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ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES PLANTES



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Pest Risk Analysis for *Cardiospermum grandiflorum*



2017

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This pest risk analysis scheme has been specifically amended from the EPPO Decision-Support Scheme for an Express Pest Risk Analysis document PM 5/5(1) to incorporate the minimum requirements for risk assessment when considering invasive alien plant species under the EU Regulation 1143/2014. Amendments and use are specific to the LIFE Project (LIFE15 PRE FR 001) ‘Mitigating the threat of invasive alien plants to the EU through pest risk analysis to support the Regulation 1143/2014’.

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Photo: *Cardiospermum grandiflorum* (Photo by Johannes J Le Roux)

EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION

Pest risk analysis for *Cardiospermum grandiflorum* Swartz

This PRA follows EPPO Standard PM5/5 Decision support scheme for an Express Pest Risk Analysis

PRA area: EPPO region **First draft prepared by:** Johannes J Le Roux

Location and date: Paris (FR), 2016-10-17/21

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LIFE15 PRE FR 001

Mitigating the threat of invasive alien plants to the EU through pest risk analysis to support the Regulation 1143/2014

In partnership with

EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION

And

NERC CENTRE FOR ECOLOGY AND HYDROLOGY



**Centre for
Ecology & Hydrology**
NATURAL ENVIRONMENT RESEARCH COUNCIL

Review Process

- This PRA on *Cardiospermum grandiflorum* was first drafted by Johannes J Le Roux
- The PRA was evaluated in an Expert Working Group (EWG) at the EPPO Headquarters between 2016-10-17/21
- Following the finalisation of the document by the EWG the PRA was peer reviewed by the following:
 - (1) The EPPO Panel on Invasive Alien Plants (November and December 2016)
 - (2) The EPPO PRA Core members (December and January 2016/17)

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Summary¹ of the Express Pest Risk Analysis for *Cardiospermum grandiflorum* Swartz

PRA area: EPPO region

Describe the endangered area:

Based on species distribution modeling, suitable areas have been identified for the establishment of *C. grandiflorum* in the Mediterranean biogeographical region, including Portugal, Spain, and Italy, while areas in North Africa (i.e., Morocco and Algeria) are marginally suitable. In addition, areas of Israel and countries bordering the Adriatic and Ionian Sea are marginally suitable for the establishment of *C. grandiflorum* (see Appendix 1 and 2).

The most limiting environmental factors for the establishment of *C. grandiflorum* are temperature and rainfall. In specific situations, such as urban environments, old fields, Insubria (Great Lakes in Northern Italy and Southern Switzerland), meso-climatic conditions may help overcome these limitations.

Specific habitats, within the endangered area most suitable for establishment, include woodlands, forests, wastelands, riparian systems, old fields, fallow gardens, successional habitats, roadsides, and urban habitats.

Cardiospermum grandiflorum has already been introduced and showed invasive tendencies in Malta. In France and Italy the species is considered transient and may become established.

Main conclusions

Cardiospermum grandiflorum presents a moderate phytosanitary risk for the endangered area within the EPPO region with moderate uncertainty. The risk of further spread within and among countries is moderate. The overall likelihood of *C. grandiflorum* continuing to enter the EPPO region is moderate because the species is traded by a small number of suppliers.

Given the species' known occurrences within the EPPO region and its desirable characteristics as an ornamental, it remains likely that it could be moved non-commercially (e.g., through seed exchange by collectors), resulting in further human-assisted spread.

Natural dispersal from existing populations within the region is the most likely mode of further spread. The seed-carrying balloons of *C. grandiflorum* can float for extensive periods in watercourses (e.g., along rivers and across the sea) and are carried by wind and thus can cover substantial distances over short time scales.

Under climate change the range of suitable habitat for establishment is expected to expand and shift northwards.

Entry and establishment

The pathways identified are: Plants or seed for planting (moderate likelihood of entry).

Within the EPPO region, *Cardiospermum grandiflorum* already has been introduced and shows invasive tendencies in Malta. In France the species is considered casual and in Italy the species is considered transient and may become established.

¹ The summary should be elaborated once the analysis is completed

The overall likelihood of *C. grandiflorum* entering the EPPO region (via the pathway plants for planting) is moderate with low uncertainty. There is some evidence that the plant is available from a small number of horticultural suppliers within the EPPO region. The overall likelihood of *C. grandiflorum* establishing in the EPPO region is moderate (natural habitat) and high (managed habitat) with low uncertainty. The species already is present within the EPPO region, in particular in Malta where there is evidence of invasive tendencies (smothering behaviour).

Cardiospermum grandiflorum may establish throughout climatically suitable regions within the EPPO region. Climate change could increase the likelihood of establishment, spread, and impact in other areas of the EPPO region.

Spread

The rating for spread of *C. grandiflorum* within the EPPO region is moderate with moderate uncertainty. *C. grandiflorum* fruits (balloons) and seeds are well adapted for extreme (i.e. inter-continental) long-distance dispersal (Gildenhuis *et al.* 2015a). That is, seed-carrying balloons can float for extensive periods in watercourses and so cover substantial distances over short time scales, e.g. along rivers and even across the sea. The known presence of the species within the EPPO region makes natural dispersal the most likely mode of spread within the region. For human assisted spread, Online vendors still sell seeds of the genus, but mostly for *C. halicacabum*. Within the EPPO region several traders do list the species. Many of these traders misidentify the species, i.e. selling *C. halicacabum* under the name *C. grandiflorum*. It is possible that the species may still be in the horticultural trade within the PRA area since it is already present in several EPPO countries and may therefore be traded as whole plants.

Potential impacts in the PRA area

The overall potential impact of the species is moderate with high uncertainty. The high uncertainty reflects the difficulty in assessing impacts due to conflicting information on the species. For example, in Australia and South Africa, the species does not exhibit the invasive tendencies in the Mediterranean areas that are seen in the more tropical and sub-tropical regions of these countries (Personal Communication Jaco Le Roux, 2016). However, in Malta, where the species has formed extensive invasive populations, there may be impacts on biodiversity.

Although empirical data are lacking, *C. grandiflorum* is considered an ecological “transformer” species in its invasive ranges in South Africa and Australia (Henderson 2001, Carroll *et al.* 2005a). Infestations of *C. grandiflorum* can cause problems commonly associated with invasive climbing vines (e.g., cover tree canopies). Along forest margins and watercourses, and in urban open spaces, especially in subtropical regions, the species smothers indigenous vegetation, thereby blocking sunlight and photosynthesis and outcompeting native plants.

Climate change

By the 2070s, under climate change scenario RCP8.5 (RCP8.5 is the most extreme of the RCP scenarios, and may therefore represent the worst case scenario for a reasonably anticipated climate change), projected suitability for *C. grandiflorum* increases, most notably in Italy and northwards into the Atlantic Biogeographic Region as far north as The Netherlands and southern Britain (Fig. 6). Presumably this is driven by increases in summer and winter temperatures. There is little increase in suitability around the Mediterranean coastlines, which may be because of reduced predicted precipitation

The PRA results suggest that *C. grandiflorum* poses a moderate risk to the endangered area

(Mediterranean biogeographical region) with moderate uncertainty.

Given the significant impact of the species in other parts of the world and the risk to the PRA area, the EWG recommends the following measures for the endangered area:

International measures:

For the pathway plant for planting the EWG recommends that:

Plants labeled or otherwise identified as *Cardiospermum grandiflorum* should be prohibited for import into and movement within countries in the endangered area,
Cardiospermum grandiflorum is banned from sale within the endangered area,
Cardiospermum grandiflorum should be recommended as a quarantine pest within the endangered area.

National measures:

Cardiospermum grandiflorum should be monitored and eradicated where it occurs in the endangered area. In addition, public awareness campaigns to prevent spread from existing populations or from gardens in countries at high risk are necessary. If these measures are not implemented by all countries, they will not be effective since the species could spread from one country to another. National measures should be combined with international measures, and international coordination of management of the species among countries is recommended.

The EWG recommends the prohibition of selling and, movement of the plant. These measures, in combination with management plans for early warning, obligation to report findings, eradication, and containment plans, and public awareness campaigns should be implemented.

Containment and control of the species in the PRA area

Eradication measures should be promoted where feasible with a planned strategy to include surveillance, containment, treatment, and follow-up measures to assess the success of such actions. As highlighted by EPPO (2012), regional cooperation is essential to promote phytosanitary measures and information exchange in identification and management methods. Eradication only may be feasible in the initial stages of infestation, and should be a priority. The EWG considers this possible at the current level of species occurrence in the EPPO region.

General considerations should be taken into account for all potential pathways where, as detailed in EPPO (2014), these measures should involve awareness raising, monitoring, containment, and eradication measures. NPPOs should facilitate collaboration with all sectors to enable early identification, including education measures to promote citizen science and linking with universities, land managers, and government departments.

Import for plant trade: Prohibition of the import, selling, planting, and movement of the plant in the endangered area.

Unintended release into the environment: The species should be placed in NPPO alert lists and a ban from sale is recommended in countries most prone to invasion. Export of the plant should be prohibited within the EPPO region. Integrated management measures are recommended to include control of existing populations with manual and mechanical techniques, targeted herbicides, and biological control techniques. Monitoring and surveillance for early detection in countries most prone to risk. NPPOs should report new findings in the EPPO region.

Intentional release into the environment: Prohibition on planting the species or allowing the

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

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

<p>Phytosanitary risk for the <u>endangered area</u> (current/future climate)</p> <p>Pathway for entry Plants for planting: Moderate/Moderate Likelihood of establishment in natural areas: Moderate/High Likelihood of establishment in managed areas: High/High Spread: Moderate/High</p> <p>Impacts in the current area of distribution Biodiversity and environment: Moderate/high Ecosystem services: Moderate/High Socio-economic: Moderate/High</p> <p>Impacts (EPPO region) Biodiversity and environment: Moderate/high Ecosystem services: Moderate/High Socio-economic: Moderate/High</p>	<p>High <input type="checkbox"/></p>	<p>Moderate <input checked="" type="checkbox"/></p>	<p>Low <input type="checkbox"/></p>
<p>Level of uncertainty of assessment (current/climate change)</p> <p>Pathway for entry Plants for planting: Low Likelihood of establishment in natural areas: Low/High Likelihood of establishment in managed areas: Low/High Spread: Low/High</p> <p>Impacts in the current area of distribution Biodiversity and environment: Moderate/high Ecosystem services: Moderate/High Socio-economic: Moderate/High</p> <p>Impacts (EPPO region) Biodiversity and environment: Moderate/high Ecosystem services: Moderate/High Socio-economic: Moderate/High</p>	<p>High <input type="checkbox"/></p>	<p>Moderate <input checked="" type="checkbox"/></p>	<p>Low <input type="checkbox"/></p>
<p>Other recommendations:</p> <ul style="list-style-type: none"> • <i>Inform EPPO or IPPC or EU</i> • The EWG recommends a PRA is conducted on the closely related species <i>Cardiospermum halicacabum</i>. 			

- ***Inform industry, other stakeholders***
- Ask industry to confirm if there is mislabelling of *Cardiospermum halicacabum* and *Cardiospermum grandiflorum*
- ***Specify if surveys are recommended to confirm the pest status***
- Assess the current impact of *Cardiospermum grandiflorum* in Malta and other regions where the species *is established*.
- Specific studies on the species biology are necessary.

Express Pest Risk Analysis:
Cardiospermum grandiflorum

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Date: 2016-10-17

Stage 1. Initiation

Reason for performing the PRA:

Cardiospermum grandiflorum currently has a relatively limited distribution in the EPPO area, with known records from France (Landes and Alpes-Maritimes departments), Italy (Catania, Canalicchio; Sicily, Lombardia and Liguria), Malta, Portugal (Madeira Island), and Spain (Canary Islands: Gran Canaria, Tenerife Island, La Gomera, La Palma) (Ameen (2013), DAFF (2011), EPPO (2012), Informatore Botanico Italiano (2014)). Malta is the only region invasive populations of the species are reported as widespread in natural areas where they smother and outcompete native plant communities (Ameen 2013). It is anticipated that the species' potential use as an ornamental plant and its capacity for extreme long-distance natural dispersal, especially via water courses (including open ocean) poses a risk for future establishment into the EPPO region. Whilst the trade of *C. grandiflorum* appears to be relatively low based on online trading inventories, other closely related species such as *C. halicacabum* are readily available. Many instances of mislabeling of these two species have been noted by the EWG in online catalogs. The fruits and seeds of *Cardiospermum* species are well adapted for natural long-distance water dispersal. For example, inflated fruit capsules floated in seawater for more than 6 months can harbor viable seeds (Gildenhuis *et al.* 2013).

While the species commonly flourishes under tropical to subtropical moist conditions in both native and introduced areas, accounts of establishment have been noted in Mediterranean-type regions. For example, the species has been recorded as established from South Africa's Cape Floristic Region (JJ Le Roux, personal observation) and in Western Australia (Carroll *et al.* 2005a, FloraBase 2012), and has been reported as having formed invasive populations in Malta (Ameen 2013). In Malta, a congeneric species, *C. halicacabum*, is recorded. Bioclimate suitability modeling suggests that Mediterranean areas are suitable for the species' establishment, albeit with relatively low probability compared to tropical and subtropical regions (Gildenhuis *et al.* 2013, USDA 2013).

Cardiospermum grandiflorum is perceived to have major biodiversity impacts in invaded areas, such as in Australia (New South Wales and Queensland) and eastern parts of South Africa (Carroll *et al.* 2005a, Gildenhuis *et al.* 2013), where dense infestations can smother large swathes of underlying vegetation, including trees of up to 16 to 20 m in height (Carroll *et al.*, 2005a). *Cardiospermum grandiflorum* thus putatively outcompetes native plants by depriving them of sunlight and restricting photosynthesis. A congeneric species, *C. halicacabum*, has substantial economic impacts on agricultural productivity (Brighenti *et al.* 2003, Dempsey *et al.* 2011). Similar impacts may manifest from *C. grandiflorum* invasions in agricultural settings. The species has been on the EPPO 'List of Alien Invasive Plants'

since 2013 and is included in the Global Invasive Species Database. It has been listed as a noxious weed (prohibited plants that must be controlled as they serve no economic purpose and possess characteristics that are harmful to humans, animals or the environment) in South Africa and in the Australian states of New South Wales and Queensland, Australia. For example, in Australia, southeastern Queensland, the species is ranked 13th in terms of potential environmental impacts out of 66 'priority' environmental weeds (Batianoff and Butler 2003). The presence of the species in the EPPO region (with highly invasive populations in at least one locality, Malta), high dispersal capabilities, as well as the potential continued use of this plant as an ornamental species within EPPO countries, indicate that a PRA is needed.

PRA area:

The EPPO region (see https://www.eppo.int/ABOUT_EPPO/images/clickable_map.htm).

Stage 2. Pest risk assessment

1. Taxonomy: *Cardiospermum grandiflorum* Sw. (Kingdom Plantae; Phylum Magnoliophyta; Class Magnoliopsida; Superorder Rosanae; Order Sapindales; Family Sapindaceae; Genus *Cardiospermum*). (Integrated Taxonomic Information System, accessed 15 August 2016)

EPPO Code: CRIGR

Main synonyms: *Cardiospermum barbicaule* Baker, *Cardiospermum coluteoides* Kunth, *Cardiospermum duarteanum* Cambess., *Cardiospermum elegans* Kunth, *Cardiospermum grandiflorum* f. *elegans* (Kunth) Radlk., *Cardiospermum grandiflorum* f. *hirsutum* (Willd.) Radlk., *Cardiospermum grandiflorum* var. *hirsutum* Hiern, *Cardiospermum hirsutum* Willd., *Cardiospermum hispidum* Kunth, *Cardiospermum inflatum* Vell. *Cardiospermum macrophyllum* Kunth, *Cardiospermum pilosum* Vell. *Cardiospermum velutinum* Hook. & Arn., *Cardiospermum vesicarum* Humb.

Common names: Balloon vine, blaasklimop (Afrikaans), grand balloon vine, heart pea, heart seed, heart seed vine, intandela (Zulu), kopupu takaviri (Cook Islands), showy balloon vine.

