EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION
ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES PLANTES

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

Pest Risk Analysis for *Ambrosia confertiflora*

2018
EPPO
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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: *Ambrosia confertiflora* invasion in Israel.

EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION

Pest risk analysis for *Ambrosia confertiflora*

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

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The pest risk analysis for *Ambrosia confertiflora* has been performed under the LIFE funded 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

In partnership with

EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION

And

NERC CENTRE FOR ECOLOGY AND HYDROLOGY

Review Process

- This PRA on *Ambrosia confertiflora.* was first drafted by Jean-Marc Dufour-Dror.
- The PRA was further evaluated by international experts which made up an Expert Working group that physically met in Paris in 2017.
- The PRA has been reviewed by the EPPO Panel on Invasive Alien Plants in 2017.
- The PRA was reviewed by the EPPO Core Members for PRA in 2017/18.

Contents

Summary[1] of the Express Pest Risk Analysis for *Ambrosia confertiflora*

PRA area: EPPO region https://www.eppo.int/ABOUT_EPPO/images/clickable_map.htm

Describe the endangered area:

Ambrosia confertiflora is capable of establishing in the Mediterranean biogeographical regions including the EU countries where the species has a high suitability: Spain, Italy (Southern Sardinia, Sicily), Greece, Cyprus and the wider EPPO region countries: Israel, Jordan, Turkey, Morocco, Algeria and Tunisia. A small region in Russia (close to the Georgian boarder) also shows suitability (see appendix 1). The Expert Working Group (EWG) considers that the endangered area will be the regions which show high suitability for establishment (see appendix 1). Therefore, the endangered area is EU countries: Spain, Italy (Southern Sardinia, Sicily), Greece, and the wider EPPO region: Turkey, Israel, Jordan, Morocco, Algeria and Tunisia.

Habitats within the endangered area include: various natural and disturbed habitats, including dry plains and semi-arid valleys, degraded pastures, cultivated orchards, summer field crops (cotton and water melon) avocado and date groves, along roadsides, river-banks (including dry riverbeds), in wastelands and other disturbed areas (Jean Marc Dufour-Dror, pers. comm., 2017).

Main conclusions

Ambrosia confertiflora presents a high phytosanitary risk for the endangered area with high uncertainty. A high level of uncertainty is associated with this species as there are few published scientific studies to assess ecological impacts of the species. In addition, variation in severity of impacts are seen across its introduced range. In Israel, the EWG considers the species has high impacts on ecosystem services (provisioning, regulating and cultural ecosystem services) and native biodiversity compared to that seen in Australia, where impacts are not widespread. Coupled with this is the low likelihood of entry from any of the detailed pathways. The risk of further spread within and among countries within the region is high. The overall likelihood of *A. confertiflora* continuing to enter the EPPO region is low. The fact that no trade and commercial activities exist between the infested area (Israel) and the rest of the EPPO region via land (except for Jordan), may reduce the proliferation risk of *A. confertiflora* (i.e. potentially infested products cannot be exported from Israel via Lebanon or Syria due to the permanent and lasting state of war existing between these countries).

Entry and establishment

Ambrosia confertiflora is not traded within the EPPO region. The species is already present and established within the PRA area in Israel. The species is currently absent from Europe. There is no clear information on how the species was introduced into Israel. To-date the species has not be intercepted along any pathway into the EPPO region. The EWG considers the pathways detailed in the PRA are the *most* feasible pathways for the entry of the species into the region based on the experience with similar non-native plant occurrences. The pathways reviewed in the PRA are: contaminant of livestock, contaminant of animal feed mixture, contaminant of machinery and equipment and contaminant of travellers.

Impacts in the PRA area

Ambrosia confertiflora forms dense stands that can outcompete native plant species (Jean Marc Dufour-Dror, pers. comm., 2017; Yair et al., 2017). The plant has the ability to modify vegetation dynamics (Israel Ministry of Environmental Protection, 2013). A monoculture can act to suppress understory native plants which results in environmental impacts, in particular in humid habitats, in grasslands and in dry river beds (Jean Marc Dufour-Dror, pers. comm., 2017). In Israel, the plant spreads rapidly in wetlands and thrives along riverbanks where it displaces native species and creates pure stands (JM Dufour-Dror, pers. comm., 2014).

[1] The summary should be elaborated once the analysis is completed

A. confertiflora is also a serious pest in cultivated fields, citrus groves and orchards in general (Israel Ministry of Environmental Protection, 2013), and in grape (Conabio Website). It competes for nutrients and interferes with the harvest (Parsons & Cuthbertson 2001). The plant spreads among cultivated fields and mixes with crops which cannot be harvested properly. Proliferation of *A. confertiflora* has devastating effects on organic farming as chemical application in such areas is prohibited. It has caused great damage to *Moringa* spp. fields in the Sharon region (JM Dufour-Dror, pers. comm., 2014). The burrs of the plant contaminate wool and can lower its value (Parsons & Cuthbertson, 2001).

Infestations in recreational sites may be problematic because of unpleasant smell of the plant and mainly because of possible dermatitis and allergies caused by the plant (though not clearly established so far). In addition, the monocultures can prevent access to sites and rivers. The plant also invades gardens and parks and is reported to disrupt their maintenance (Israel Ministry of Environmental Protection, Undated).

Given the similarity in both land use and climate between the EPPO Mediterranean region and Israel, compared to that with Australia, the EWG expect the impacts will be of a similar magnitude to those in Israel. The EWG considers the magnitude of impacts will be similar to that in the current area of distribution, and uncertainty will remain high for all categories (impact on biodiversity, impact on ecosystem services and socio-economic impact). This is mainly due to the fact that impacts have not been measured in the PRA area. The text relates equally to EU Member States and non-EU Member States in the EPPO region.

