouting from the basal stems can be foliar sprayed with Glyphosate at approximately 1-2% (BRAIN 1997; Weedbusters, 2017). It is important to note that 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	See chemical control table (Rapid Eradication). Chemical management of *C. grandiflorum* may be restricted where it grows close to water sources due to legal requirements.
Effort required e.g. period of time over which measure need to be applied to have results	See chemical control table (Rapid Eradication). Considering the low acceptance of the use of pesticides in the environment, considerable public outreach efforts may have to be undertaken to increase acceptance of the measure.
Resources required [1] e.g. cost, staff, equipment etc.	See chemical control table (Rapid Eradication).
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	See chemical control table (Rapid Eradication).

Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	See chemical control table (Rapid Eradication). The use of herbicides is generally the least supported method by the general public for controlling invasive alien plants (Bremner & Park, 2007). For instance, in south-western USA, a large majority (64%) of the citizens rated chemical control of invasive alien plants as being not acceptable at all or only slightly acceptable (12% rated as highly acceptable). In contrast, acceptability was much higher for mechanical methods (53 % highly acceptable, 21% not at all or slightly acceptable) and for biological control (27% not or slightly acceptable, 44% highly acceptable) (Brunson & Tanaka, 2011).
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	See chemical control table (Rapid Eradication).
Level of confidence [2] See guidance section	**Moderate.** There is little information about control of large areas invaded by *C. grandiflorum*.

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	**Classical biological control** against *C. grandiflorum* has only been explored in South Africa. Studies started in 2003 to search for biological control agents (Simelane *et al*., 2011). Three promising agents were identified: a seed-feeding weevil *Cissoanthonomus tuberculipennis* (further researched by Lampert *et al*., 2013), a fruit-galling midge *Contarinia* spp., and the rust fungus *Puccinia arechavaletae* (Simelane *et al*., 2011). Concerns about their potential impacts on non-target *Cardiospermum* species and their uncertain native status in southern Africa had initially prevented their release (Gildenhuys *et al.*, 2013). In 2013, the release of *C. tuberculipennis* was

	granted in KwaZulu Natal Province by the relevant regulatory authorities (Simelane *et al.*, 2014). **Neo-classical biological control** (i.e. the use of natural enemies that are native to the introduced range), is also a possible management approach (EPPO, 2016). Soapberry bugs of the genera *Leptocoris*, *Jadera* and *Boisea* (Rhopalidae) feed exclusively on seeds of Sapindaceae and are natural seed predators of *Cardiospermum* spp. in both their native and non-native areas (Carroll *et al.*, 2005b), and native American soapberry bugs can destroy the seeds of an introduced Sapindaceae (*Koelreuteria elegans*) at a very high percentage (Carroll *et al.*, 2003). However, the genera *Leptocoris*, *Jadera* and *Boisea* are absent from the European continent (EPPO, 2016). 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	Moderate to high. A three-year monitoring conducted since the release of the biological control agent *Cissoanthonomus tuberculipennis* in South Africa, shows that establishment and dispersal of the weevil has been rapid (33 to 37km/year), and that populations have been increasing at almost all the study sites. By the year 2017, 50% seed predation was measured at different sites. Reduction in seed bank densities and seedling recruitment was observed at some sites, which is promising considering that the invasiveness of *C. grandiflorum* is attributed to its prolific seed production (David Simelane, *Pers. Comm*.). However, the effectiveness and the host specificity under field conditions of this biological control agent remains to be further assessed (EPPO, 2016).
Effort required e.g. period of time over which measure need to be applied to have results	As the biological control agent *C. tuberculipennis* readily establishes itself and spreads naturally after establishment (Simelane *et al.*, 2014), the measure needs to be applied theoretically only once per infested area, and presupposes the availability rearing facilities and knowledge.
Resources required [1] e.g. cost, staff, equipment etc.	On average, three years of research are required for any tested and introduced biocontrol agent against weeds. With technical support and facilities, the costs were estimated to be about 460,000 USD in 1997 (McFadyen, 1998), registration costs in the European Union, would add another >30,000 EUR (Sheppard *et al.*, 2006). However, prior use elsewhere also reduces the cost of a biocontrol program. Taking Switzerland as an example, projects may last anything between 5 and 20 years, and depend on the size of the area where the agent will be applied, whether follow-up monitoring and evaluation is included, or if they are closely related to non-target risks. Costs of one million CHF (ca. 875,000 Euro) may be roughly estimated, but they could be significantly less or

	more (Tim Haye, *Pers. Comm*).
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	In South Africa, emphasis was put on potential adverse effects on non-target Sapindaceae, including *Cardiospermum* spp. which are native or with doubtful native status in southern Africa, and monitoring of non-target impacts on *C. corindum* and *C. pechueli* was strongly recommended (Gildenhuys *et al.*, 2015a; 2015b; Simelane *et al.*, 2014). In Europe (and the northern temperate hemisphere), the only native Sapindaceae belong to the genera *Acer* and *Aesculus*, both belonging to the subfamily Hyppocastanoideae which is phylogenetically quite distant from *Cardiospermum* (subfamily Sapindoideae) (Bürki *et al*., 2010). However, several Sapindoideae are important ornamental plants in Europe, including *Koelreuteria* spp. (Cullen *et al*., 2011), and natural enemies of *Cardiospermum* have been shown to be able attack *Koelreuteria elegans* in Florida (Carroll *et al.*, 2003).
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	See chemical control table (relative acceptance of different control methods). In biological control, general public understanding of the scientific aspects, and the risks and potential benefits is judged to be unsatisfactory (Sheppard *et al.*, 2006).
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	None available for *C. grandiflorum*.
Level of confidence [2] See guidance section	**Moderate to high** as shown by recent studies (including unpublished yet) in South Africa.

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Personal Communications – An online enquiry was sent to the following people and institutions. We express our gratitude to the respondents.
Biosecurity Queensland, Department of Agriculture, Fisheries and Forestry of the State of Queensland.
Brisbane Rainforest Action & Information Network, PO Box 443 The Gap Qld 4061, Australia.
Cape Town Early Detection and Rapid Response (EDRR) Project. www.capetowninvasives.org.za. Cape Town, South Africa.
David Simelane – Agricultural Research Council-Plant Protection Research Institute, Private Bag X134, Queenswood, 0121 South Africa.
Sibyl Rometsch, Christophe Bornand, Michael Jutzi – Info Flora. The National Data and Information Center on the Swiss Flora. Bern, Geneva, Lugano, Switzerland
Tim Haye – Head Arthropod Biological Control, CABI, Rue des Grillons, Delemont, Switzerland.
Weedbusters, c/- PO Box 1493, Waikato Mail Centre, Hamilton 3240, New Zealand.

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.

(see http://www.waikato.ac.nz/library/study/referencing/styles/apa)