Plant type: Annual or perennial vine-like climber

Related species in the EPPO region:

Horticulture: *Cardiospermum halicacabum* L.

2. Pest overview

Introduction

The genus *Cardiospermum* L. encompasses 17 shrub, subshrub, and climber species, commonly referred to as balloon vines (Gildenhuis *et al.* 2013). Most balloon vine species are restricted to the Neotropics from southeastern Brazil to northcentral Mexico (Ferrucci and Umdiriri 2011), with most species (12) found in Brazil. The biogeography (native vs. non-native ranges) of some balloon vine species remains inconclusive (Gildenhuis *et al.* 2013, 2015a). For example, it was only recently discovered that *Cardiospermum corindum* from southern Africa several million years ago diverged from its New World conspecific populations, and therefore should be regarded as native to these areas and not non-native as previously was assumed (Gildenhuis *et al.* 2015a, 2015b).

Cardiospermum grandiflorum is a large (up to 8 m in height), semi-woody annual or perennial often draping over other vegetation. The stems usually are covered with reddish green bristly hairs. Bright green leaves are strongly serrated and sometimes hairy. White or yellow, fragrant flowers (7-11 mm in size) on compact heads appear from late spring to early summer (GISD 2015). The species has elongated inflated balloon-like fruit 4.5–6.5 cm in length. Fruits consist of three dorsally keeled membranous capsules, each consisting of three internal blades (Weckerle and Rutishauser 2005). The fruit are septifragal with the capsules breaking away from each other when fruit are ripe, changing colour from green to brown (Weckerle and Rutishauser 2005). Three seeds normally are produced per fruit, each having a characteristic round or kidney-shaped hilum (Weckerle and Rutishauser 2005). The species is also capable of vegetative reproduction through coppicing or suckering (Personal Communication, Le Roux, 2017).

Cardiospermum grandiflorum has a near-cosmopolitan distribution, in part owing to its widespread introduction globally for ornamental purposes (Ferrucci and Umdiriri 2011, Urdampilleta *et al.* 2013; see also section 6). However, unresolved biogeographic statuses (alien or native), in particular in the species' distribution in tropical parts of Africa, remain problematic (Gildenhuis *et al.* 2015a). For example, the species has been variously regarded as native (Perreira *et al.* 2012) and alien (Mosango *et al.*, 2001) in Uganda. Fruit morphology differs substantially between Ugandan specimens and those from the Neotropics (S.P. Carroll, personal communication) and divergence between Ugandan and South American taxa may pre-date possible human-mediated dispersal (Gildenhuis *et al.* 2015a). Irrespective of these issues, the species is conclusively non-native in at least 14 countries (see section 6). In the EPPO area the species has non-native records from France (Landes and Alpes-Maritimes departments, considered a casual species and may be in the process of becoming naturalised), Italy (Catania, Canalicchio; Liguria, Sicilia), Malta, Portugal (Madeira Island), and Spain (Canary Islands: Gran Canaria, Tenerife, La Gomera, La Palma). The fruits of balloon vines are extremely well adapted for natural long-distance dispersal. For example, *C. grandiflorum* seeds retained viability after fruit floated for more than six months in seawater (Gildenhuis *et al.* 2013). At the same time, *Cardiospermum* seeds may be dispersed by wind after the dry fruit capsules open, with each of the three seeds attached at the center of a disk-shaped sail.

Reproduction

The breeding system of *C. grandiflorum* is not well understood. The species' flowers are functionally unisexual (Acevedo-Rodríguez 2005). In addition, experimental data from

closely related species support potential self-compatibility. *Cardiospermum halicacabum* is self-compatible, producing a high percentage of viable seeds when self-fertilized (Acevedo-Rodríguez, 2005). Another congener, *C. canescens*, exhibits geitonogamy, that is, successful pollination between flowers of the same plant (Solomon Raju *et al.* 2011). Temperature seems to impact phenology of *C. grandiflorum*, with warmer climates supporting longer flowering periods. The species is thought to form large seed banks, as individual plants can produce hundreds of seeds (JJ Le Roux, personal observation) especially in dense invasive populations (FloraBase 2012). Seeds can remain viable for up to two years (Vivian-Smith *et al.* 2002). The fruits of *C. grandiflorum* are well-adapted for wind and water dispersal (Gildenhuis *et al.* 2013). Seed germination success and optimal growth requirements are not well studied in *C. grandiflorum*, but again, research on the closely related *Cardiospermum halicacabum* may provide insights into key requirements on the reproductive biology of the species. For *C. halicacabum* optimum germination takes place at 35 °C, with well-drained soil conditions increasing germination success (Johnston *et al.* 1979, Jolley *et al.* 1983, Dempsey 2011). *Cardiospermum grandiflorum* is also capable of vegetative reproduction through resprouting.

Natural enemies

Cardiospermum grandiflorum produces numerous secondary compounds (e.g., flavone aglycones and cyanogenic compounds) that likely protect it against herbivores such as soapberry bugs (Subramanyam *et al.* 2007). Soapberry bugs from the genera *Leptocoris*, *Jadera* and *Boisea* (family Rhopalidae) feed exclusively on seeds of Sapindaceae and are natural seed predators of *Cardiospermum* globally, including in their non-native ranges (Carroll *et al.* 2005b). Soapberry bugs co-occur with the widespread distribution of *Cardiospermum* (excluding Europe) and thus may impact reproduction globally. For example, American soapberry bugs can destroy ca. 95% of invasive balloon vine seeds (Carroll *et al.* 2003).

Habitat and environmental requirements

Cardiospermum grandiflorum thrives in well-drained soil types. Research on invasive populations of *C. grandiflorum* from Australia found soil types to vary substantially among regions of high-density populations indicating a wide edaphic tolerance by the species. It also has been noted that optimal growth takes place in well-lit (sunny) locations, although it is capable of germinating under dark conditions (ARC 2011). Seeds and young plants are able to survive flooded, saturated, and dry conditions, while performing best in intermediate conditions (Dempsey 2011). In both native and introduced ranges, *C. grandiflorum* performs best in subtropical climates, in habitats such as forest margins, along watercourses, and in disturbed urban open areas (Carroll 2005a, Gildenhuis *et al.* 2013). The species also responds rapidly to environmental disturbances (Carroll *et al.* 2005a) and is commonly observed in highly disturbed habitats such as abandoned agricultural fields, urban environments, and areas outside domestic gardens (JJ Le Roux, personal observation).

Identification

Cardiospermum grandiflorum is a large, semi-woody annual or perennial often draping over other vegetation (see Figure 1; Appendix 3). While the fruit of *C. grandiflorum* can be variable (size and shape), their distinct shape and coverage by hairs make the species easily recognizable and distinguishable from closely related taxa such as *C. halicacabum* and *C. corindum*. *Cardiospermum grandiflorum* has hairy ribbed stems that are reddish-green in colour covered in bristly hairs. Leaves are compound and up to 16 cm long and are dark green and heavily serrated. The species' flowers have four petals that are white with a yellow

lip (see Figure 2, Appendix 3). Flowers are fragrant and grow in clusters with a pair of tendrils at the flower base. Fruits are balloon-shaped, up to 65 mm long, inflated, representing a 3-angled and pointed tipped capsule, covered in fine bristly hair. Young fruit capsules are green, turning brown as the fruit matures. Each fruit is septifragal and contains three black seeds each with a characteristic white heart-shape hilum (Weckerle and Rutishauser 2005).

Symptoms

Although empirical data are lacking, *C. grandiflorum* is considered an ecological 'transformer' species in its invasive ranges in South Africa and Australia (Henderson 2001, Carroll *et al.* 2005a). Infestations of *C. grandiflorum* can cause problems commonly associated with invasive climbing vines. The species can grow into the upper canopy of native tree communities (Figure 3, Appendix 3). Along forest margins and watercourses (Figure 4, Appendix 3), and in urban open spaces, especially in subtropical regions, the species smothers indigenous vegetation, thereby blocking sunlight and reducing photosynthesis, and thus outcompeting native plants. In East Africa, where the species is presumably native, dense populations of *C. grandiflorum* are reported to hinder the free movement of wildlife and livestock (BioNET International 2016). In Australia native soapberry bugs (genera *Leptocoris*, *Jadera* and *Boisea*) prefer *C. grandiflorum* as their primary host to native *Sapindaceae* plants (Carroll & Loye 2012).

Existing PRAs

USA: United States Department of Agriculture (USDA) conducted a weed risk assessment using the Plant Protection and Quarantine Weeds Risk Assessment (PPQ WRA) model (Koop *et al.* 2012). This model assumes geographic and climatic 'neutrality' and therefore aims to determine the baseline weed/invasive potential of a particular species for the entire US. Based on these analyses, *C. grandiflorum* scored 17 for establishment and spread potential in the US, and 2.5 for potential impacts, which falls within the category 'High Risk'. The species also has been evaluated using the Australian/New Zealand Weed Risk Assessment adapted for Hawai'i (HWRA) by the Pacific Island Ecosystems at Risk and scored a total of 18, again falling in the category 'High Risk' (PIER 2013).

Europe (overall): The current PRA is being conducted under the LIFE project (LIFE15 PRE FR 001) within the context of European Union regulation 1143/2014, which requires a list of invasive alien species (IAS) to be drawn up to support future early warning systems, control and eradication of IAS.

Socio-economic benefits

Cardiospermum grandiflorum is available in the ornamental trade within the EPPO region and is listed as present in various botanical gardens. Numerous extracts from the species have been reported for their medicinal uses. For example, root derivatives of the plant have been shown to offer laxative, emetic, and diuretic effects. The leaves of the plant have been used to alleviate swelling, oedema and pulmonary complications (GISD 2015) and may have anti-bacterial activity (Nnamani *et al.* 2012). Up to date, no commercial enterprises make use of this species in the production of medicinal products.

3. Is the pest a vector? **No**

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

No vector required for entry of *C. grandiflorum* into PRA area.

5. Regulatory status of the pest

Australia: *Cardiospermum grandiflorum* is regulated under legislation (Environment Protection and Biodiversity Conservation Act 1999) in New South Wales and listed as Class 4: "A locally controlled weed. The growth and spread of this species must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed"; in Queensland as Class 3: "This species is primarily an environmental weed and a pest control notice may be issued for land that is, or is adjacent to, an environmentally significant area (throughout the entire state). It is also illegal to sell a declared plant or its seed in this state"; in Western Australia as Unassessed - "This species is declared in other states or territories and is prohibited until assessed via a weed risk assessment (throughout the entire state)".

South Africa: In South Africa control of the species is enabled by the Conservation of Agricultural Resources (CARA) Act 43 of 1983, as amended, in conjunction with the National Environmental Management: Biodiversity (NEMBA) Act 10 of 2004. Currently *C. grandiflorum* is listed as a Category 1b "invader species" on the NEMBA mandated list of 2014 (Government of the Republic of South Africa, 2014). Category 1b means that the "invasive species that may not be owned, imported into South Africa, grown, moved, sold, given as a gift or dumped in a waterway". Category 1b species are major invaders that may need government assistance to remove. All Category 1b species must be contained, and in many cases they already fall under a government sponsored management programme." (www.environment.gov.za).

New Zealand: *Cardiospermum grandiflorum* is currently legally listed (under the country's Biosecurity Act 1993) as an 'Unwanted Organism'.

6. Distribution

Continent	Distribution (list countries, or provide a general indication , e.g. present in West Africa)	Provide comments on the pest status in the different countries where it occurs (e.g. widespread, native, introduced....)	Reference
Africa	Algeria, Guinea-Bissau, Guinea, Sierra Leone, Angola, Benin, Botswana, Cameroon, Central African Republic, Côte d'Ivoire, Democratic Republic of Congo, Ghana, Guinea, Kenya, Liberia, Namibia, Nigeria, Rwanda, Sierra Leone, South Africa, southern Malawi, southern Mozambique, South Sudan, Swaziland, Togo, Uganda, western Tanzania, Zambia, Zimbabwe	Conflicting information exists on the status (native or introduced/invasive) of <i>C. grandiflorum</i> in Africa. While some sources consider it native to tropical regions of Africa, others note its status as an invader of the continent is unknown. For some countries (e.g. Uganda) both morphological (S. Carroll personal communication) and phylogenetic data suggest a native range distribution. The species is definitely non-native to South Africa and Namibia. Given that some accessions from tropical Africa (Uganda) are now considered native and the species' cosmopolitan distribution and dispersal capabilities, it is reasonable to assume that tropical African populations are likely native. It is also possible that the species is under cultivation in some parts of Africa. It is noteworthy that the species is considered invasive in some parts of its native East African ranges (Kenya and Uganda, A.B.R. Witt, personal communication). Areas of geographic uncertainty (native vs. introduced) include southern African distributions of the species in Zimbabwe, southern Malawi, and southern Mozambique.	Cowling <i>et al.</i> (1997), DAFF (2011), ISSG (2007), Gildenhuis <i>et al.</i> (2015), GISD (2015), McKay <i>et al.</i> (2010)
America	Argentina, Belize, Bolivia, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, USA (Hawaii and Puerto Rico), Venezuela	The species has a wide Neotropical native range from southern Mexico to Brazil and Caribbean (type specimen from Jamaica). All central and south American countries are considered part of the species' native range distribution. Distributions in the USA represent non-native naturalised populations of the species.	Carroll <i>et al.</i> 2005a, USDA 2013
Asia	Sri Lanka	<i>Cardiospermum grandiflorum</i> is considered introduced to Sri Lanka	CABI (2016), USDA (2013)
Europe	France (only in Landes and Alpes-Maritimes departments), Italy (mainland and the Island of Sicily), Malta, Portugal (only in	Invasive species perceived to have significant environmental impacts in Malta. In France and Italy the species is considered casual and may be in the process of establishment. The status of	Ameen (2013), DAFF (2011), EPPO (2012), Informatore Botanico

Continent	Distribution (list countries, or provide a general indication , e.g. present in West Africa)	Provide comments on the pest status in the different countries where it occurs (e.g. widespread, native, introduced....)	Reference
	Madeira Island), Spain (only in Canary Islands: Gran Canaria, Tenerife, La Gomera, La Palma)	The situation of the species in Spain and Portugal is currently unknown.	Italiano (2014)
Oceania	Australia, Cook Islands, Fiji, French Polynesia, New Zealand	All are invaded regions, particularly in Australia. Uncommon in New Zealand following extensive management efforts against the weed.	Carroll <i>et al.</i> 2005a, EPPO 2012, USDA 2013, Gildenhuis <i>et al.</i> 2015, GISD (2015),

Introduction

Cardiospermum grandiflorum has a wide Neotropical native range from southern Mexico to Brazil and Caribbean (type specimen from Jamaica) (Appendix 4, Figure 1). The species has been introduced intentionally to many regions of the world as a popular ornamental plant. The species is widespread and highly invasive in subtropical regions in Australia and South Africa.

Africa

The introduction of *Cardiospermum grandiflorum* into South Africa as an ornamental plant occurred around 100 years ago (Simelane *et al.* 2011). The species has rapidly spread and is considered invasive in five of the country's nine provinces, of which the Kwazulu-Natal and the Eastern Cape provinces are the most severely affected (Henderson 2001, Simelane *et al.* 2011). Little information is available about the species' introduction history into other non-native ranges in southern Africa (Angola, Botswana, Namibia, Mozambique, Swaziland, Zimbabwe) (EWG opinion). Some uncertainty exists about the species' status (native or introduced) in tropical Africa. For some countries (e.g., Uganda) both morphological and phylogenetic data suggest a native range distribution. In this PRA tropical regions of Africa were regarded as native range distributions. See Appendix 4, Figure 2.

Oceania

The first herbarium records of *C. grandiflorum* date back to 1923 in Australia, from around Sydney, New South Wales (Carroll *et al.* 2005a). The species is now abundant throughout the east coast of Australia between Sydney and Cairns. Inland spread of the species to forested areas such as Toowoomba (Queensland) and the Blue Mountains (New South Wales) recently has been observed (Carroll *et al.* 2005a, E. Gildenhuis, pers. obs.). The species is present in isolated populations in the north island of New Zealand around Auckland. The species is now rare (possibly eradicated) from the country following extensive management efforts. *Cardiospermum grandiflorum* is widespread and invasive on Rarotonga, Cook Islands, and Tahiti, but exact dates of introduction are not known. See Appendix 4, Figure 3.