Climate change
With climate change, it is predicted that *Ambrosia confertiflora* will be capable of establishing in the Mediterranean biogeographical region. The countries where the species has a high suitability include: Spain, Southern France, Italy (Southern Sardinia, Sicily), Greece, Bulgaria, Romania, Hungary, Ukraine, Turkey, Israel, Jordan, Morocco, Algeria and Tunisia. A region in Russia, close to the Georgian border also shows suitability (see appendix 1).

The pathways identified in the PRA are:

- **Contaminant of animal feed mixture**

Certification scheme for pest free production from country of origin can reduce the potential contamination for the identified pathway - Contaminant of animal feed mixture. All the measures or combination of measures identified as being appropriate for each pathway or for the commodity can be considered for inclusion in phytosanitary regulations in order to offer a choice of different measures to trading partners. Data requirements for surveillance and monitoring to be provided by the exporting country should be specified. In addition to the measure(s) selected to be applied by the exporting country, a phytosanitary certificate (PC) may be required for certain commodities. The PC is an attestation by the exporting country that the requirements of the importing country have been fulfilled. In certain circumstances, an additional declaration on the PC may be needed (see EPPO Standard PM 1/1(2) Use of phytosanitary certificates).

- **Contaminant of machinery and equipment**

Cleaning or disinfection of machinery/vehicles in combination with internal surveillance and/or eradication or containment campaign can act to reduce the risk along this pathway.

- **Contaminant of travelers, their clothes and shoes**

Publicity awareness campaigns should be initiated to enhance public awareness on pest risks especially at key international travel hubs.

- **Contaminant of livestock**

Strengthen boarder control for inspection of livestock. Provide inspectors with identification material for all plant parts.

International measures

Ambrosia confertiflora should be recommended for regulation within the endangered area. With this, the import into and movement within countries in the endangered area, of plants labeled or otherwise identified as *Ambrosia confertiflora* should be prohibited. *Ambrosia confertiflora* should be banned from sale within the endangered area,

National measures

Ambrosia confertiflora 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 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. 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 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 natural environment

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 natural environment

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).			
Phytosanitary risk (including impacts on biodiversity and ecosystem services) for the *<u>endangered area</u>* **(current/future climate)** Contaminant of livestock: Low/Low Contaminant of animal feed mixture: Low/Low Contaminant of machinery and equipment: Low/Low Contaminant of travelers: Low/Low Likelihood of establishment in natural areas: High/High Likelihood of establishment in managed areas: High/High Spread: High/High **Impacts (EPPO region)** Biodiversity: High/High Ecosystem services: High/High Socio-economic: High/High	High X	Moderate ☐	Low ☐
Level of uncertainty of assessment **(current/future climate)** Contaminant of livestock: High/High Contaminant of animal feed mixture: High/High Contaminant of machinery and equipment: High/High Contaminant of travelers: High/High Likelihood of establishment in natural areas: Low/High Likelihood of establishment in managed areas: Low/High Spread: Moderate/High **Impacts (EPPO region)** Biodiversity: High/High Ecosystem services: High/High Socio-economic: High/High	High X	Moderate ☐	Low ☐
Other recommendations: *Recommend that Israel control and contain A. confertiflora in consultation with surrounding countries.*			

Express Pest Risk Analysis:

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(*Ambrosia confertiflora* DC*)*

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Date: 01 September 2017

Stage 1. Initiation

Reason for performing the PRA:
Ambrosia confertiflora is a perennial herbaceous plant native to southern west USA and northern Mexico (USDA (2017); Flora of North America, 2017; Ríos et al., (1998); CONABIO (2017); Liogier and Martorell (2000)). *A. confertiflora* is highly invasive in Israel where it spreads in natural and disturbed habitats, as well as in cultivated lands (Dufour Dror and Yaacoby, 2013; Dufour-Dror, 2016). *A. confertiflora* has a clear invasive pattern and is, so far, recorded, within the EPPO region, only in Israel. The plant forms dense stands and outcompetes native herbaceous species. It thrives along riverbanks, along roadsides, in refusal sites and other disturbed habitats. It establishes in fields, orchards (avocado, dates, and olives). Its distribution is not limited to disturbed habitats and it is spreading mainly by human causes. *Ambrosia confertiflora* was included on the EPPO List of Invasive Alien Plants in 2014. In 2016, the species was prioritized (along with 36 additional species from the EPPO List of Invasive Alien Plants and a recent horizon scanning study[2]) for PRA within the LIFE funded project Mitigating the threat of invasive alien plants to the EU through pest risk analysis to support the Regulation 1143/2014. *A. confertiflora* was one of 16 species identified as having a high priority for PRA (see Branquart et al., 2016; Tanner et al., 2017).

PRA area: EPPO region (EPPO region https://www.eppo.int/ABOUT_EPPO/images/clickable_map.htm)

The risk assessments were prepared according to EPPO Standard PM5/5 (slightly adapted) which has been approved by the 51 EPPO Member Countries, and which sets out a scheme for risk analysis of pests, including invasive alien plants (which may be pests according to the definitions in the International Plant Protection Convention). EPPO engages in projects only when this is in the interests of all its member countries, and it was made clear at the start of the LIFE project that the PRA area would be the whole of the EPPO region. Furthermore, we believe that since invasive species do not respect political boundaries, the risks to the EU are considerably reduced if neighbouring countries of the EPPO region take equivalent action on the basis of broader assessments and recommendations from EPPO.

All information relating to EU Member States is included in the Pest risk analysis and information from the wider EPPO region only acts to strengthen the information in the PRA document. The PRA defines the endangered area where it lists all relevant countries within the endangered area, including EU Member States. The distribution section lists all relevant countries in the EPPO region (including by default those of EU Member States and biogeographical regions which are specific to EU member States). Habitats and where they occur in the PRA are defined by the EUNIS categorization which is relevant to EU Member States. Pathways are defined and relevant to the EU Member States and the wider EPPO Member countries, and where the EWG consider

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2 http://ec.europa.eu/environment/nature/invasivealien/docs/Prioritising%20prevention%20efforts%20through%20horizon%20scanning.pdf

they may differ between EU Member States and non-EU EPPO countries, this is stated. The establishment and spread sections specifically detail EU Member States. When impacts are relevant for both EU Member States and non-EU EPPO countries this is stated ‘The text within this section relates equally to EU Member States and non-EU Member States in the EPPO region’. Where impacts are not considered equal to EU Member States and non-EU Member States this is stated and further information is included specifically for EU member States. For climate change, all countries (including EU Member States) are detailed.

Stage 2. Pest risk assessment

1. Taxonomy: *Ambrosia confertiflora* DC.
Phylum: Spermatophyta, Subphylum: Angiospermae, Class: Dicotyledonae, Order: Asterales, Family: Asteraceae, Genus: Ambrosia.

EPPO code: FRSCO

Synonyms
Ambrosia caudata (Rydb.) Shinners, *Ambrosia simulans* Shinners, *Franseria caudata* Rydb. *Franseria confertiflora* (DC.) Rydb., *Franseria hispidissima* Rydb., *Franseria incana* Rydb. *Franseria pringlei* Rydb., *Franseria strigulosa* Rydb., *Franseria tenuifolia* Harv. & A.Gray *Franseria tenuifolia* var. *tripinnatifida* A.Gray, *Gaertneria tenuifolia* (Harv. & A.Gray) Kuntze, *Gaertneria tenuifolia* Harv. & A.Gray
(according to ThePlantList.org http://www.theplantlist.org/tpl/record/gcc-42004)

Common names: Burr ragweed, Slimleaf bursage (USA) [source Parsons & Cuthbertson 2001]**,** Week leaf burr ragweed, Herbe blanche, Ajenjo del campo, Yerba de la oveja, Altamisa falsa, Escoba amarga Mexicana [source EPPO (2017) https://gd.eppo.int/taxon/FRSCO]

Plant type: Erect perennial herb (Hemicryptophyte)

Related species in the EPPO region:

Non-native species: *Ambrosia artemisiifolia* (EPPO code AMBEL), *Ambrosia psilostachya* (EPPO code AMBPS), *Ambrosia trifida* (EPPO code AMBTR), *Ambrosia tomentosa* (FRSTO), *Parthenium hysterophorus* (PTNHY),

Native species: *Ambrosia maritima* (EPPO Code AMBMA),

Figure 1 and 2 provide a comparison of *Ambrosia* species present within Europe which can all be confused with *A. confertiflora*. Careful identification is needed to tell the species apart (see figures 1 and 2) and section 2 (pest overview: identification) as many of the species traits overlap.

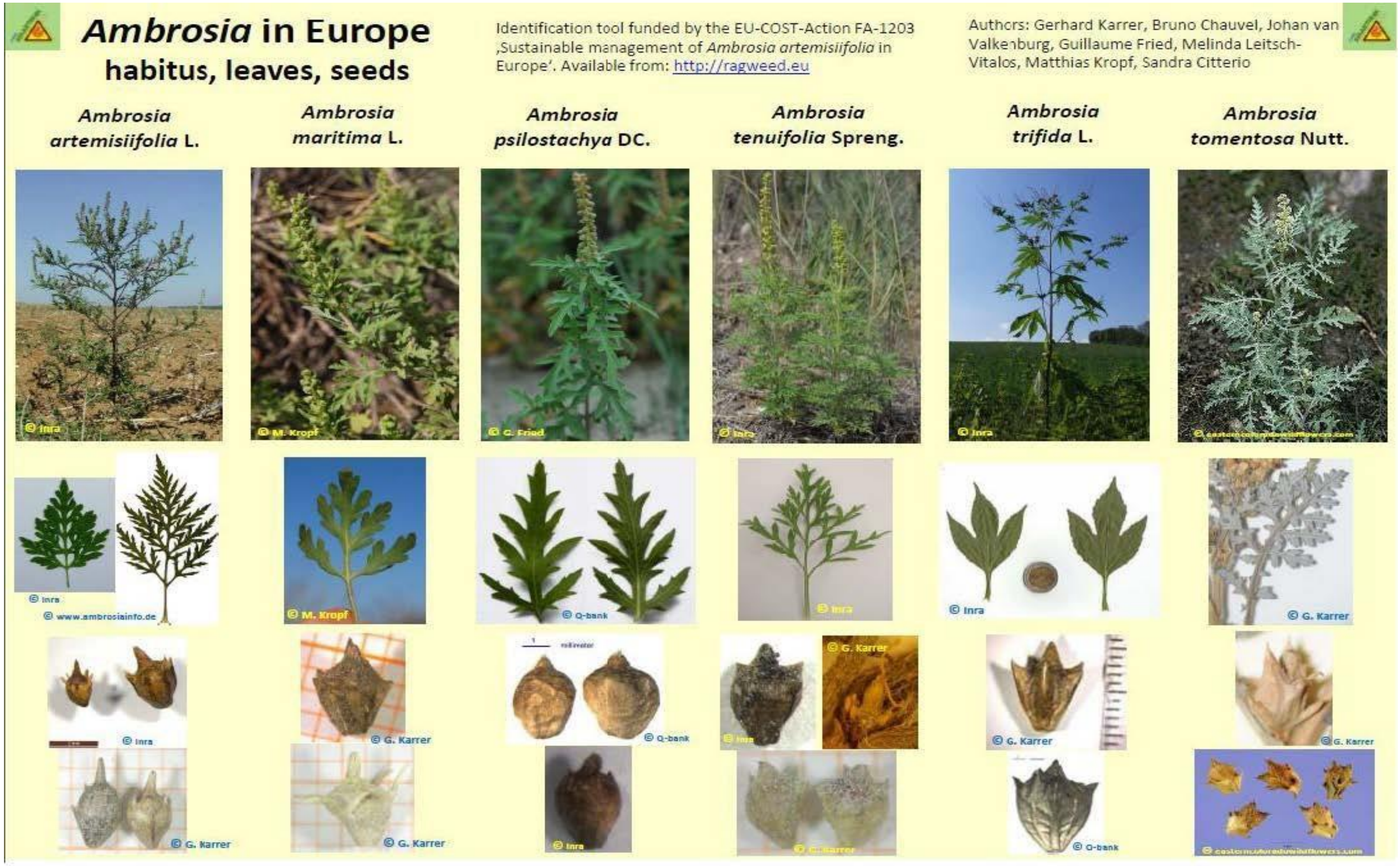

Figure 1. Shows a comparison of the *Ambrosia* species present in Europe (Figure taken from http://ragweed.eu)