Americas

The species has a wide Neotropical native range from southern Mexico to Brazil and Caribbean (type specimen from Jamaica). All central and south American countries are

considered part of the species' native range distribution. Distributions in the USA represent non-native naturalised populations of the species. There also is a single record from Los Angeles, California (Gildenhuis *et al.* 2013). See Appendix 4, Figure 4.

Europe

In Europe, the species has non-native records from France (Landes and Alpes-Maritimes departments, considered a casual species in the process of becoming established), Italy (Catania, Canalicchio; Sicilia, Liguria.), Malta (considered as an invasive species), Portugal (Madeira Island), and Spain (Canary Islands: Gran Canaria, Tenerife, La Gomera, La Palma). See Appendix 4, Figure 5. In the Alpes-Maritimes department in France, the species was first recorded in Menton in the City of Beausoleil in an urban area.

Asia

Some consider parts of Asia as the native range of the species (CABI 2016). The species is considered as introduced to Sri Lanka. See Appendix 4, Figure 6.

7. Habitats and their distribution in the PRA area

Habitats	EUNIS habitat types	Status of habitat (eg threatened or protected)	Present in PRA area (Yes/No)	Comments (e.g. major/minor habitats in the PRA area)	Reference
Grasslands and lands dominated by forbs, mosses or lichens	E1: Dry grassland E2: Mesic grasslands E3: Seasonally wet and wet grasslands E5: Woodland fringes and clearings and tall forb stands E7: Sparsely wooded grasslands	In Part	Yes	Major habitat within the EPP0 region	EWG opinion
Woodland	G1: Broadleaved deciduous woodland (including riparian woodland) G2: Broadleaved evergreen woodland G4: Mixed deciduous and coniferous woodland G5: Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice	In part	Yes	Major habitat within the EPP0 region	EWG opinion
Regularly or recently cultivated agricultural, horticultural and domestic habitats	I1: Arable land and market gardens I2: Cultivated areas of gardens and parks	None	Yes	Major habitat within the EPP0 region	EWG opinion
Constructed, industrial and other artificial habitats	J4: Transport networks and other constructed hard-surfaced areas J5: Highly artificial man-made waters and associated structures J6: Waste deposits	None	Yes	Major habitat within the EPP0 region	EWG opinion

Habitats	EUNIS habitat types	Status of habitat (eg threatened or protected)	Present in PRA area (Yes/No)	Comments (e.g. major/minor habitats in the PRA area)	Reference
X: Habitat complexes	X06: Crops shaded by trees X07: Intensively-farmed crops interspersed with strips of natural and/or semi-natural vegetation X09: Pasture woods (with a tree layer overlying pasture) X10: Mosaic landscapes with a woodland element (bocages) X11: Large parks X13: Land sparsely wooded with broadleaved deciduous trees X14: Land sparsely wooded with broadleaved evergreen trees X15: Land sparsely wooded with coniferous trees X16: Land sparsely wooded with mixed broadleaved and coniferous trees X22: Small city centre non-domestic gardens X23: Large non-domestic gardens X24: Domestic gardens of city and town centres X25: Domestic gardens of villages and urban peripheries	None	Yes	Major habitat within the EPP0 region	EWG opinion

C. grandiflorum prefers open habitat, though it may thrive in forest edges (CABI 2015). *Cardiospermum grandiflorum* thrives in well-drained soil types. Research on invasive populations of *C. grandiflorum* from Australia found soil types to vary substantially among regions of high-density populations indicating a wide edaphic tolerance by the species. It also has been noted that optimal growth takes place in well-lit (sunny) locations, although it is capable of germinating under dark conditions (ARC 2011). Seeds and young plants are able to survive flooded, saturated, and dry conditions, while performing best in intermediate conditions (Dempsey 2011). In both native and introduced ranges, *C. grandiflorum* performs best in subtropical climates, in habitats such as forest margins, along watercourses, and in disturbed urban open areas (Carroll 2005a, Gildenhuis *et al.* 2013). The species also responds rapidly to environmental disturbances (Carroll *et al.* 2005a) and is commonly observed in highly disturbed habitats such as abandoned agricultural fields, urban environments, and areas outside domestic gardens (JJ Le Roux, personal observation)

8. Pathways for entry

Possible pathways (in order of importance)	Pathway: Plants or seeds for planting
Short description explaining why it is considered as a pathway	Most non-native <i>Cardiospermum</i> species, including <i>C. grandiflorum</i> , primarily have been introduced as an ornamental species. These species are popular because of their ease to grow and showy fruit capsules.
Is the pathway prohibited in the PRA area?	No evidence of regulation within the PRA area
Has the pest already been intercepted on the pathway?	Yes, the commodity is for sale seeds
What is the most likely stage associated with the pathway?	Individual live plants (though this is mostly within the EPPO region as oppose to entry into the PRA area) or seeds (both within and from outside the EPPO region).
What are the important factors for association with the pathway?	While trade using the normal avenues (e.g. online market places like Ebay.com) currently lists <i>C. grandiflorum</i> infrequently, a congeneric species, <i>C. halicacabum</i> is readily available. It is possible that some traders may confuse these two species as the latter frequently is mislabelled as <i>C. grandiflorum</i> .
Is the pest likely to survival transport and storage in this pathway?	Yes, if the intention is to introduce propagules (plants or seeds) for ornamental purposes then survival is essential.
Can the pest transfer from this pathway to a suitable habitat?	Yes, through direct human actions. Planted individuals can easily spread via wind or water dispersed seeds. The species responds well to anthropogenic disturbances in urban (city) and rural (e.g. agriculture) areas.
Will the volume of movement along the pathway support entry?	The species is already present in the EPPO region and we found little evidence for on-going trade in the species.
Will the frequency of movement along the pathway support entry?	See answer under ‘Will the volume of movement along the pathway support entry?’
Likelihood of entry	Low Moderate X High
Rating of uncertainty	Low X Moderate High

Do other pathways need to be considered?

No

9. Likelihood of establishment in the natural environment PRA area

Note: Based on the species distribution modeling, suitable areas for *C. grandiflorum* have been identified as suitable for establishment in the Mediterranean biogeographical region (See appendix 1 and 2). Areas in Portugal, Spain and Italy are suitable for the establishment of the species and areas in North Africa (Morocco and Algeria) are marginally suitable. In addition, areas of Israel and countries bordering the Adriatic and Ionian Sea provide marginally suitable areas for the establishment of *C. grandiflorum*. The authors of the PRA acknowledge that there are a number of caveats to the modelling the species distribution and for this species they include: (1) The GBIF API query used to did not appear to give completely accurate results. For example, in a small number of cases, GBIF indicated no Tracheophyte records in grid cells in which it also yielded records of the focal species. (2) We located additional data sources to GBIF, which may have been from regions without GBIF records. (3) Other variables potentially affecting the distribution of the species, such as soil nutrients, were not included in the model.

Cardiospermum grandiflorum is already present in the natural environment in Malta where it also shows invasive tendencies. The species is also casual and may be in the process of establishing in France and Italy. The species also has annual and perennial forms/behaviour, and it is likely that annual forms are better suited for climatic conditions within the EPPO region. In Australia and South Africa, the species does not exhibit the invasive tendencies in the Mediterranean areas that are seen in the more tropical and sub-tropical regions of these countries (personal communication JJ Le Roux 2016; CABI 2016).

Natural habitats within the endangered area include woodland, forests, wasteland, grassland, riparian systems and successional habitats.

Rating of the likelihood of establishment in the natural environment	Low <input type="checkbox"/>	Moderate <input checked="" type="checkbox"/>	High <input type="checkbox"/>
Rating of uncertainty	Low <input checked="" type="checkbox"/>	Moderate <input type="checkbox"/>	High <input type="checkbox"/>

10. Likelihood of establishment in managed environment in the PRA area

Cardiospermum grandiflorum responds well to human-mediated environmental disturbances (Personal Coomunication, Le Roux). This is especially true in areas previously invaded by the species where seed banks respond to the availability of light. Irrespective, release of the species into disturbed areas, e.g. agricultural land and their boundaries, old fields, road sides, water course banks, etc. are expected to be highly suitable for establishment in areas meeting the species' climatic requirements. The species also grows well along roadsides, urban areas within its non-native range where it is non-invasive. For example, in Italy (Liguria), *C. grandiflorum* is established in disturbed, peri-urban areas.

As already mentioned, the most limiting environmental factors for establishment of *C. grandiflorum* are temperature and rainfall. However, urban environments (home gardens, disturbed habitats in cities, roadsides etc.) often create microclimates that may overcome these limitations.

Managed habitats within the PRA area include old fields, road sides, water course banks, agricultural lands, home gardens and roadsides.

Rating of the likelihood of establishment in the managed environment	Low <input type="checkbox"/>	Moderate	High X
Rating of uncertainty	Low X	Moderate <input type="checkbox"/>	High <input type="checkbox"/>

11. Spread in the PRA area

Natural spread

Cardiospermum grandiflorum fruits (balloons) and seeds are well adapted for extreme (i.e. inter-continental) long-distance dispersal (Gildenhuis *et al.* 2015a). That is, seed-carrying balloons can float for extensive periods in watercourses and so cover substantial distances over short time scales, e.g. along rivers and even across the sea. Previous research has shown balloons floated in seawater for 6 months to carry viable seeds (Gildenhuis *et al.* 2013). Within balloons individual seeds are attached to circular sails that may deploy once the fruit dehisces, further aiding in wind dispersal. The known presence of the species within the EPPO region makes natural dispersal the most likely mode of spread within the region.

Human assisted spread

The main pathway historically for this species has been the ornamental industry and the use of the species as a garden plant. Online vendors still sell seeds of the genus, but mostly for *C. halicacabum*. Within the EPPO region several traders do list the species. Many of these traders misidentify the species, i.e. selling *C. halicacabum* under the name *C. grandiflorum*. It is possible that the species may still be in the horticultural trade within the PRA area since it is already present in several EPPO countries and may therefore be traded as whole plants. In some instances a congeneric species, *C. halicacabum*, has been mislabelled as *C. grandiflorum* by these traders. However, given the species' known occurrences within the EPPO region and its desirable characteristics as an ornamental, it remains likely that it could be moved around non-commercially, and therefore, we cannot rule out the potential for further human-assisted spread.

Rating of the magnitude of spread	Low <input type="checkbox"/>	Moderate X	High <input type="checkbox"/>
Rating of uncertainty	Low X	Moderate <input type="checkbox"/>	High <input type="checkbox"/>

12. Impact in the current area of distribution

12.01 Impacts on biodiversity

In its invasive range *C. grandiflorum* typically forms dense draping carpets/mats, smothering large areas of underlying vegetation (Ameen, 2013; McKay *et al.* 2010). For example, in Australia these carpets can cover native vegetation in riparian ecosystems in uninterrupted stands sometimes several kilometres in size, including trees of up to 20 m high (Carroll *et al.* 2005a). The resultant exclusion of sunlight negatively impacts photosynthesis, leading to the competitive exclusion of other species, including natives. *Cardiospermum grandiflorum* therefore has the potential to negatively affect overall ecosystem processes and plant communities (Ameen 2013, Coutts-Smith and Downey 2006). While empirical data on the species' impacts are currently lacking, its potential impacts can be deduced from similar invasive growth forms elsewhere in the world. For example, the woody vine *Clematis vitalba*

is a vigorous climber that, similar to balloon vine, smothers vegetation. In New Zealand *C. vitalba* has had serious biodiversity impacts (Ogle *et al.* 2000). In South Africa *C. grandiflorum* is considered a 'transformer' species (Henderson 2001, Carroll *et al.* 2005a) where it is a major weed in riparian zones (banks of watercourses).

In Malta, there is evidence of impacts on biodiversity as the species has formed extensive invasive populations (EWG opinion). The invaded area in Malta may present unique micro-climatic conditions for the species due to it being a steep-sided dry valley (EWG opinion).

An intriguing example of the possible long-term impacts of invasive balloon vines on native biodiversity includes an evolved increase in rostrum length of the Australian soapberry bug, *Leptocoris tagalicus*, in response to feeding preferentially on invasive *C. grandiflorum* rather than its native Sapindaceae host (Carroll *et al.* 2005b). This impact is unlikely to be replicated in the EPPO region, as the region falls outside the native range distributions of soapberry bugs.

Management

To date, managing *C. grandiflorum* invasions has mostly involved manual removal or burning. Manual removal involves cutting plants at the base. Roots are dug up after the above ground biomass has died off to avoid resprouting.

Chemical control of larger plants includes treatment with paraquat (please note that paraquat is banned in some EPPO countries), glufosinate-ammonium, lactofen, carfentrazone-ethyl, sulfentrazone, glyphosate or 2, 4-dichlorophenoxy acetic acid (see Brighenti *et al.* 2003). This does not mean the chemicals are available or legal to use and countries should check to ensure chemicals are licensed for use in their country. In addition, the use of chemical control could potentially be problematic for two reasons, firstly because of non-target impact on underlying vegetation and, secondly, the high risk of environmental contamination because of the species' typical proximity to waterways (Simelane *et al.* 2011). A potential problem with both manual and chemical management is the species' ability to form relatively large seed banks (potentially hundreds per plant), so that once the weedy canopy is cleared or died off, seeds start to sprout as they respond strongly to the availability of light (FloraBase 2012).

Classical biological control has only been explored against the species in South Africa. Since the inception of a biological control program in 2003, ten insects and two fungal agents have either been recorded on the target weed in the native South American range or have been undergoing host-specificity testing in South Africa (McKay *et al.* 2010, Simelane & Mawela 2013). Eight of these insects displayed wider host ranges, capable of feeding and developing on other cosmopolitan *Cardiospermum* species in South Africa, in particular *C. halicacabum* and *C. corindum*. This is problematic for the region because, while both *C. grandiflorum* and *C. halicacabum* are non-native in South Africa, *C. corindum* is considered native (Gildenhuis *et al.* 2015a, 2015b). Of those potential biological control agents tested to date, most were largely restricted to its taxonomic family (Sapindaceae) or genus, but not necessarily to the species *Cardiospermum grandiflorum*. One promising seed-feeding Curculionid weevil, *Cissoanthonomus tuberculipennis*, was released in South Africa's KwaZulu Natal Province in late 2013 (Simelane *et al.* 2014). The effectiveness of this biological control agent and its host specificity under field conditions remains to be assessed.

“Neoclassical” biological control, that is, the use of natural enemies that are native to the introduced range, represents a possible management approach worthwhile to mention with

regards to *C. grandiflorum*. Soapberry bugs (genera *Leptocoris*, *Jadera* and *Boisea* from the family Rhopalidae) feed exclusively on seeds of Sapindaceae and are natural seed predators of *Cardiospermum* species in both their native and non-native regions (Carroll *et al.* 2005b). Soapberry bugs co-occur with the widespread distribution of *Cardiospermum* and thus may be a factor in the genus' reproduction globally. For example, native American soapberry bugs can destroy ca. 95% of introduced balloon vine seed crops there (Carroll *et al.* 2003). A treatment of soapberry bugs that feed on *C. halicacabum* and *C. grandiflorum* can be found in Carroll and Loye (2012). In the European context such neoclassical biological might occur if insects utilising native Sapindaceae shift onto balloon vine. However, the genera *Leptocoris*, *Jadera* and *Boisea* are absent from the continent.

According to the available information, to-date there are no impacts recorded on red list species and species listed in the Birds and Habitats Directives.