Six *Ambrosia* species in Europe

comparison of traits

Species	***A. artemisiifolia* L.**	***A. maritima* L.**	***A. psilostachya* DC.**	***A. tenuifolia* Spreng.**	***A. trifida* L.**	***A. tomentosa* Nutt.**
Life form	Annual	Biennial, perennial	Perennial	Perennial	Annual	Perennial
Plant size (cm)	10 to 250	20-80	10 to 90	20-100	40 to 400	15-60
Belowground	Taproot	Taproot	Root sprouter	Root sprouter	Taproot	Root sprouter
Stem	+/- intensively branched, branches with wide angles	Intensively branched, stems lignified towards the base, sprouts from lower aerial stem buds	Few branches, with narrow angles	Few branches, with narrow angles	+/- intensively branched	Few subordinated branches
Leaves	Pinnatifid to bipinnate, rarely entire; leaf segments broadened and separated, rarely narrow; lower leaves with distinct narrow petiole; upper leaves alternate; long and short hairs mixed	Pinnatifid to bipinnate, leaf segments rounded; lower leaves with distinct stalks; upper leaves alternate; dense hairs all around	Pinnatifid, rarely entire; leaf segments lineal and connected, often sharped towards the tip; +/- sessile; upper leaves alternate; dense short hairs	Bipinnate to pinnatifid; leaf segments as narrow as the rachis, lineal, connected; lower leaves with distinct narrow petiole; upper leaves alternate; dense short hairs	Palmate, 1 to 5 lobes; glabrous or few short hairs; all leaves opposite	Pinnatifid, leaf segments narrow and rounded; middle and upper leaves alternate; extremely dense white hairs below; above greenish-grey
Diaspore (mm)	2-4; 1-seeded	3.5-5; 1-seeded	2-3; 1-seeded	2-3.5; 1-seeded	>6; 1-seeded	4-6; 2-seeded
Diaspore coat	Few hairs and glands; 2-5 short lateral spines with sharpened tips; dark brown	Few hairs, dense glands; 4-6 distinct lateral spines + 1 central lobed spine; olive to dark brown	Few glands and short hairs; blunt, short lateral spines few or none; dark brown	Short hairs and glands, 2-5 lateral short blunt spines; olive to dark brown	Glabrous or few hairs; 2-4 indistinct lateral spines; dark brown to black	+/- glabrous, 4-10 distinct long straight or hooked spines; light brown
Reproductive mode	Sexual (seeds)	Sexual (seeds)	Mostly vegetative, rarely by seeds	Vegetative; very rarely by seeds	Sexual (seeds)	Vegetative, and sexual (seeds)
Smell (leaves)	None	Distinct, aromatic	Distinct	None	None	None
Origin	N-America	Europe, Africa	N-America	S-America	N-America	N-America
Habitat types (in Europe)	Field, riverbank, ruderal, roadside, orchard, pasture	Coastal dune	Sandy coast, riverbank, field, dry grassland, roadside, ruderal, orchard, vineyard	Abandoned field, grassland, pasture, sandy coast, marshland, vineyard	Field, sandy riverbank	Abandoned field, pasture
Distribution in Europe	Widespread; all Europe except Mediterranean and far North	Critically endangered, in many places extinct; formerly cultivated	Scattered; European lowlands and coastal areas, more frequent to the South	Scattered; Southern Europe	Scattered; Central and Southern Europe	Very rare; Spain
Allergenicity	High	Unknown	Medium	Unknown	High	Medium

Figure 2. Shows a comparison of the *Ambrosia* species traits present in Europe (Figure taken from http://ragweed.eu)

2. Pest overview

Introduction

Ambrosia confertiflora is a perennial herb native to northern Mexico and to the southwestern United States USDA (2017); Flora of North America, 2017; Ríos et al., (1998); CONABIO (2017); Liogier and Martorell (2000). This species has been introduced to Australia and Israel (Yair, 2017). *A. confertiflora* has serious agricultural and environmental impacts, and its pollen is reported as a severe allergen in Israel (Yair, 2017). This species has a very limited distribution in the EPPO region, and can be considered an emerging invader at the EPPO region scale. *A. confertiflora* forms very dense stands. The plant modifies the vegetation cover and consequently the whole ecosystem (Israel Ministry of Environmental Protection, 2013), readily suppressing understory native plants which results in environmental impacts, in particular in humid habitats, in grasslands and in dry river beds. In Israel, the plant spreads rapidly in wetlands and thrives along riverbanks where it displaces native species and creates pure stands (Pers Comm. Jean Marc, Dufour, 2017).

Environmental requirements

The establishment of populations in the Jordan valley, along roadsides, near Jericho, and more recently in the Negev suggests that the plant can cope easily with arid conditions, i.e. high summer temperatures, extended dry season. This is supported by this species' distribution in its native range where it is most common in arid to semi-arid climates (Calflora, 2017; Flora of North America, 2017). However, it appears to have a wide environmental tolerance in its native range, occurring in temperatures from -1 to 35 ºC, precipitation levels from 230 to 1040 mm, altitudes from 10 to 2000 m in regions where the growing season ranges from 5 to 12 months (Calflora, 2017; Flora of North America, 2017). In Israel it is commonly associated with open habitats along rivers or in seasonally moist habitats (Yair, 2017). Growth trials have shown that the plant grows better in warm conditions (22/28 and 28/34°C night/day cycle) and shoot elongation is slower in cold conditions (10/16°C and 16/22°C night/day cycle) and in these conditions the plant remains in a rosette form (Yair, 2017).

Germination of seeds is best when seeds are on the soil surface (no germination was detected when seeds were planted at depths below 4 cm depth) and at moderate temperatures (e.g. 10-15 ºC (Yair, 2017), suggesting autumn or spring germination. This is supported by Australian observations that this species germinates mostly in autumn (Parsons & Cuthbertson, 2001). It is recorded that in California (USA) *A. confertiflora* can tolerate a wide pH – from 5.4 to 7.4 (Calflora, 2017).

Habitats

In the native range (Arizona), *Ambrosia confertiflora* grows in dry or moist, rocky, sterile, or fertile soil. Abundant along city streets, highways, waste places, and edges of cultivated fields, also on barren mesas and slopes in southern and central Arizona; less troublesome northward, except in local areas where colonies have become established (e.g. around Flagstaff); 1,000 (304.8 m) to 7,000 (2133.6 m) feet elevation.

In Israel, *Ambrosia confertiflora* occurs in various natural and disturbed habitats, including dry plains and semi-arid valleys, degraded pastures, cultivated orchards, summer field crops (cotton and water melon) avocado and date groves, along roadsides, river-banks, and wadi beds (dry river beds), in wastelands and other disturbed areas (Pers Comm. Jean Marc, Dufour, 2017).

In Australia, the species is a weed in degraded pasture land and agricultural land occurring also in open disturbed areas (Parsons and Cuthbertson, 2001).

Identification

Ambrosia confertiflora is a perennial species 20–80 (–150+) cm in height (see figures 1 & 2). Stems erect leaves opposite at the base, alternate higher up with petioles 10–35 mm; lanceolate to ovate in outline, 40–85(–150) × 20–35(–55) mm overall, laciniate 2–4-pinnately lobed (lobes ± lanceolate); bases cuneate to truncate, ultimate margins entire, abaxial and adaxial faces strigillose to sericeous (often grayish) and gland-dotted. Pistillate heads clustered, proximal to staminates; florets 1(–2). Staminate heads: peduncles 0.5–2 mm; involucres cup-shaped, 1.5–3+ mm diameter, strigillose; florets 5–20+. Fruit a spiny bur, pyramidal to pyriform, 1–2 mm long, strigillose to pilosulous, spines (1–)5–12+, mostly distal, stoutly conic to subulate, 0.5–1 mm, tips uncinate. $2n$ = 72, 108 (Flora of North America, 2017).

The leaves have short petioles and are bipinnate, divided into long lobes; their margins have sparse short hairs. The leaves are opposite at the base of the stem and alternate on the upper part of the plant. The leaves release a characteristic strong smell that may help to identify the plant. *Ambrosia confertiflora* is monoecious and has male and female yellow or greenish flowers (Figure 3). The male flowers are numerous and small (diameter about 1 mm) and are borne on erect clusters (Figure 4). The female flowers lack petals and are concentrated in the leaf axils in a cup-shaped involucre. The fruit is a burr with 10-20 hooked spines and includes a single seed. The seeds are brown and their diameter is 3-4 mm. In Israel, the species blooms from September through December.

Symptoms

The plant forms dense stands, up to 180 stems per square meter, which can displace native vegetation (Yair et al., 2017; Pers Comm. Jean Marc, Dufour, 2017). The plant can modify the vegetation cover and consequently the ecosystem (Israel Ministry of Environmental Protection, 2013), suppressing understory native plants which can result in environmental impacts, in particular in humid habitats, in grasslands and in dry river beds (Figure 5). In Israel, the plant spreads rapidly in wetlands and thrives along riverbanks (Figure 6) where it displaces native species and creates pure stands which lead to the degradation (negative impact on biodiversity and ecosystem services) of natural ecosystems in riparian habitats (JM Dufour-Dror, pers. comm., 2014). The plant is able to spread within water. However, at present no quantitative data is available for distances for spread in Israel.

Socio-economic benefits of the species

To-date, within the EPPO region, there are no known socio-economic benefits derived from the plant species *Ambrosia confertiflora*. The species is not known to be available via the horticulture industry. Extracts from the plant are being explored for a number of medical purposes but no 'product' is available yet (Coronado Aceves *et al*, 2016).

Existing PRAs

A weed risk assessment was conducted by Australia, where the species scored 11 (equally a serious weed) (Pheloung, 1995) highlighting the species should be rejected from import. An invasiveness assessment and impact assessment has also been produced by Australia (http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/invasive_burr_ragweed). The assessment of plant invasiveness is done by evaluating biological and ecological characteristics such as germination requirements, growth rate, competitive ability, reproduction methods and dispersal mechanisms where each category scores a different ranking. For dispersal, *Ambrosia confertiflora* scored medium/high for the number of mechanisms for dispersal and high for the distance for dispersal.

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

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

5. Regulatory status of the pest

At present, within the EPPO region, there is no regulations specific to *Ambrosia confertiflora*. *A. confertiflora* has been included on the EPPO List of Invasive Alien Plants in 2014. In 2016, the species was prioritized (along with 36 additional species from the EPPO List of Invasive Alien Plants and a recent horizon scanning study[3]) for PRA within the LIFE funded project "Mitigating the threat of invasive alien plants to the EU through pest risk analysis to support the Regulation 1143/2014'. *A. confertiflora* was one of 16 species identified as having a high priority for PRA. The plant is listed as 'invasive' in the book 'Alien invasive plants in Israel' (Dufour-Dror 2012).

Ambrosia confertiflora is declared 'Noxious' in South Australia (proclaimed plant as *Ambrosia* spp.) (Natural Resources Management Act, 2004). In addition, in Australia, the species is a non-saleable weed.