<i>Rating of the magnitude of impact in the current area of distribution</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i> X	<i>High</i>
<i>Rating of uncertainty</i>	<i>Low</i>	<i>Moderate</i> X	<i>High</i> <input type="checkbox"/>

12.02. Impact on ecosystem services

Ecosystem service	Does the IAS impact on this Ecosystem service? Yes/No	Short description of impact	Reference
Provisioning	Yes	In East Africa, dense populations of invasive <i>C. grandiflorum</i> have been reported to hinder the free movement of wildlife and livestock (BioNET International 2016). These impacts are well documented for congeneric species such as <i>C. halicacabum</i> that can reduce soybean crop yields by up to 26%.	BioNET International 2016, Johnston <i>et al.</i> 1979, Jolley <i>et al.</i> 1983, Voll <i>et al.</i> 2004, Subramanyam <i>et al.</i> 2007, Murty and Venkaiah 2011, Dempsey <i>et al.</i> 2011, Brighenti <i>et al.</i> 2003.
Regulating	Yes	Impediment on photosynthesis, reducing biodiversity	Carroll <i>et al.</i> 2005a
Supporting	Yes	Relative primary production by competitive displacement of native vegetation. Possibly could interfere with stability of riparian habitats when displacing native flora, e.g. increased bank erosion	Carroll <i>et al.</i> 2005a, Ameen, 2013, McKay <i>et al.</i> 2010
Cultural	Yes	Aesthetic impacts can occur when the species smothers natural areas	EWG opinion

Ecosystem service impacts are rather hard to assess, given that many descriptions in the literature are based on observational rather than empirical data, with the current status of impacts in any particular area unknown. The assessment is therefore given a “moderate” uncertainty rating.

Rating of the magnitude of impact in the current area of distribution	Low <input type="checkbox"/>	Moderate <input checked="" type="checkbox"/>	High
Rating of uncertainty	Low <input type="checkbox"/>	Moderate <input checked="" type="checkbox"/>	High <input type="checkbox"/>

12.03. Describe the adverse socio-economic impact of the species in the current area of distribution

Dense stands of *C. grandiflorum* have been reported as being able to restrict the free movement of wildlife and livestock (BioNET International 2016). The largest potential costs would potentially lie in the control of this species once established and widespread. Mechanical control of balloon vine is extremely difficult and costly, as dead plant material has to be removed to restore exposure of the understory to sunlight (ARC 2011). Such costs would be escalated by the need to prevent contamination of watercourses, along which the species are most likely to establish, when using chemical control. Biological control programmes can be costly and in South Africa research costs associated with these programmes are typically over 500,000 Euros per target species (van Wilgen *et al.* 2004).

Cardiospermum (note this relates to several species) invasions also have substantial economic impacts on sugarcane and soybean production (Johnston *et al.* 1979, Jolley *et al.* 1983, Subramanyam *et al.* 2007, Murty and Venkaiah 2011). For example, in Brazil *C. halicacabum* can reduce soybean crop yields by up to 26% (Dempsey *et al.* 2011, Brighenti *et al.* 2003). The problem with controlling *Cardiospermum* infestations in soybean crops is the difficulty of mechanically excluding their seeds, which represent soybean seeds in size and shape (Brighenti *et al.* 2003). It is foreseeable that, when climatic requirements are met, the species may pose an economic threat to agricultural crop yields.

<i>Rating of the magnitude of impact in the current area of distribution</i>	<i>Low</i>	<i>Moderate X</i>	<i>High</i> <input type="checkbox"/>
<i>Rating of uncertainty</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate X</i>	<i>High</i> <input type="checkbox"/>

13. Potential impact in the PRA area

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

Magnitude of impact is hard to assess due to the conflicting information on the species. For example, in Australia and South Africa, countries with both subtropical and Mediterranean-type regions, the species does not exhibit the invasive tendencies in the Mediterranean areas that are seen in the more tropical and sub-tropical regions of these countries (personal communication JJ Le Roux, 2016; CABI 2016).

In Malta, there is evidence of impacts on biodiversity as the species has formed extensive invasive populations (EWG opinion). The invaded area in Malta may present unique micro-climatic conditions for the species due to it being a steep-sided dry valley (EWG opinion).

In the absence of specific data on impacts in the PRA area the rating of magnitude of impact is given as moderate (there is already evidence the species is having an impact) but the uncertainty is raised to high as it is not clear if these impacts will be realised throughout areas of potential establishment in the PRA area.

Impacts on biodiversity

<i>Rating of the magnitude of impact in the area of potential establishment</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate X</i>	<i>High</i> <input type="checkbox"/>
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<i>Rating of uncertainty</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i> <input type="checkbox"/>	<i>High</i> X
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Impacts on ecosystem services

<i>Rating of the magnitude of impact in the area of potential establishment</i>	<i>Low</i>	<i>Moderate</i> X	<i>High</i> <input type="checkbox"/>
<i>Rating of uncertainty</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i> <input type="checkbox"/>	<i>High</i> X

Socio-economic impacts

<i>Rating of the magnitude of impact in the area of potential establishment</i>	<i>Low</i>	<i>Moderate</i> X	<i>High</i> <input type="checkbox"/>
<i>Rating of uncertainty</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i>	<i>High</i> X

14. Identification of the endangered area

Based on the species distribution modeling, suitable areas for establishment of *C. grandiflorum* have been identified in the Mediterranean biogeographical region. Areas in Portugal, Spain and Italy are suitable for the establishment of the species and areas in North Africa (Morocco and Algeria) are marginally suitable. In addition, areas of Israel and countries bordering the Adriatic and Ionian Sea provide marginally suitable areas for the establishment of *C. grandiflorum*.

Habitats within the endangered area include woodland, forests, wasteland, riparian systems, old fields, fallow gardens, successional habitats, roadsides, urban habitats.

15. Climate change

15.01. Define which climate projection you are using from 2050 to 2100*

Climate projection RCP 8.5 2070

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

Temperature (yes)

Precipitation (yes)

CO₂ levels (yes)

Sea level rise (no)

Salinity (no)

Nitrogen deposition (yes)

Acidification (no)

Land use change (yes)

Other (please specify)

<p>Are the introduction pathways likely to change due to climate change? (If yes, provide a new risk and uncertainty score)</p>	<p>Reference</p>
<p>The introduction pathways are unlikely to change as a result of climate change. Therefore, the scores will remain the same.</p>	<p>EWG opinion</p>
<p>Is the risk of establishment likely to change due to climate change? (If yes, provide a new risk and uncertainty score)</p>	<p>Reference</p>
<p>Yes, temperature is an important factor in the reproductive cycle (e.g. seed germination) of the species.</p> <p>Under predicted future climate conditions (using scenario RCP 8.5 (2070)) in general, the potential area for establishment in the EPPO region will increase. The extent of suitable areas will increase in the Atlantic biogeographical region (France, Germany, Belgium, Netherlands and England), even including a very small area of the Continental biogeographical region.</p> <p>Therefore, a new score for risk and uncertainty for predicted future climatic conditions is: Risk= High, Uncertainty=High</p>	<p>(Johnston <i>et al.</i> 1979, Jolley <i>et al.</i> 1983, Dempsey 2011)</p>
<p>Is the risk of spread likely to change due to climate change? (If yes, provide a new risk and uncertainty score)</p>	<p>Reference</p>
<p>Yes, temperature impacts the phenology of <i>C. grandiflorum</i>, with warmer climates supporting longer flowering periods. This will potentially lead to higher reproductive output under predicted future climate conditions (using scenario RCP 8.5 (2070)). Increased flood events resulting from climate change could facilitate the spread of seeds into new regions.</p> <p>Therefore, a new score for risk and uncertainty for predicted future climatic conditions is: Risk= High, Uncertainty=High</p>	<p>FloraBase 2012</p>
<p>Will impacts change due to climate change? (If yes, provide a new risk and uncertainty score)</p>	<p>Reference</p>
<p>Yes, it is expected that a larger part of the EPPO region will be suited to the climatic requirements of the species, and thus that the area occupied by the species, and performance of the species will increase.</p> <p>Therefore, a new score for risk and uncertainty for predicted future climatic conditions is: Risk=High, Uncertainty=High</p>	<p>EWG opinion</p>

16. Overall assessment of risk

The overall likelihood of *Cardiospermum grandiflorum* continuing to enter into the EPPO region is moderate with a moderate uncertainty. There is some evidence that the plant is available from a small number of horticultural suppliers within the EPPO region. The overall likelihood of *C. grandiflorum* establishing in the EPPO region is moderate with a low uncertainty - the species is already present within the EPPO region, in particular in Malta where there is evidence that the species shows invasive tendencies. The overall potential impact of the species is moderate with a high uncertainty. The high uncertainty reflects the difficulty in assessing impacts due to the lack of published research and the apparent differences in performance across climatic regions. In Australia and South Africa, countries with both subtropical and Mediterranean-type regions, the species does not exhibit the invasive tendencies in the Mediterranean areas that are seen in the more tropical and subtropical regions of these countries (personal communication, JJ Le Roux, 2016; CABI 2016). However, in Malta, there is evidence of impacts on biodiversity as the species has been reported to have formed invasive populations.

The most limiting environmental factors for the establishment of *C. grandiflorum* are temperature and rainfall. In specific situations, e.g. urban environments, Insubria (Great Lakes in Northern Italy and Southern Switzerland), meso-climatic conditions may exist that help overcome these limitations.

Pathways for entry:

Plants for planting

Rating of the likelihood of entry for the pathway, plants or seeds for planting	Low	Moderate X	High
Rating of uncertainty	Low X	Moderate	High

Rating of the likelihood of establishment in the natural environment in the PRA area

Rating of the likelihood of establishment in the natural environment	Low	Moderate X	High
Rating of uncertainty	Low X	Moderate	High

Rating of the likelihood of establishment in the managed environment in the PRA area

Rating of the likelihood of establishment in the natural environment	Low	Moderate	High X
Rating of uncertainty	Low X	Moderate	High

Magnitude of spread

Rating of the magnitude of spread	Low	Moderate X	High
Rating of uncertainty	Low X	Moderate	High

Impact on biodiversity

Rating of the magnitude of impact in the current area of distribution (Biodiversity)	Low	Moderate X	High
Rating of uncertainty	Low	Moderate X	High

Impact on ecosystem services

Rating of the magnitude of impact in the current area of	Low	Moderate X	High
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<i>distribution (ecosystem services)</i>			
<i>Rating of uncertainty</i>	<i>Low</i>	<i>Moderate X</i>	<i>High</i>

Impact on socio-economics

<i>Rating of the magnitude of impact in the current area of distribution (ecosystem services)</i>	<i>Low</i>	<i>Moderate X</i>	<i>High</i>
<i>Rating of uncertainty</i>	<i>Low</i>	<i>Moderate X</i>	<i>High</i>

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

New rating for impacts within the EPPO region:

Impact on biodiversity

<i>Rating of the magnitude of impact in the current area of distribution (Biodiversity)</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate X</i>	<i>High</i> <input type="checkbox"/>
<i>Rating of uncertainty</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i> <input type="checkbox"/>	<i>High X</i>

Negative impact the pest may have on categories of ecosystem services

<i>Rating of the magnitude of impact in the current area of distribution (ecosystem services)</i>	<i>Low</i>	<i>Moderate X</i>	<i>High</i> <input type="checkbox"/>
<i>Rating of uncertainty</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i> <input type="checkbox"/>	<i>High X</i>

Socio-economic impact of the species

<i>Rating of the magnitude of impact in the current area of distribution (ecosystem services)</i>	<i>Low</i>	<i>Moderate X</i>	<i>High</i> <input type="checkbox"/>
<i>Rating of uncertainty</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i>	<i>High X</i>

Stage 3. Pest risk management

17. Phytosanitary measures

The results of this PRA show that *Cardiospermum grandiflorum* poses a moderate risk to the endangered area (Mediterranean biogeographical region) with a moderate uncertainty.

The major pathway(s) being considered:

(1) Plants for planting

Given the significant impact of the species in other parts of the world and the identified risk to the PRA area, the EWG recommends the following measures for the endangered area:

International measures:

For the pathway plant for planting:

- prohibition of import into and movement within countries in the endangered area, of plants labeled or otherwise identified as *Cardiospermum grandiflorum*,
- commend that *Cardiospermum grandiflorum* is banned from sale within the endangered area,
- *Cardiospermum grandiflorum* should be recommended as a quarantine pest within the endangered area.

National measures

Cardiospermum grandiflorum should be monitored and eradicated, contained or controlled where it occurs in the endangered area. In addition, public awareness campaigns to prevent spread from existing populations or from botanic gardens in countries at high risk are necessary. If these measures are not implemented by all countries, they will not be effective since the species could spread from one country to another. National measures should be combined with international measures, and international coordination of management of the species between countries is recommended.

The EWG recommends the prohibition of selling and movement of the plant. These measures, in combination with management plans for early warning; obligation to report findings, eradication and containment plans, and public awareness campaigns should be implemented.

Containment and control of the species in the PRA area

Eradication measures should be promoted where feasible with a planned strategy to include surveillance, containment, treatment and follow-up measures to assess the success of such actions. As highlighted by EPPO (2012), regional cooperation is essential to promote phytosanitary measures and information exchange in identification and management

methods. Eradication may only be feasible in the initial stages of infestation, and this should be a priority. The EWG considers that this is possible at the current level of occurrence the species has in the EPPO region.

General considerations should be taken into account for all potential pathways, where, as detailed in EPPO (2014), these measures should involve awareness raising, monitoring, containment and eradication measures. NPPOs should facilitate collaboration with all sectors to enable early identification including education measures to promote citizen science and linking with universities, land managers and government departments.

Import for plant trade

Prohibition of the import, selling, planting, and movement of the plant in the endangered area.

Unintended release into the wild

The species should be placed on NPPO's alert lists and a ban from sale would be recommended in countries most prone to invasion. Export of the plant should be prohibited within the EPPO region. Management measures would be recommended to include an integrated management plan to control existing populations including manual and mechanical techniques, targeted herbicides and proven biological control techniques. Monitoring and surveillance including early detection for countries most prone to risk. NPPOs should report any finding in the whole EPPO region in particular the Mediterranean area.

Intentional release into the wild

Prohibition on planting the species or allowing the plant to grow in the wild.

Natural spread (method of spread within the EPPO region):

Increase surveillance in areas where there is a high risk the species may invade. NPPO's should provide land managers and stakeholders with identification guides and facilitate regional cooperation, including information on site specific studies of the plant, control techniques and management.

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

17.01 Management measures for eradication, containment and control

Manual control

To date, managing *C. grandiflorum* invasions has mostly involved manual removal or burning. Manual removal involves cutting plants at the base. Roots are dug up after the above ground biomass has died off to avoid resprouting.

This section lists chemicals that have been cited for use against the species. This does not mean the chemicals are available or legal to use and countries should check to ensure chemicals are licensed for use in their country. Chemical control of larger plants includes treatment with paraquat, glufosinate-ammonium, lactofen, carfentrazone-ethyl, sulfentrazone, glyphosate (see Brighenti *et al.* 2003). However, the use of chemical control could potentially be problematic for two reasons, firstly because of non-target impact on underlying vegetation

and, secondly, the high risk of environmental contamination because of the species' typical proximity to waterways (Simelane *et al.* 2011). A potential problem with both manual and chemical management is the species' ability to form relatively large seed banks (potentially hundreds per plant), so that once the weedy canopy is cleared or died off, seeds start to sprout as they respond strongly to the availability of light (FloraBase 2012).

Classical biological control has only been explored against the species in South Africa. Since the inception of a biological control program in 2003, ten insects and two fungal agents have either been recorded on the target weed in the native South American range or have been undergoing host-specificity testing in South Africa (McKay *et al.* 2010, Simelane & Mawela 2013). Eight of these insects displayed wider host ranges, capable of feeding and developing on other cosmopolitan *Cardiospermum* species in South Africa, in particular *C. halicacabum* and *C. corindum*. This is problematic for the region because, while both *C. grandiflorum* and *C. halicacabum* are non-native in South Africa, *C. corindum* is considered native (Gildenhuys *et al.* 2015a, 2015b). Of those potential biological control agents tested to date, most were largely restricted to its taxonomic family (Sapindaceae) or genus, but not necessarily to the species *Cardiospermum grandiflorum*. One promising seed-feeding Curculionid weevil, *Cissoanthonomus tuberculipennis*, was released in South Africa's KwaZulu Natal Province in late 2013 (Simelane *et al.* 2014). The effectiveness of this biological control agent and its host specificity under field conditions remains to be assessed.

“Neoclassical” biological control, that is, the use of natural enemies that are native to the introduced range, represents a possible management approach worthwhile to mention with regards to *C. grandiflorum*. Soapberry bugs (genera *Leptocoris*, *Jadera* and *Boisea* from the family Rhopalidae) feed exclusively on seeds of Sapindaceae and are natural seed predators of *Cardiospermum* species in both their native and non-native regions (Carroll *et al.* 2005b). Soapberry bugs co-occur with the widespread distribution of *Cardiospermum* and thus may be a factor in the genus' reproduction globally. For example, native American soapberry bugs can destroy ca. 95% of introduced balloon vine seed crops there (Carroll *et al.* 2003). A treatment of soapberry bugs that feed on *C. halicacabum* and *C. grandiflorum* can be found in Carroll and Loye (2012). In the European context such neoclassical biological might occur if insects utilising native Sapindaceae shift onto balloon vine. However, the genera *Leptocoris*, *Jadera* and *Boisea* are absent from the continent.

18. Uncertainty

Uncertainty should also be considered in the context of species distribution modelling (SDM). Here records for *C. grandiflorum* and synonyms were retrieved from GBIF and other online sources, and were also digitised from occurrences that were either mapped or clearly georeferenced in published sources. This may mean that the realised climatic niche of *C. grandiflorum* is under-characterised. In addition, georeferenced records used in our SDMs were usually without information on population persistence – if records within the EPPO area, or in climatically similar areas, are typically of ‘casual’ occurrences, rather than established populations, it may be that our SDMs over-emphasise the likelihood of establishment in climatically marginal habitats.

Level of uncertainty per sections:

Pathway for entry: Moderate

Likelihood of establishment: Low
Establishment in natural areas: Low
Establishment in managed areas: Low
Spread: Low
Impacts (current area): Moderate
Potential impacts in PRA area: High

19 Remarks

- **Inform EPPO or IPPC or EU**
- The EWG recommends a PRA is conducted on the closely related species *Cardiospermum halicacabum*.
- **Inform industry, other stakeholders**
- Ask industry to confirm if there is mislabelling between *Cardiospermum halicacabum* and *Cardiospermum grandiflorum*
- **Specify if surveys are recommended to confirm the pest status**
- Assess the current impact of *Cardiospermum grandiflorum* in Malta and other regions where the species is considered established/invasive. Also specific studies on the species biology are necessary given that most of the information refers to *C. halicacabum*.

20. REFERENCES

Acevedo-Rodríguez P (2005) Vines and climbing plants of Puerto Rico and the Virgin Islands. *Contributions from the United States National Herbarium* 51: 1–483.

Ameen J (2013) Valley flora being slowly choked by invasive plant. *Times of Malta*, Allied Newspapers Ltd. From <http://www.timesofmalta.com/articles/view/20130309/local/Valley-flora-being-slowly-choked-by-invasive-plant.460792>. [Retrieved August 15, 2016]

ARC 2011. Southern Africa Plant Invaders Atlas (SAPIA) News. From <http://www.arc.agric.za/home.asp?pid=1&toolid=2&sec=1001>. [Retrieved July 28, 2016]

Batianoff GN and Butler DW (2003) Impact assessment and analysis of sixty-six priority invasive weeds in south-east Queensland. *Plant Protection Quarterly* 18:, 11–17.

BioNET-International 2016. From [http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Cardiospermum_grandiflorum_\(Balloon_Vine\).htm](http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Cardiospermum_grandiflorum_(Balloon_Vine).htm). [Retrieved August 25, 2016]

Brighenti AM, Voll E and Gazziero DLP (2003) Biology and management of *Cardiospermum halicacabum*. *Planta Daninda* 21: 229–237.

Carroll SP, Marler M, Winchell R and Dingle H (2003) Evolution of cryptic flight morph and life history differences during host race radiation in the soapberry bug, *Jadera haematoloma* Herrich-Schaeffer (Hemiptera: Rhopalidae). *Annals of the Entomological Society of America* 96: 135–143.

Carroll SP, Mathieson M and Loye JE (2005a) Invasion history and ecology of the environmental weed balloon vine, *Cardiospermum grandiflorum* Swartz, in Australia. *Plant Protection Quarterly* 20: 140-144.

Carroll S.P., Loye J.E., Dingle H., Mathieson M., Famula T.R. and Zalucki P. (2005b) And the bleak shall inherit - evolution in response to invasion. *Ecology Letters* 8: 944–951.

Carroll SP and Loye JE (2012) Soapberry bug (Hemiptera: Rhopalidae: Serinethinae) native and introduced host plants: biogeographic background of anthropogenic evolution. *Annals of the Entomological Society of America* 105: 671–684.

Coutts-Smith AJ and Downey PO (2006) Impact of weeds on threatened biodiversity in New South Wales. Technical Series no. 11, CRC for Australian Weed Management, Adelaide.

Cowling RM, Richardson DM and Pierce SM (1997) *Vegetation of Southern Africa*. Cambridge, UK, Cambridge University Press. pp. 615.

DAFF (2011) Balloon vine *Cardiospermum grandiflorum*. Department of Agriculture and Forestry. Queensland, University of Queensland.

Dempsey MA (2011) Anatomical and morphological responses of *Cardiospermum halicacabum* l. (balloon vine), to four levels of water availability. MSc Dissertation University of North Texas.

EPPO (2012) *Cardiospermum grandiflorum* (Sapindaceae). From https://www.eppo.int/INVASIVE_PLANTS/iap_list/Cardiospermum_grandiflorum.htm. [accessed 20 July 2016]

Ferrucci MS and Umdiriri JD (2011) *Cardiospermum bahianum* (Sapindaceae: Paullinieae), a new species from Bahia, Brazil. *Systematic Botany* 34: 950–956.

FloraBase (2012) *Cardiospermum grandiflorum* Sw. From <https://florabase.dpaw.wa.gov.au/browse/profile/17318> [Accessed 23 August 2016]

GBIF.org (2016) GBIF Home Page. Available from: <http://gbif.org> [3rd May 2016].

Gildenhuis E, Ellis AG, Carroll S and Le Roux JJ (2013) The ecology, biogeography, history and future of two globally important weeds: *Cardiospermum halicacabum* Linn. and *C. grandiflorum* Sw. *Neobiota* 19: 45–65.

Gildenhuis E, Ellis AG, Carroll SP and Le Roux JJ (2015a) Combining known native range distributions and phylogeny to resolve biogeographic uncertainties of balloon vines (*Cardiospermum*, Sapindaceae). *Diversity and Distributions* 21: 163–174.

Gildenhuis E, Ellis AG, Carroll SP and Le Roux JJ (2015b) From the Neotropics to the Namib: evidence for rapid ecological divergence following extreme long-distance dispersal. *Botanical Journal of the Linnean Society* 179: 477–486.

GISD (2015) Global Invasive Species Database, Species profile *Cardiospermum grandiflorum*. From: <http://www.iucngisd.org/gisd/species.php?sc=1346>. [Accessed 23 August 2016]

Henderson L (2001) Alien weeds and invasive plants. Agricultural Research Council, Cape Town, pp. 60–61.

ISSG (2007) Invasive Species Specialist Group, Global Invasive Species Database. From <http://www.issg.org/database/welcome/>. [Accessed July 25, 2016]

Johnston KS, Murray DS and Williams JC (1979) Germination and emergence of balloonvine (*Cardiospermum halicacabum*). *Weed Science* 27: 73–76.

Jolley ER, Walker RH, McGuire JA, Johnston SK, Murray DS. and Williams JC (1983) Balloonvine biology and control in soybeans. Alabama agricultural experiment station, Auburn University 547: 1–36.

Koop A, Fowler L, Newton L and Caton B (2012) Development and validation of a weed screening tool for the United States. *Biological Invasions* 14: 273–294.

McKay F, Oleiro M, Fourie A and Simelane D (2010) Natural enemies of balloon vine *Cardiospermum grandiflorum* (Sapindaceae) in Argentina and their potential use as a biological control agent in South Africa. *International Journal of Tropical Insect Science* 30: 67–76.

Mosango M, Maganyi O and Namaganda M (2001) A floristic study of weed species of Kampala (Uganda). *Systematics and Geography of Plants* 71: 223–236.

Murty PP and Venkaiah M (2011) Biodiversity of weed species in crop fields of north coastal Andhra Pradesh, India. *Indian Journal of Fundamental and Applied Life Sciences* 1: 59–67.

Nnamani PO, Kenekwue FC and Oguamanam WN (2012) *Cardiospermum grandiflorum* leaf extract potentiates amoxicillin activity of *Staphylococcus aureus*. *Journal of Medicinal Plants Research* 6: 901–905.

Ogle CC, Cock GDL, Arnold G and Micklethorn N (2000) Impact of an exotic vine *Clematis vitalba* (F. *Ranunculaceae*) and of control measures on plant biodiversity in indigenous forest, Taihape, New Zealand. *Austral Ecology* 25: 539–551.

PIER (2013) Pacific Island Ecosystems at Risk, From http://www.hear.org/pier/species/cardiospermum_grandiflorum.htm. [Accessed August 15, 2016].

Perreira C, Carroll S and Loye J (2012) *Leptocoris ursulae*, a new species of soapberry bug from Uganda (Heteroptera: Rhopalidae, Serinethinae). *Entomologische Zeitschrift* 122: 123–124.

Simelane DO, Fourie A and Mawela KV (2011) Prospective agents for the biological control of *Cardiospermum grandiflorum* Sw (sapindaceae) in South Africa. *African Entomology* 19: 269–277.

Simelane DO and Mawela KV (2013) Biological control of balloon vine *Cardiospermum grandiflorum* in South Africa: targeting the seed output with the weevil *Cissoanthonomus tuberculipennis*. *Plant protection news* (ed. by M. Truter and A. Dippenaar-Schoeman), pp. 9–10. Agricultural Research Council, Pretoria, South Africa.

Solomon Raju AJ, Venkata Ramana K, Govinda Rao N and Varalakshmi P (2011) Monoecy and entomophily in *Cardiospermum canescens* Wall. (Sapindaceae), a medicinally valuable herbaceous vine. *Current Science* 101: 617–619.

Subramanyam R, Newmaster SG, Paliyath G and Newmaster CB (2007) Exploring ethnobiological classifications for novel alternative medicine: A case study of *Cardiospermum halicacabum* L. (Modakathon, Balloon Vine) as a traditional herb for treating rheumatoid arthritis. *Ethnobotany* 19: 1–18.

UH (2010) Weed risk assessments for Hawaii and Pacific Islands, University of Hawaii (UH). From <http://www.botany.hawaii.edu/faculty/daehler/wra/>. [Retrieved August 8, 2016].

Urdampilleta LD, Coulleri JP, Ferrucci MS and Forni-Martins ER (2013) Karyotype evolution and phylogenetic analyses in the genus *Cardiospermum* L. (Paullinieae, Sapindaceae). *Plant Biology* 15: 868–881.

USDA (2013) Weed risk assessment for *Cardiospermum grandiflorum* Sw. (Sapindaceae) - Balloon vine. From

https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Cardiospermum_grandiflorum_WRA.pdf. [Accessed August 15, 2016].

van Wilgen BW, de Wit MP, Anderson HJ, Le Maitre DC, Kotze IM, Ndala S, Brown B and Rapholo MB (2004) Costs and benefits of biological control of invasive alien plants: case studies from South Africa. *South African Journal of Science* 100: 113–122.

Vivian-Smith G and Panetta FD (2002) Going with the flow: dispersal of invasive vines in coastal catchments. *Coast to Coast* 2002: 491–494.

Voll E, Brighenti AM, Gazziero DLP and Adegas FS (2004) Population dynamics of *Cardiospermum halicacabum* and competition with soybeans. *Pesquisa Agropecuária Brasileira* 39: 27–33.

Weber E (2003) *Invasive plants of the World*. CABI Publishing, CAB International, Wallingford, UK.

Weckerle CS and Rutishauser R (2005) Gynoecium, fruit and seed structure of *Paullinieae* (*Sapindaceae*). *Botanical Journal of the Linnean Society* 147: 159–189.

Appendix 1. Projection of climatic suitability for *Cardiospermum grandiflorum* establishment

Aim

To project the suitability for potential establishment of *Cardiospermum grandiflorum* in the EPPO region, under current and predicted future climatic conditions.

Data for modelling

Climate data were taken from ‘Bioclim’ variables contained within the WorldClim database (Hijmans *et al.*, 2005) originally at 5 arcminute resolution (0.083 x 0.083 degrees of longitude/latitude) but bilinearly interpolated to a 0.1 x 0.1 degree grid for use in the model. Based on the biology of the focal species, the following climate variables were used in the modelling:

- Mean temperature of the warmest quarter (Bio10 °C) reflecting the growing season thermal regime. The USDA APHIS risk assessment mentions 4 °C as a minimum growth temperature (USDA APHIS, 2013), so low temperatures should limit growth.
- Mean minimum temperature of the coldest month (Bio6 °C) reflecting exposure to frost. Reports suggests that *C. grandiflorum* requires coldest month temperatures above 0°C (CABI, 2015).
- Mean annual precipitation (Bio12 ln+1 transformed mm), as a measure of moisture availability. Minimum precipitation requirements of 250 mm are reported (USDA APHIS, 2013).
- Precipitation of the driest quarter (Bio17 ln + 1 transformed) as a further measure of drought stress.

To estimate the effect of climate change on the potential distribution, equivalent modelled future climate conditions for the 2070s under the Representative Concentration Pathway (RCP) 8.5 were also obtained. This assumes an increase in atmospheric CO₂ concentrations to approximately 850 ppm by the 2070s. Climate models suggest this would result in an increase in global mean temperatures of 3.7 °C by the end of the 21st century. The above variables were obtained as averages of outputs of eight Global Climate Models (BCC-CSM1-1, CCSM4, GISS-E2-R, HadGEM2-AO, IPSL-CM5A-LR, MIROC-ESM, MRI-CGCM3, NorESM1-M), downscaled and calibrated against the WorldClim baseline (see http://www.worldclim.org/cmip5_5m). RCP8.5 is the most extreme of the RCP scenarios, and may therefore represent the worst case scenario for a reasonably anticipated climate change.

In the models we also included measures of habitat availability:

- Density of permanent rivers was estimated from the Vector Map (United States National Imagery Mapping Agency, 1997). River vectors were rasterised at 0.02 x 0.02 degree resolution. Then, we calculated the proportion of these grid cells containing rivers within each of the 0.1 x 0.1 degree cells used in the model. River banks are a primary habitat of *C. grandiflorum* (USDA APHIS, 2013, CABI, 2015).
- Tree cover was estimated from the MODerate-resolution Imaging Spectroradiometer (MODIS) satellite continuous tree cover raster product, produced by the Global Land Cover Facility (<http://glcf.umd.edu/data/vcf/>). The raw product contains the percentage cover by trees in each 0.002083 x 0.002083 degree grid cell. We aggregated this to the mean cover in our 0.1 x 0.1 degree grid cells. *C. grandiflorum* prefers open habitat, though it may thrive in forest edges (CABI 2015).

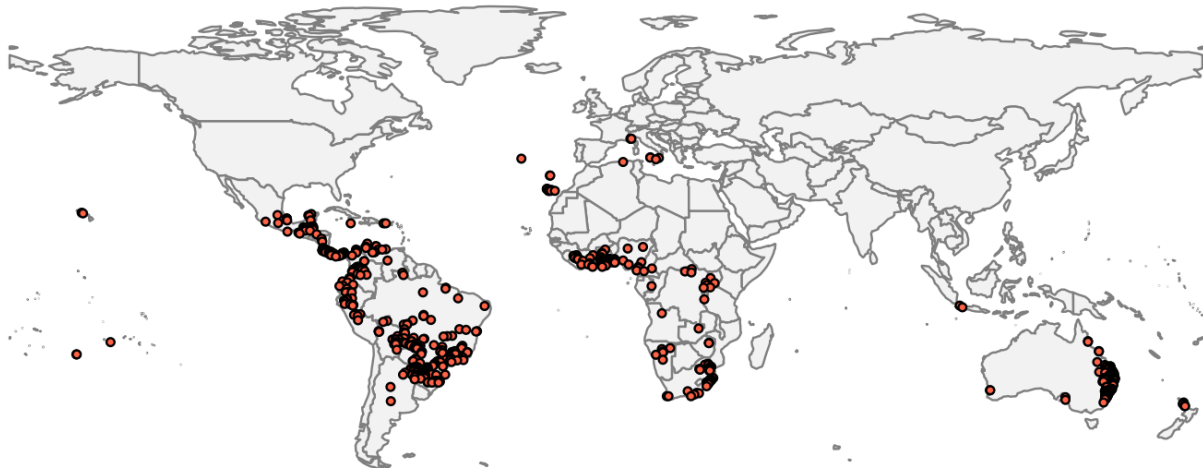
- Human influence index as *C. grandiflorum*, like many invasive species, is known to associate with anthropogenically disturbed habitats (USDA APHIS, 2013). We used the Global Human Influence Index Dataset of the Last of the Wild Project (Wildlife Conservation Society - WCS & Center for International Earth Science Information Network - CIESIN - Columbia University, 2005), which is developed from nine global data layers covering human population pressure (population density), human land use and infrastructure (built-up areas, nighttime lights, land use/land cover) and human access (coastlines, roads, railroads, navigable rivers). The index ranges between 0 and 1 and was log+1 transformed for the modelling to improve normality.