[3] http://ec.europa.eu/environment/nature/invasivealien/docs/Prioritising%20prevention%20efforts%20through%20horizon%20scanning.pdf

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, non-native, established….)*	***Reference***
Africa	Absent, No records		
America	USA (Arizona, California, Colorado, Kansas, Nevada, New Mexico, Oklahoma, Tennessee, Texas, Utah) and México (Aguascalientes, Baja California Norte, Baja California Sur, Chihuahua, Coahuila, Colima, Durango, Guanajuato, Guerrero, Jalisco, México, Nuevo León, Querétaro, San Luis Potosí, Sinaloa, Sonora, Tamaulipas and Zacatecas). Puerto Rico	Native to North America	USDA (2017); Flora of North America, 2017; Ríos et al., (1998); CONABIO (2017); Liogier and Martorell (2000).
Asia	Israel and West Bank	Highly invasive in Israel and the Palestinian Authority (West Bank)	Dufour-Dror (2012); Dufour-Dror & Fragman-Sapir (2018).
Europe	Absent (No records)		
Oceania	Australia (New South Wales: Central Western Slopes and North Western Plains, Menindee on the Far Western Plains of the NSW Queensland: Drillham Cloyna-Windera area, Burnett Pastoral District)	Non-native and noxious weed.	Parsons & Cuthbertson (2001); Richardson et al (2011); Lazarides et al., (1997).

Introduction

Ambrosia confertiflora is native to North America and non-native to Australia and Israel. The species is absent from Europe (see Appendix 4, Figure 1).

North America

Ambrosia confertiflora is native to North America: USA (Arizona, California, Colorado, Kansas, Nevada, New Mexico, Oklahoma, Tennessee, Texas, Utah). It is also native to México (Aguascalientes, Baja California Norte, Baja California Sur, Chihuahua, Coahuila, Colima, Durango, Guanajuato, Guerrero, Jalisco, México, Nuevo León, Querétaro, San Luis Potosí, Sinaloa, Sonora, Tamaulipas and Zacatecas) (see Appendix 4, Figure 2).

Asia

Ambrosia confertiflora is established in Israel (Dufour-Dror, 2012). *A. confertiflora* was first recorded in Israel near to the town Zichron Yakov in 1990. *A. confertiflora* began to spread in the Shechem (Nablus) area in central Samaria during the mid-1990s. It is now widespread in Samaria (northern part of the West bank), especially along roads and in cultivated areas, but also in Nature Reserves such as Wadi Qana. The plant spread westwards and is now present in the Heffer Valley area (Sharon region), where 480 ha of riverbanks along the Alexander River are already heavily infested. The plant also spread eastward along Wadi Tirza and has reached the Northern Jordan Valley. Additional foci were recently discovered along the Yarkon River, on the Carmel mount, in the Haifa region, in the southern part of Yizre'el valley in lower Galilee, in the south near Gadera and in the Ashdod area (Israel Ministry of Environmental Protection, 2013) (see Appendix 4, Figure 3).

Between the late 1990s and the early 2000s, a massive invasion began along the Alexander River bank, apparently originating from the area of Sechem (Nablus) in central Samaria (West Bank). During the 2000s a heavy infestation was recorded along the Tirza wadi, flowing from the Sechem area to the east in the Jordan valley. Since then new occurrences have been recorded along the Jordan valley, in the lower Galilee (few sites), and last year in the Negev desert, south to Beer-Sheva.

Oceania

In Australia, the species was introduced into Queensland in 1950 and is restricted to small colonies in the western Darling Downs and the Burnett Pastoral District. In New South Wales, populations occur on the Far Western and North-Western Plains and on the Central Western Slopes, while in South Australia the species is only recorded in the surroundings of Adelaide (Parsons & Cuthbertson, 2001). There are very few records and since Parsons & Cuthberson (2001) the plant has been mentioned by Richardson et al. (2011), but apparently it does not spread vigorously in this region (see Appendix 4, Figure 4).

7. Habitats and where they occur in the PRA area

All of the habitat types detailed in the table are indicative of the habitats where the species is found in the introduced range (Israel and Australia).

Habitat (main)	**EUNIS habitat types**	**Status of habitat (e.g. threatened or protected)**	**Is the pest present in the habitat in the PRA area**	**Comments (e.g. *major/minor habitats* in the PRA area)**	***Reference***
Inland surface waters (C)	C1, C2.5, C3	Protected in part	Yes	Major habitat in term of biodiversity, rarity and sensitivity	Pers. Obs. Dufour-Dror (2012-17)
Mires, bogs and fens: valley mires, poor fens and transition mires (D)	D2	Yes	Yes	Major habitat in term of biodiversity, rarity and sensitivity	Pers. Obs. Dufour-Dror (2012-17)
Dry river bed		In part	Yes	Medium importance habitat within the PRA area	EWG opinion
Artificial habitats	E5.1	No	Yes	Commonly grows along transportation networks (roadsides and railway lines) in Israel.	Pers. Obs. Dufour-Dror (2012-17)
Grasslands (E)	E2	No	Yes	Major habitat in term of surface area considered and dispersal role	Pers. Obs. Dufour-Dror (2012-17)
Regularly or recently cultivated agricultural, horticultural and domestic habitats (I)	I1.1	No	Yes	Medium importance habitat in terms of fauna diversity (cultivated lands are used by numerous vertebrates during nocturnal activities.	Pers. Obs. Dufour-Dror (2012-17)

Where C1: surface standing water, C2.5: Temporary running waters, C3: Littoral zone of inland surface waterbodies, D2: Valley mires, poor fens and transition mires, E5.1: anthropogenic herb stands, E2Mesic grasslands, II1: Arable land and market gardens

In the EPPO region, *Ambrosia confertiflora* grows along river banks, wadi beds, roadsides, all types of cultivated areas.

Ambrosia confertiflora was first recorded in Israel on the Carmel coast in 1990. Between the late 1990s and the early 2000s, a massive invasion began along the Alexander River bank, apparently originating from the area of Sechem (Nablus) in central Samaria (West Bank). During the 2000s a heavy infestation was recorded along the Tirza wadi, flowing from the Sechem area to the east in the Jordan valley. Since then new foci have been recorded along the Jordan valley, in the lower Galilee (few sites), and last year in the Negev desert, south to Beer-Sheva.

All of the main habitat types described above are found throughout the EPPO region.

8. Pathways for entry *(in order of importance)*

Important to note: There is no clear information on how the species was introduced into Israel. It is also unknown how the species entered Australia. To-date the species has not be intercepted along any pathway into the EPPO region. The EWG considers the pathways listed below as the *most* feasible pathways for the entry of the species into the region based on the experience with similar non-native plant occurrences.

Possible pathway	**Pathway: Contaminant of livestock** **(CBD terminology: Transport-contaminant- of animals)**
Short description explaining why it is considered as a pathway	Shipments of cattle and sheep from Australia to the EPPO region – particularly Israel and Jordan.
Is the pathway prohibited in the PRA area?	No, the pathway is not prohibited in the PRA area.
Has the pest already intercepted on the pathway?	No, to-date, *A. confertiflora* has not been intercepted along this pathway.
What is the most likely stage associated with the pathway?	Fruits / seeds.
What are the important factors for association with the pathway?	The fruit/seeds are small, have spines which can adhere to various surfaces and can remain undetected.
Is the pest likely to survive transport and storage along this pathway?	Yes, the fruits/seeds can survive for over12 months.
Can the pest transfer from this pathway to a suitable habitat?	Yes, seed mix may be dispersed into suitable habitats from the original entry point.
Will the volume of movement along the pathway support entry?	Over 2 million sheep are exported from Australia each year. Reports suggest that over 64 000 sheep and 50 000 cattle were imported into Israel from Australia in 2012 (see http://www.jpost.com/Enviro-Tech/PETA-Australia-calls-for-Israel-to-stop-importing-live-animals-from-Down-Under-325867). Comparing maps from Australia showing the regions with sheep farming and the distribution map of Ambrosia confertiflora occurrences in Australia (Figure 4 in Appendix 4) it seems as if there is a good overlap.
Will the frequency of movement along the pathway support entry?	Yes. In general, the import of livestock into Israel has been steadily increasing since 2008. Israel was Australia's second largest market for cattle exports in 2013 and an important market for live sheep. Israel imported 98,096 cattle in 2013, which represented 13 per cent of cattle export volume (see Figure 5.2, page 178, file:///C:/Users/rt.EPPO/Downloads/chapter5.pdf). Post introduction of ESCAS, Australia exported 164,289 sheep and 173,877 cattle to Israel as of November 2014. Israel imported 63,150 sheep in 2015.

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

It is difficult to obtain figures of live exports of livestock from Austrlia into the EU but figures of live sheep exports into the EU were 22 actual individuals (livecorp, 2017). Therefore, for the EU, the EWG consider that the score would remain low with a high uncertainty. All European biogeographical regions will have the same likelihood of entry and uncertainty scores.

Possible pathway	**Pathway: Contaminant of animal feed mixture** **(CBD terminology: Transport – contaminant- seed contaminant)**		
Short description explaining why it is considered as a pathway	Fruit/seed may become incorporated into animal seed mixture and imported and dispersed within the PRA area (EFSA 2010). The likelihood of contamination in animal feed is elevated as regulations are less restrictive than for human consumption or seed for planting.		
Is the pathway prohibited in the PRA area?	No, the pathway is not prohibited in the PRA area.		
Has the pest already intercepted on the pathway?	No, to-date, *A. confertiflora* has not been intercepted along this pathway.		
What is the most likely stage associated with the pathway?	Fruits / seeds		
What are the important factors for association with the pathway?	The fruit/seeds are small, have spines which can adhere to various surfaces and can remain undetected.		
Is the pest likely to survive transport and storage along this pathway?	Yes, the fruit/seeds can survive for over 12 months.		
Can the pest transfer from this pathway to a suitable habitat?	Yes, seed mix may be dispersed into suitable habitats from the original entry point.		
Will the volume of movement along the pathway support entry?	Statistics are difficult to obtain for animal feed imports into the EU and the EPPO region. However, the EWG considers that there is significant potential for large volumes of animal feed entering the region.		
Will the frequency of movement along the pathway support entry?	Statistics are difficult to obtain for animal feed imports into the EU and the EPPO region. However, the EWG considers that there is significant potential for a high frequency of animal feed entering the region.		
Rating of the likelihood of entry	Low **X**	Moderate	High ☐
Rating of uncertainty	Low ☐	Moderate	High **X**

All European biogeographical regions will have the same likelihood of entry and uncertainty scores.

Possible pathway	**Pathway: Contamination of machinery and equipment** (CBD terminology: Transport- stowaway – Vehicles)
Short description explaining why it is considered as a pathway	In Israel this species was recorded in the Golan Heights for the first time at a development site where the machinery is known to have come from the infested area (T. Yacoobi, pers. comm. 2017). This species has small seeds that are likely to be transported by mud on machinery.
Is the pathway prohibited in the PRA area?	No the pathway is not prohibited along this pathway. There is legislation on the cleaning of machinery in Israel and in Norway. Second-hand agricultural machinery being imported into Israel must be cleaned before export and is inspected upon arrival in Israel. In Norway, when used machinery and equipment intended to be used in agriculture, forestry or horticulture is imported, an official statement must accompany the consignment stating that it has been thoroughly cleaned and if necessary disinfected and that it is free from soil, plant remains and contamination from pests. The country of exports plant inspection service, or an equivalent official agricultural authority shall issue this certification (Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests). There is no other known compulsory management practice for cleaning agricultural machinery, vehicles or military equipment in the EPPO region. It is only recently, that a ISPM Standard (IPPC, 2017, ISPM 41) has been drafted and adopted on ‘International movement of used vehicles, machinery and equipment’.
Has the pest already been intercepted on the pathway?	No, but as previously mentioned, it is possible that this species was introduced into the Golan Heights in this manner.
What is the most likely stage associated with the pathway?	Fruit/seeds and rhizomes are the most likely stages associated with this pathway.
What are the important factors for association with the pathway?	This species is known to be associated with agricultural areas and therefore highly likely to be transported by agricultural machinery.
Is the pest likely to survive transport and storage along this pathway?	The seeds are small and can become attached in small crevices – e.g. in tyre treads. The rhizomes are robust and highly likely to survive transportation in mud attached to machinery.