As detailed in the main text, *C. grandiflorum* may have wide edaphic tolerances. Nevertheless, we included two soil variables, derived from the GIS layers available from SoilGrids (Hengl *et al.*, 2014). Each soil property is provided at depths of 0, 5, 15, 30, 60, 100 and 200 cm as 0.002083 x 0.002083 degree rasters. These were aggregated as the mean soil property across all depths on the 0.1 x 0.1 degree raster of the model. The soil variables obtained were:

- Soil pH in water, which may affect nutrient availability to plants.
- Soil sand percentage, which affects soil drainage.

Species occurrences were obtained from the Global Biodiversity Information Facility (www.gbif.org), supplemented with data from the literature and the Expert Working Group. Occurrence records with insufficient spatial precision, potential errors or that were outside of the coverage of the predictor layers (e.g. small island or coastal occurrences) were excluded. The remaining records were gridded at a 0.1 x 0.1 degree resolution (Figure 1). In total, there were 707 grid cells with recorded occurrence of *C. grandiflorum* available for the modelling (Figure 1).

Figure 1. Occurrence records obtained for *Cardiospermum grandiflorum* used in the model, after exclusion of casual and thermally-anomalous records.



Species distribution model

A presence-background (presence-only) ensemble modelling strategy was employed using the BIOMOD2 R package v3.3-7 (Thuiller *et al.*, 2014, Thuiller *et al.*, 2009). These models contrast the environment at the species' occurrence locations against a random sample of the global background environmental conditions (often termed 'pseudo-absences') in order to

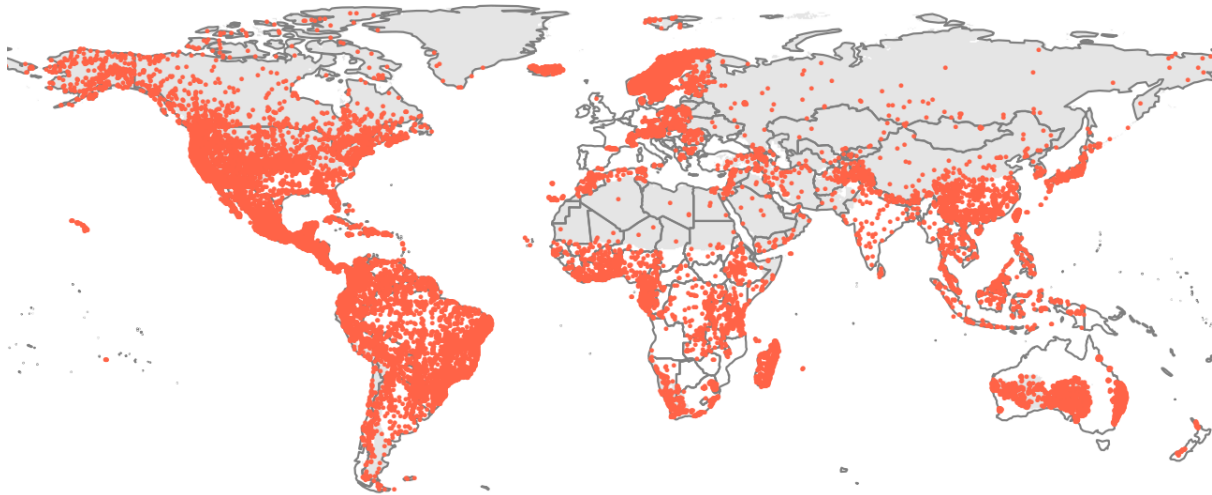
characterise and project suitability for occurrence. This approach has been developed for distributions that are in equilibrium with the environment. Because invasive species' distributions are not at equilibrium and subject to dispersal constraints at a global scale, we took care to minimise the inclusion of locations suitable for the species but where it has not been able to disperse to. Therefore the background sampling region included:

- The native continents of *C. grandiflorum*, in which the species is likely to have had sufficient time to cross all biogeographical barriers. For the model we assumed the native range to be South and north America, Asia and Africa, but excluding South Africa, Namibia, Angola, Zimbabwe, Mozambique, Botswana, Swaziland and Lesotho; AND
- A relatively small 50 km buffer around all non-native occurrences, encompassing regions likely to have had a high propagule pressure for introduction by humans and/or dispersal of the species; AND
- Regions where we have an *a priori* expectation of high unsuitability for the species (see Fig. 2). Absence from these regions is considered to be irrespective of dispersal constraints. The following rules were applied to define the region expected to be highly unsuitable for *C. grandiflorum*:
 - Mean minimum temperature of the coldest month (Bio6) < -5 °C. There is little information on frost tolerance of *C. grandiflorum*, but the coldest location with a presence in our dataset has Bio6 = 1.1 °C. The USDA APHIS risk assessment suggests *C. grandiflorum* can tolerate USDA plant hardiness zone 9, with the average most extreme minimum temperature no lower than -6.7 °C (USDA APHIS, 2013).
 - Annual precipitation (Bio12) < 250 mm. There is little information on precipitation requirements, but the APHIS risk assessment suggests a minimum requirement of approximately 250 mm (USDA APHIS, 2013). In our data, two occurrences were in drier locations (one in the Canary Islands and one in Namibia). It is possible that they are associated with wet microhabitats such as riverbanks.

Within this sampling region there was a substantial spatial biases in recording effort, which may interfere with the characterisation of habitat suitability. Specifically, areas with a large amount of recording effort will appear more suitable than those without much recording, regardless of the underlying suitability for occurrence. Therefore, a measure of vascular plant recording effort was made by querying the Global Biodiversity Information Facility application programming interface (API) for the number of phylum Tracheophyta records in each 0.1 x 0.1 degree grid cell. The sampling of background grid cells was then weighted in proportion to the Tracheophyte recording density. Assuming Tracheophyte recording density is proportional to recording effort for the focal species, this is an appropriate null model for the species' occurrence.

To sample as much of the background environment as possible, without overloading the models with too many pseudo-absences, five background samples of 10,000 randomly chosen grid cells were obtained (Figure 2).

Figure 2. Randomly selected background grid cells used in the modelling of *Cardiospermum grandiflorum*, mapped as red points. Points are sampled from the native continents, a small buffer around non-native occurrences and from areas expected to be highly unsuitable for the species (grey background region), and weighted by a proxy for plant recording effort.



Each dataset (i.e. combination of the presences and the individual background samples) was randomly split into 80% for model training and 20% for model evaluation. With each training dataset, ten statistical algorithms were fitted with the default BIOMOD2 settings, except where specified below:

- Generalised linear model (GLM)
- Generalised boosting model (GBM)
- Generalised additive model (GAM) with a maximum of four degrees of freedom per smoothing spline.
- Classification tree algorithm (CTA)
- Artificial neural network (ANN)
- Flexible discriminant analysis (FDA)
- Multivariate adaptive regression splines (MARS)
- Random forest (RF)
- MaxEnt
- Maximum entropy multinomial logistic regression (MEMLR)

Since the background sample was much larger than the number of occurrences, prevalence fitting weights were applied to give equal overall importance to the occurrences and the background. Variables importance was assessed and variable response functions were produced using BIOMOD2's default procedure. Model predictive performance was assessed by calculating the Area Under the Receiver-Operator Curve (AUC) for model predictions on the evaluation data, that were reserved from model fitting. AUC can be interpreted as the

probability that a randomly selected presence has a higher model-predicted suitability than a randomly selected absence. This information was used to combine the predictions of the different algorithms to produce ensemble projections of the model. For this, the three algorithms with the lowest AUC were first rejected and then predictions of the remaining seven algorithms were averaged, weighted by their AUC. Ensemble projections were made for each dataset and then averaged to give an overall suitability.

Results

The ensemble model had a better predictive ability (AUC) than any individual algorithm and suggested that suitability for *C. grandiflorum* was most strongly determined by the minimum temperature of the coldest month, mean temperature of the warmest quarter, soil pH, annual precipitation and precipitation of the driest quarter (Table 1). From Fig. 3, the ensemble model estimated the optimum conditions for occurrence at approximately:

- Minimum temperature of the coldest month > 9.2 °C (>50% suitability with > 2.9 °C)
- Mean temperature of the warmest quarter = 24.3 °C (>50% suitability from 19.5 to 30.0 °C)
- Soil pH = 6.0 (>50% suitability from 4.9 to 8.1)
- Annual precipitation = 1364 mm (>50% suitability from 315 to 3728 mm)
- Precipitation of the driest quarter = 414 mm

These optima and ranges of high suitability described above are conditional on the other predictors being at their median value in the data used in model fitting.

The model also characterised slight preferences for low tree cover, high human influence, and non-sandy soils (Table 1, Fig. 3). However, river density had a very low contribution to the model fit.

There was substantial variation among modelling algorithms in the partial response plots (Fig. 3). In part this will reflect their different treatment of interactions among variables. Since partial plots are made with other variables held at their median, there may be values of a particular variable at which this does not provide a realistic combination of variables to predict from. It also demonstrates the value of an ensemble modelling approach in averaging out the uncertainty between algorithms.

Global projection of the model in current climatic conditions (Fig. 4) indicates that the native and known invaded records generally fell within regions predicted to have a high suitability. Major regions without records of the species, but that are projected as suitable include Caribbean islands, south east USA, and southeast Asia. Tropical Asia is considered as part of the native range of the species, while absence from the USA may be because the species is not commonly available for purchase there (USDA APHIS, 2013).

In Europe and the Mediterranean region the model predicts that, in the current climate, there may be areas moderately suitable for establishment of the species around the Atlantic coastline from southwest France southwards and around much of the northern Mediterranean coastline up to Israel. Some of the northern African coastline of Morocco, Algeria and Tunisia also appear marginally suitable for the species. Inland regions predicted with marginal suitability are found throughout southwest Iberia and in Sardinia.

By the 2070s, under climate change scenario RCP8.5, projected suitability for *C. grandiflorum* increases, most notably in Italy and northwards into the Atlantic Biogeographic

Region as far north as The Netherlands and southern Britain (Fig. 6). Presumably this is driven by increases in summer and winter temperatures. There is little increase in suitability around the Mediterranean coastlines, which may be because of reduced predicted precipitation.

Table 1. Summary of the cross-validation predictive performance (AUC) and variable importance of the fitted model algorithms and the ensemble (AUC-weighted average of the best performing seven algorithms). Results are the average from models fitted to five different background samples of the data.

Algorithm	Predictive AUC	Variable importance								
		Minimum temperature of coldest month	Mean temperature of warmest quarter	Annual precipitation	Precipitation of driest quarter	Human influence index	River density	Tree cover	Soil pH	Soil sand content
GBM	0.8932	63.2%	20.5%	3.5%	4.5%	0.6%	0.0%	7.0%	0.4%	0.3%
ANN	0.8906	42.3%	20.6%	9.1%	8.6%	3.5%	0.3%	9.1%	3.4%	3.1%
RF	0.8818	34.5%	13.7%	10.6%	13.3%	4.0%	0.6%	9.6%	4.3%	9.3%
MaxEnt	0.8800	37.2%	21.4%	9.0%	8.3%	0.5%	0.1%	12.8%	1.9%	8.8%
GAM	0.8784	62.7%	21.3%	3.4%	4.5%	0.3%	0.0%	5.9%	0.4%	1.4%
MARS	0.8702	69.3%	12.9%	4.1%	5.1%	0.0%	0.0%	7.6%	0.4%	0.6%
GLM	0.8642	54.1%	27.7%	5.4%	4.9%	0.5%	0.1%	5.3%	0.2%	1.7%
FDA	0.8616	45.8%	15.0%	6.3%	13.6%	0.0%	0.0%	11.3%	3.2%	4.9%
CTA	0.8502	47.4%	17.0%	11.4%	6.6%	0.8%	0.0%	13.4%	2.3%	0.9%
MEMLR	0.8074	39.3%	9.4%	10.0%	14.5%	8.5%	0.7%	7.0%	0.6%	9.9%
Ensemble	0.8924	51.9%	19.7%	6.5%	7.1%	1.3%	0.2%	8.2%	1.6%	3.6%

Figure 3. Partial response plots from the fitted models, ordered from most to least important. Thin coloured lines show responses from the seven algorithms, while the thick black line is their ensemble. In each plot, other model variables are held at their median value in the training data. Some of the divergence among algorithms is because of their different treatment of interactions among variables.

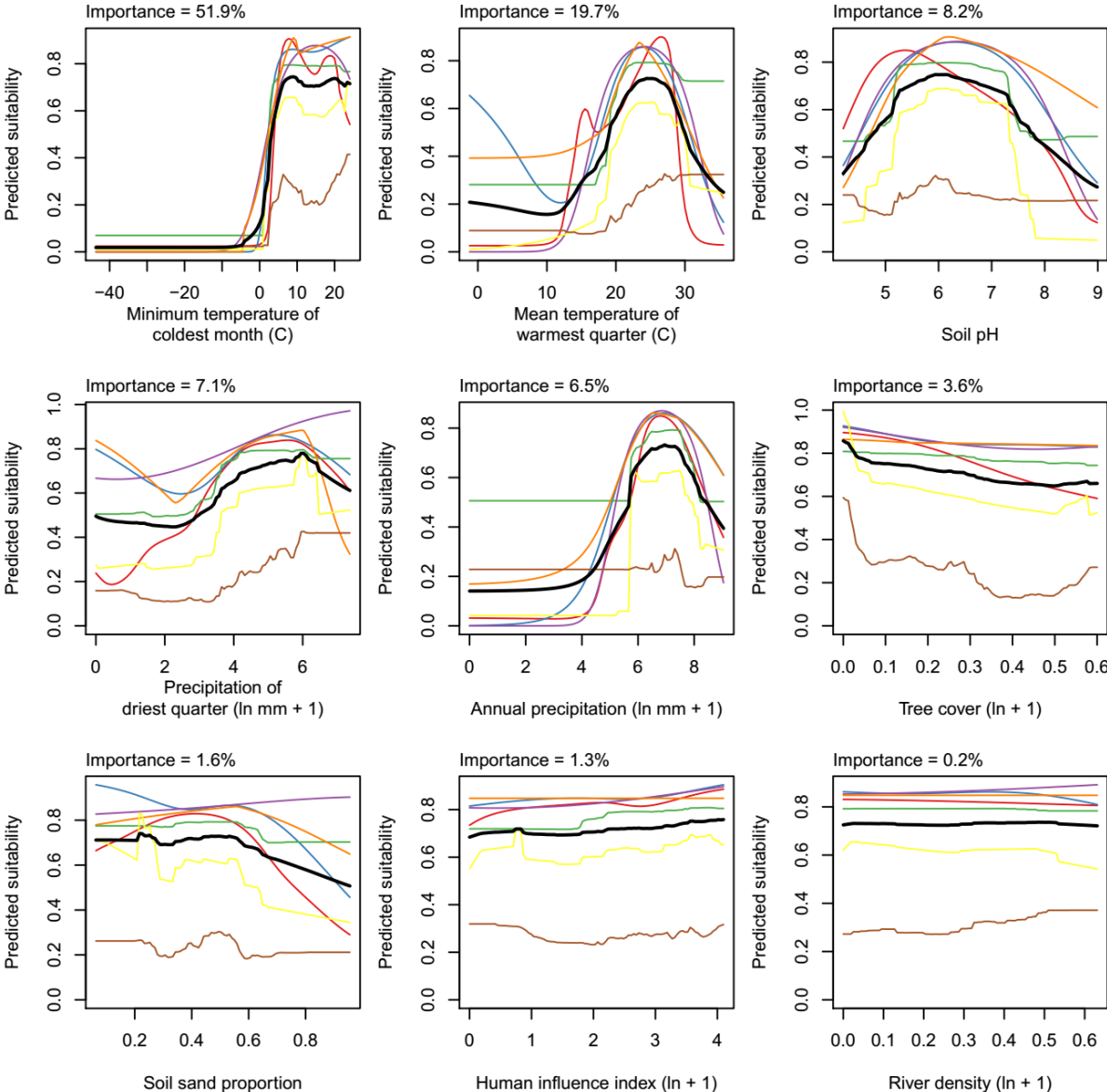


Figure 4. Projected global suitability for *Cardiospermum grandiflorum* establishment in the current climate. For visualisation, the projection has been aggregated to a 0.5 x 0.5 degree resolution, by taking the maximum suitability of constituent higher resolution grid cells. Values > 0.5 may be suitable for the species. The white areas have climatic conditions outside the range of the training data so were excluded from the projection.

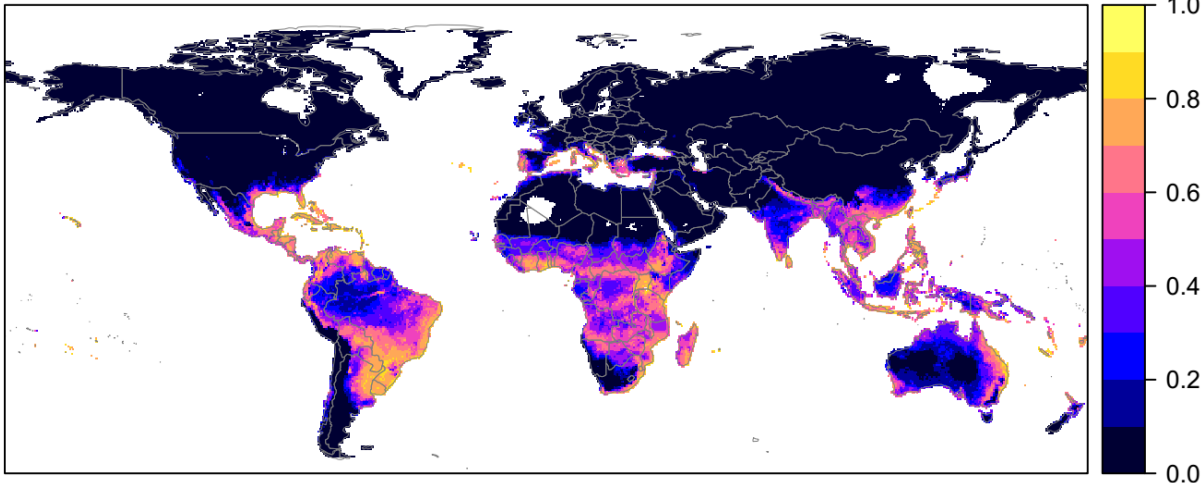


Figure 5. Projected current suitability for *Cardiospermum grandiflorum* establishment in Europe and the Mediterranean region. For visualisation, the projected suitability has been smoothed with a Gaussian filter with standard deviation of 0.1 degrees longitude/latitude. The white areas have climatic conditions outside the range of the training data so were excluded from the projection.

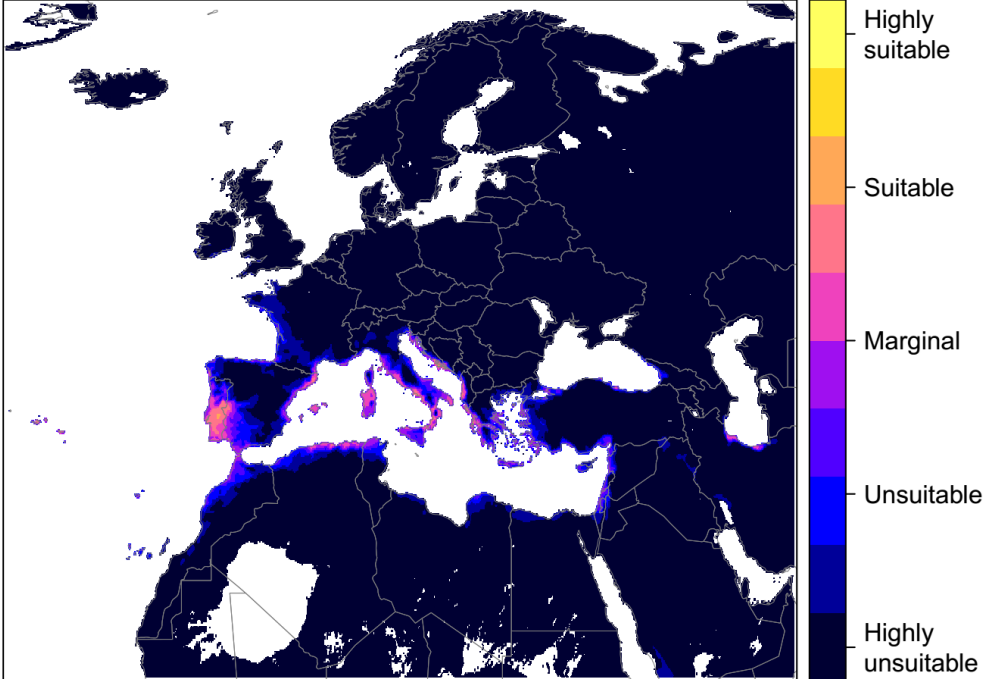
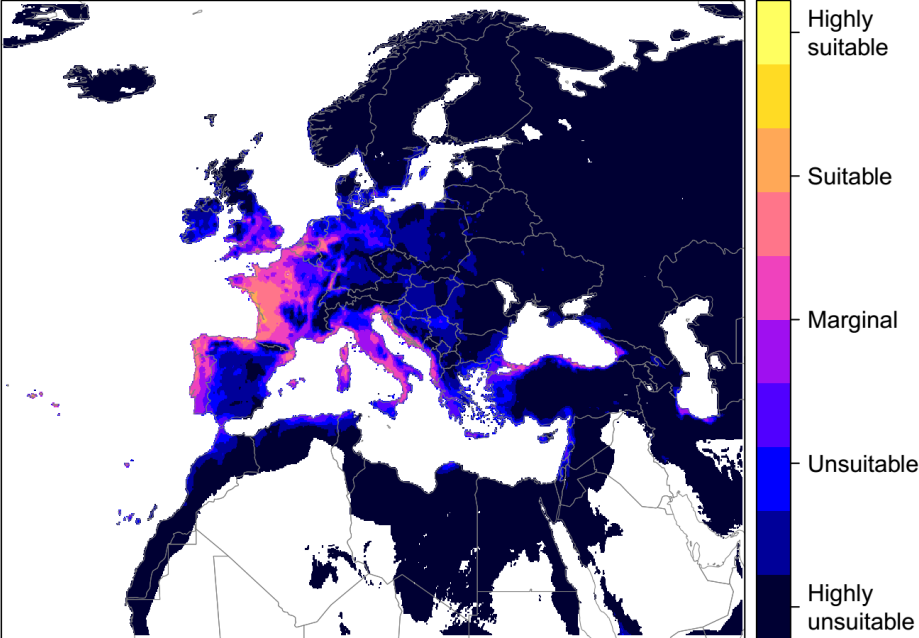


Figure 6. Projected suitability for *Cardiospermum grandiflorum* establishment in Europe and the Mediterranean region in the 2070s under climate change scenario RCP8.5, equivalent to Fig. 5.



Caveats to the modelling

To remove spatial recording biases, the selection of the background sample was weighted by the density of Tracheophyte records on the Global Biodiversity Information Facility (GBIF). While this is preferable to not accounting for recording bias at all, a number of factors mean this may not be the perfect null model for species occurrence:

- The GBIF API query used to did not appear to give completely accurate results. For example, in a small number of cases, GBIF indicated no Tracheophyte records in grid cells in which it also yielded records of the focal species.
- We located additional data sources to GBIF, which may have been from regions without GBIF records.

Other variables potentially affecting the distribution of the species, such as soil nutrients, were not included in the model.

The climate change scenario used is the most extreme of the four RCPs. However, it is also the most consistent with recent emissions trends and could be seen as worst case scenario for informing risk assessment.

References

R. J. Hijmans, S. E. Cameron, J. L. Parra, P. G. Jones and A. Jarvis (2005) Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* **25**, 1965-1978.

USDA APHIS (2013) Weed Risk Assessment for *Cardiospermum grandiflorum* Sw. (Sapindaceae) – Balloon vine. United States Department of Agriculture, Raleigh, NC.

CABI (2015) *Cardiospermum grandiflorum* (balloon vine). In *Invasive Species Compendium*, Wallingford, UK.

United States National Imagery Mapping Agency (1997) Vector map level 0 (VMAP0). USGS Information Services, Denver, CO.

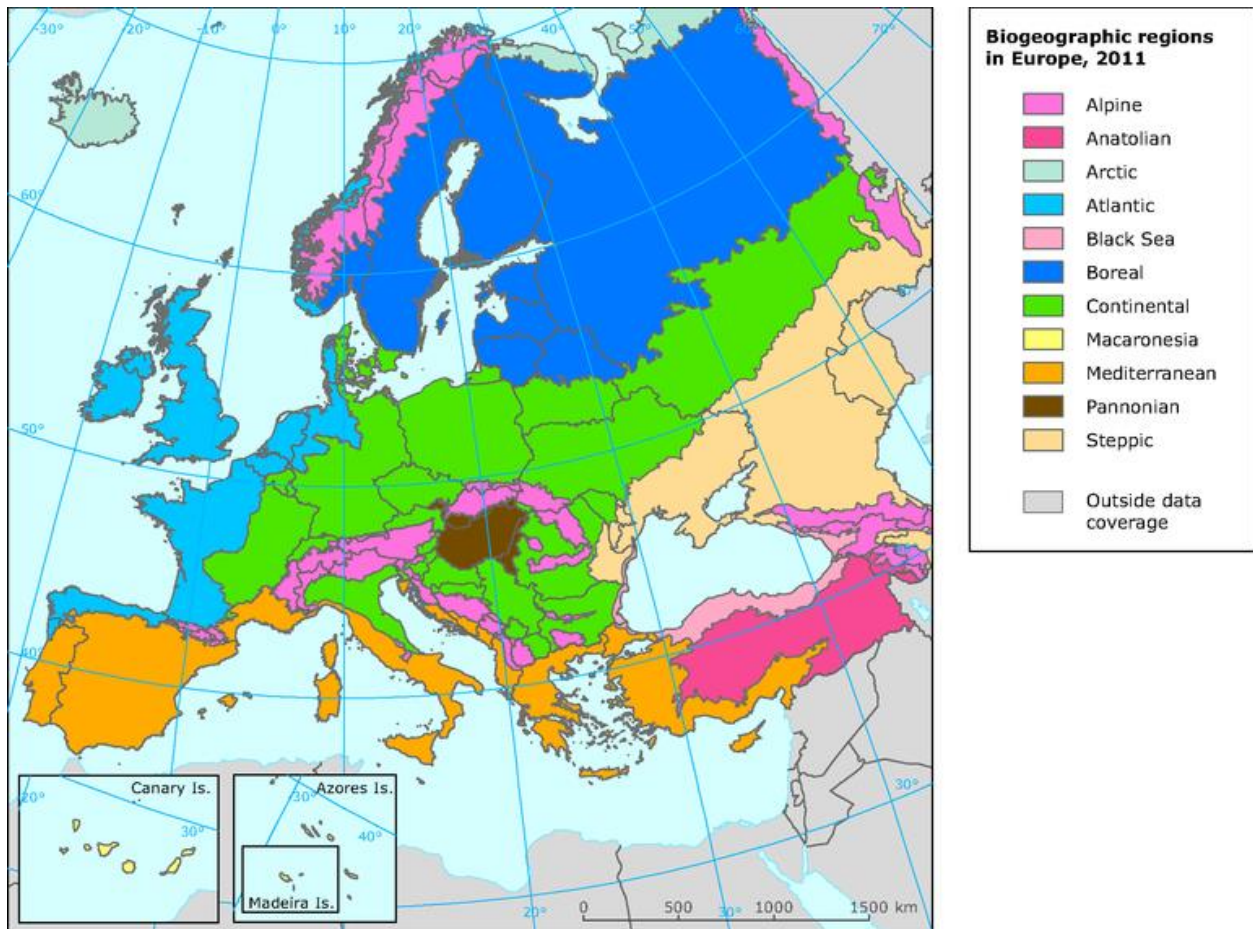
Wildlife Conservation Society - WCS & Center for International Earth Science Information Network - CIESIN - Columbia University (2005) Last of the Wild Project, Version 2, 2005 (LWP-2): Global Human Influence Index (HII) Dataset (Geographic). NASA Socioeconomic Data and Applications Center (SEDAC), Palisades, NY.

T. Hengl, J. M. de Jesus, R. A. MacMillan, N. H. Batjes, G. B. Heuvelink, E. Ribeiro, A. Samuel-Rosa, B. Kempen, J. G. Leenaars & M. G. Walsh (2014) SoilGrids1km—global soil information based on automated mapping. *PLoS One* **9**, e105992.

W. Thuiller, D. Georges & R. Engler (2014) biomod2: Ensemble platform for species distribution modeling. R package version 3.3-7 Available at: <https://cran.r-project.org/web/packages/biomod2/index.html>.

W. Thuiller, B. Lafourcade, R. Engler & M. B. Araújo (2009) BIOMOD—a platform for ensemble forecasting of species distributions. *Ecography* **32**, 369-373.

Appendix 2 Biogeographical regions in Europe



Appendix 3. Relevant illustrative pictures (for information)

Figure 1. *Cardiospermum grandiflorum* growing up supporting vegetation.



Figure 2. *Cardiospermum grandiflorum* flowers



Figure 3. *Cardiospermum grandiflorum* smothering native vegetation in South Africa



Figure 4. *Cardiospermum grandiflorum* growing along riparian habitat



Appendix 4. Distribution maps of *Cardiospermum grandiflorum*
Figure 1. Global distribution (from GBIF)

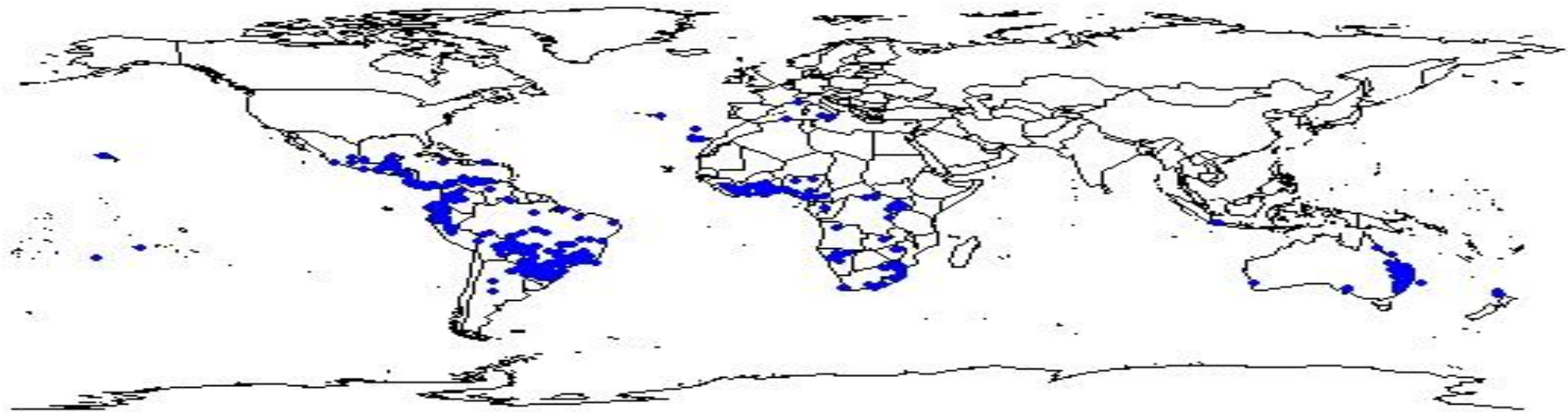


Figure 2. Distribution maps of *Cardiospermum grandiflorum* in Africa (from GBIF)

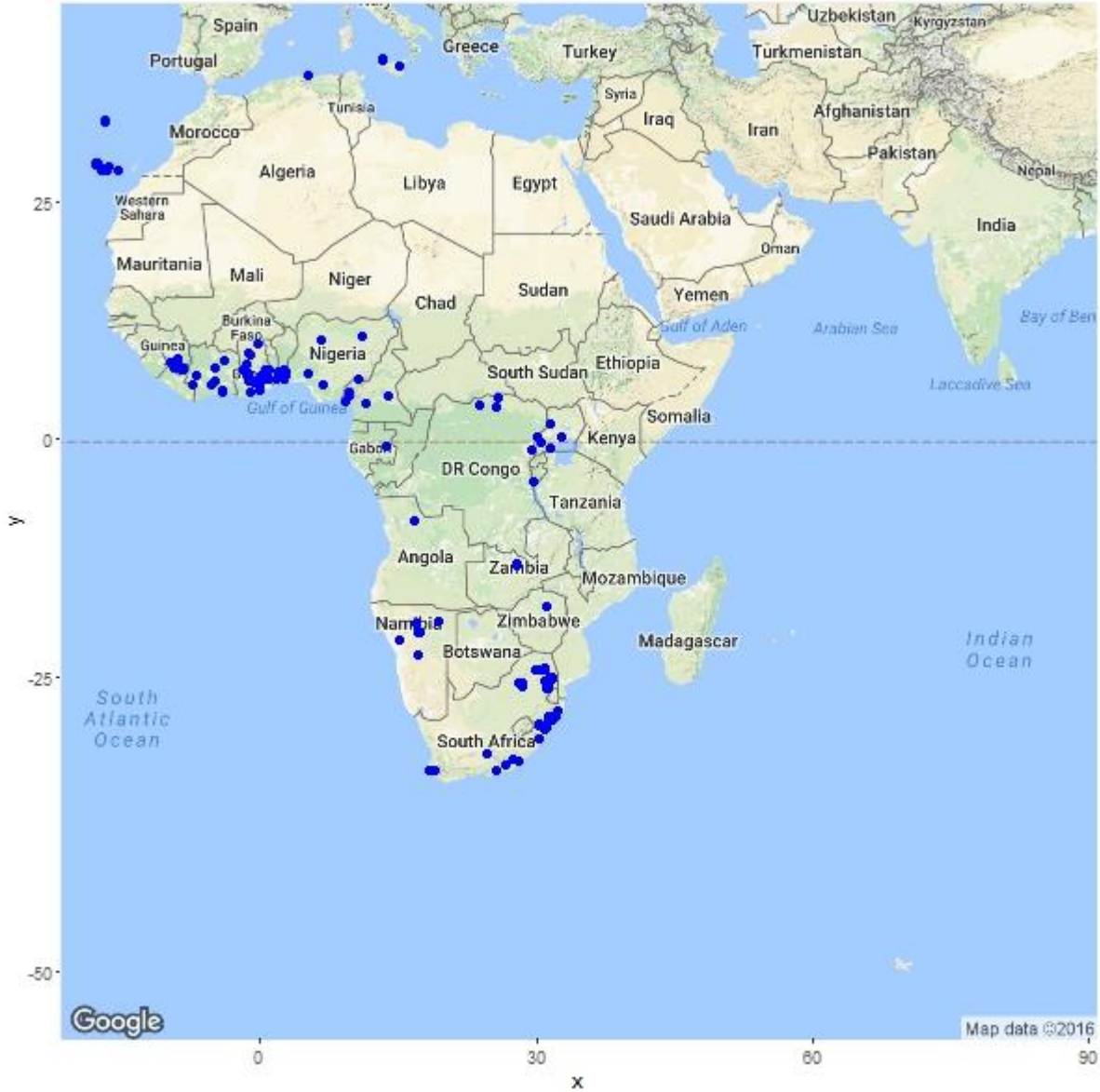


Figure 3. Distribution maps of *Cardiospermum grandiflorum* in Oceania (from GBIF)

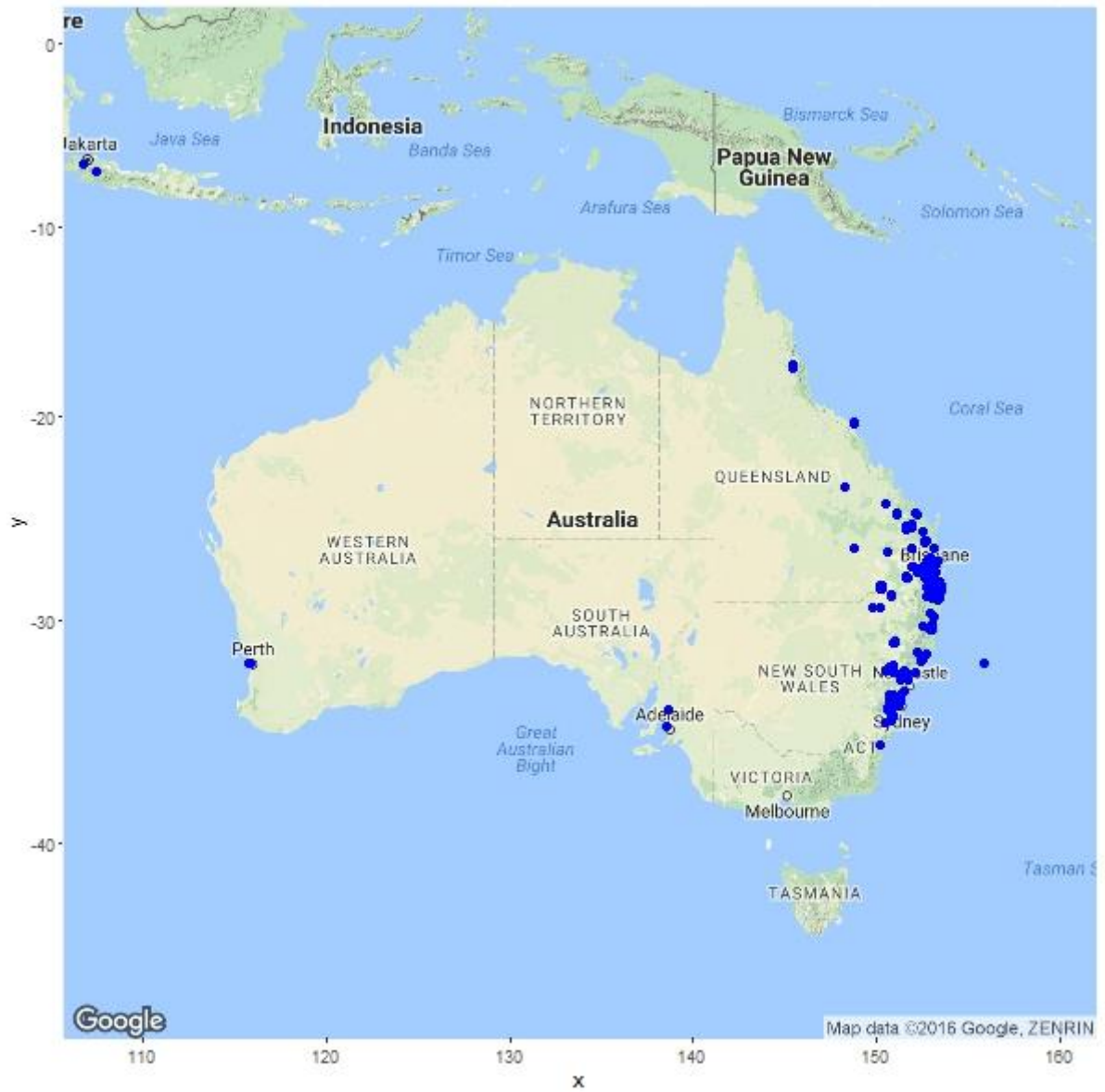


Figure 4. Distribution maps of *Cardiospermum grandiflorum* in South America (from GBIF)

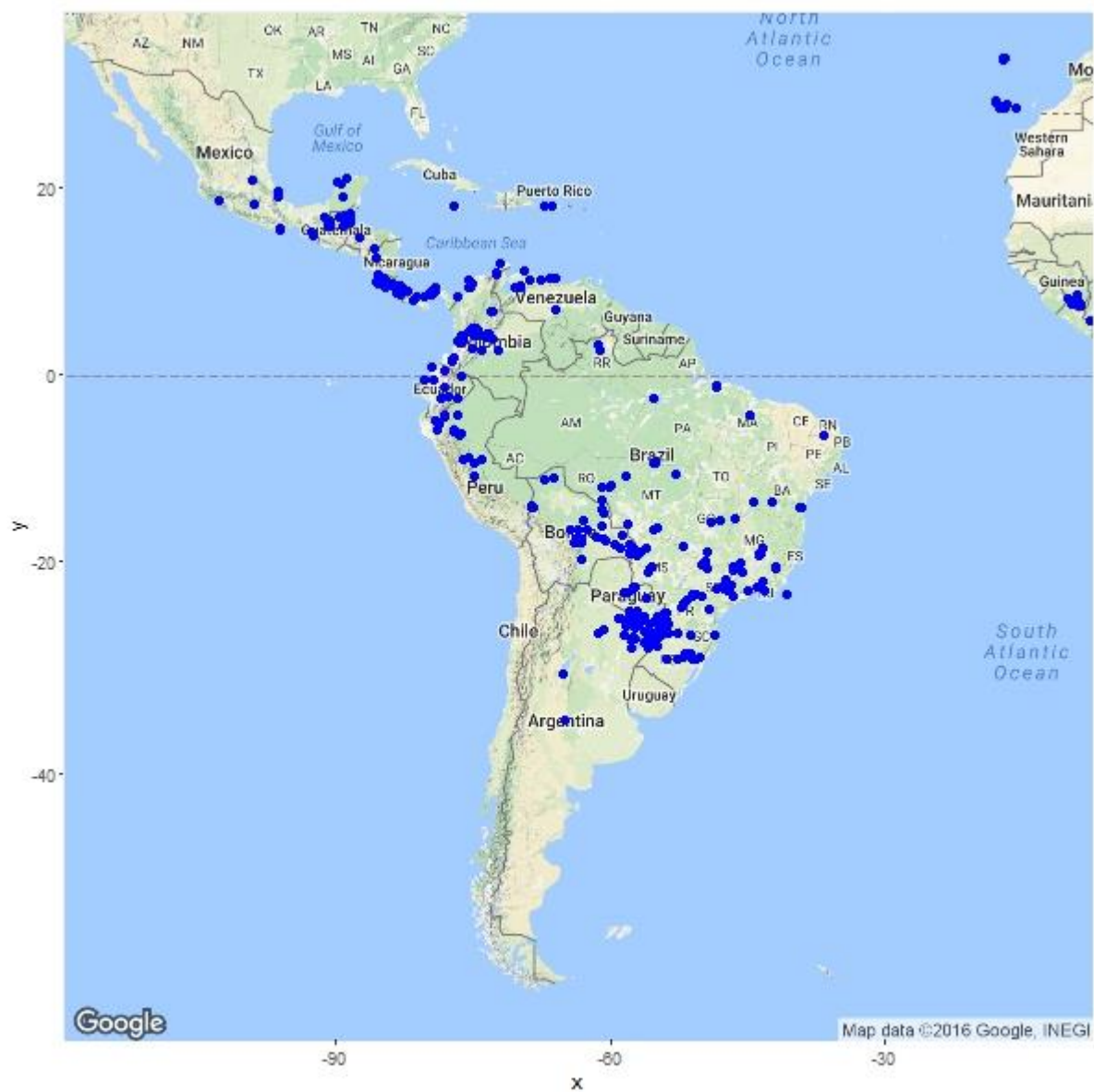


Figure 5. Distribution maps of *Cardiospermum grandiflorum* in Europe (from GBIF)

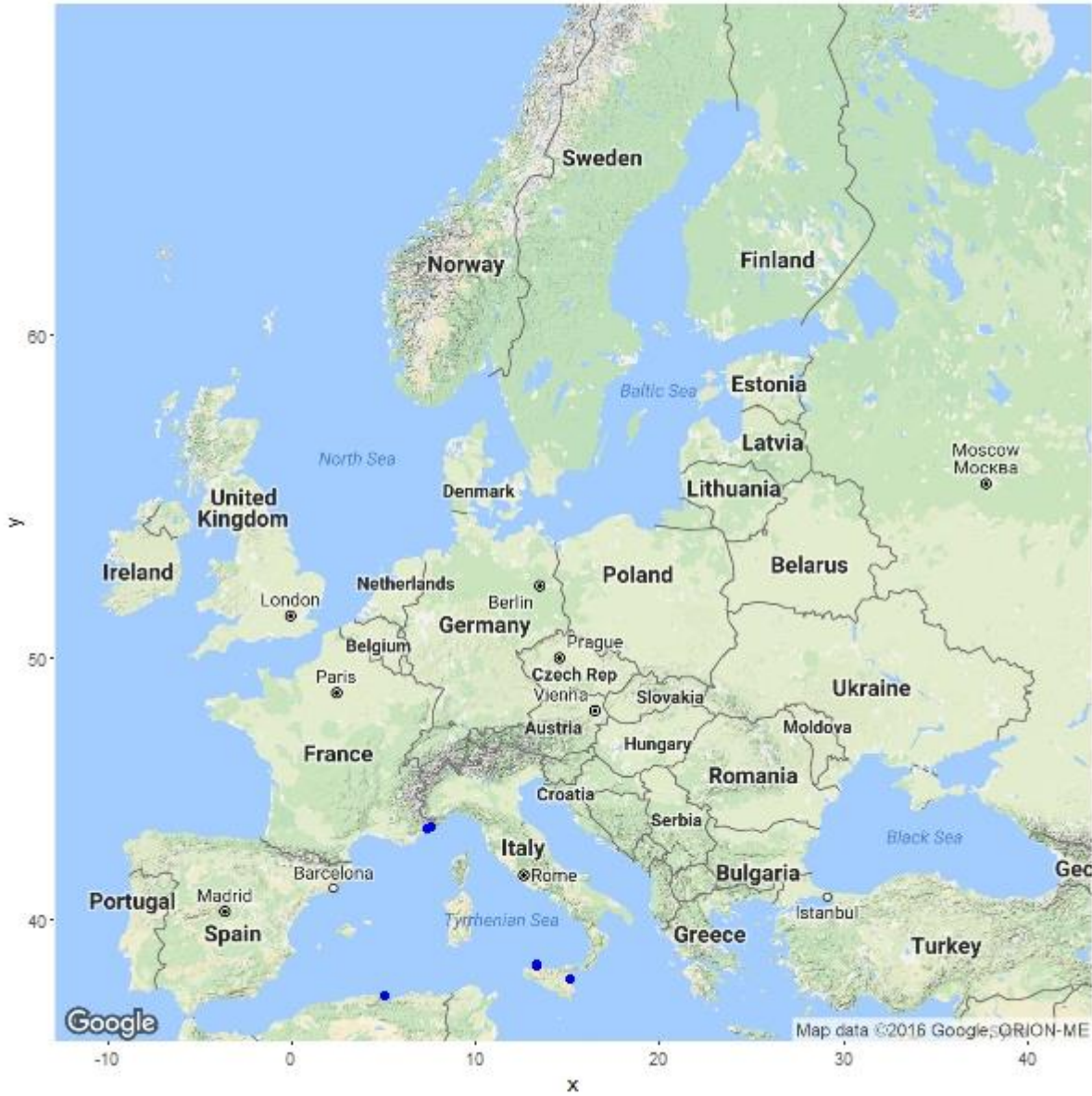


Figure 6. Distribution maps of *Cardiospermum grandiflorum* in Asia (from GBIF)