Can the pest transfer from this pathway to a suitable habitat?	Yes, this species can invade agricultural lands.
Will the volume of movement along the pathway support entry?	It is difficult to estimate the volume of machinery and equipment entering the EPPO region. Only a small fragment of rhizome will regenerate into a viable plant.
Will the frequency of movement along the pathway support entry?	It is difficult to estimate the frequency of machinery and equipment entering the EPPO region. However, just one event could lead to the entry of the species and establishment in a region.
Rating of the likelihood of entry	Low X Moderate ☐ High ☐
Rating of uncertainty	Low ☐ Moderate High X

All European biogeographical regions will have the same likelihood of entry and uncertainty scores.

Possible pathway	**Pathway: Contaminant of travelers, their clothes and shoes**
Short description explaining why it is considered as a pathway	The fruits have hooked spines that can attach easily to clothing, boot or shoelaces. The plant forms near monospecific stands in habitats where people walk (e.g. natural areas and agricultural land, roadsides).
Is the pathway prohibited in the PRA area?	No, the pathway is not prohibited in the PRA area. The European Code of Conduct on international travel and invasive alien species can be followed (https://rm.coe.int/european-code-of-conduct-on-international-travel-and-invasive-alien/168075e833)
Has the pest already intercepted on the pathway?	No, up to now, *A. confertiflora* fruits have not been intercepted along this pathway.
What is the most likely stage associated with the pathway?	Fruits
What are the important factors for association with the pathway?	The fruits are less than 5 mm, have hooked spines, and can attach to clothing and shoes and may be easily undetected.
Is the pest likely to survive transport and storage along this pathway?	Yes, fruits are likely to survive all modes of transport, but information on dormancy is lacking.
Can the pest transfer from this pathway to a suitable habitat?	Yes, *A. confertiflora* can establish in a variety of habitats (agricultural land, roadsides etc.).
Will the volume of movement along the pathway support entry?	The volume of people travelling to the PRA area is high. There is no data available, the volume of people travelling is considered to be high. There is an estimated 700 million people crossing international borders as tourists each year (McNeely, 2006). Millions of people visit the EPPO region every year from countries where A. confertiflora occurs.
Will the frequency of movement along the pathway support entry?	The frequency of people travelling to the PRA area is high. Flights with travelers from all over the world arrive daily in the EPPO region.
Rating of the likelihood of entry	*Low* **X** *Moderate* ☐ *High* ☐
Rating of uncertainty	*Low* ☐ *Moderate* *High* **X**

All European biogeographical regions will have the same likelihood of entry and uncertainty scores.

Note: It should be noted that for all of the pathways detailed in this section, only a small number of seeds are needed to potentially produce viable plants. As an individual plant can produce *** seeds per year just a few number of individuals can lead to extensive populations.

Do other pathways need to be considered? **No**

9. Likelihood of establishment in the natural environment in the PRA area

In Israel, *A. confertiflora* will readily grow in a Mediterranean semi to arid environment (Yair et al., 2017). The presence of a dry season and high summer temperatures do not restrict the occurrence of the species. Frost and low winter temperatures may act as limiting factors. In the natural environment, the most sensitive habitats are wetlands and all types of humid habitats in the climatic zones mentioned above. The natural instability of riverbanks in Mediterranean and arid environments (seasonal floods) increases significantly the risk of dispersal and establishment of new foci. Yet, dry habitats are also at risk as suggest the distribution of foci in the infested area.

The establishment of foci in the Jordan valley, along roadsides (Figure 7), near Jericho, and more recently in the Negev suggests that the plant can cope easily with arid conditions, i.e. high summer temperatures, extended dry season. This is supported by this species' distribution in its native range where it is most common in arid to semi-arid climates (Calflora, 2017; Flora of North America, 2017). However, it appears to have a wide environmental tolerance in its native range, occurring in mean temperatures from -1 to 35 ºC, precipitation levels from 230 to 1040 mm, altitudes from 10 to 2000 m in regions where the growing season ranges from 5 to 12 months (Calflora, 2017; Flora of North America, 2017). In Israel it is commonly associated with open habitats along rivers or in seasonally moist habitats (Yair, 2017). Growth trials have shown that the plant grows better in warm conditions (22/28 and 28/34°C night/day cycle) and shoot elongation is slower in cold conditions (10/16°C and 16/22°C night/day cycle) and in these conditions the plant remains in a rosette form (Yair, 2017).

Germination is best when seeds are on the soil surface (no germination was detected when seeds were planted at depths below 4 cm depth) and at moderate temperatures (16/22°C night/day cycle) (Yair, 2017), suggesting autumn or spring germination. This is supported by Australian observations that this species germinates mostly in autumn (Parsons & Cuthbertson, 2001). It is recorded that in California (USA) *A. confertiflora* can tolerate a wide pH – from 5.4 to 7.4 (Calflora, 2017).

Within the EPPO region, establishment in the natural environment will be restricted. The species distribution models suggest a large part of the region is unsuitable (see Appendix 1). *Ambrosia confertiflora* is capable of establishing in the Mediterranean biogeographical regions including the EU countries where the species has a high suitability: Spain, Italy (Southern Sardinia, Sicily), Greece, Cyprus and the wider EPPO region countries: Israel, Jordan, Turkey, Morocco, Algeria and Tunisia. The countries where the species has a high suitability include: Spain, Italy (Southern Sardinia, Sicily), Greece, Cyprus, Israel, Jordan, Turkey, Morocco, Algeria and Tunisia. A small region in Russia (close to the Georgian boarder) also shows suitability (see appendix 1).

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

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

A. *confertiflora* has been shown to colonize and persists in managed environments within the EPPO region, including cultivated habitats in Israel and along transportation networks (pers comm. Yaacobi, 2017; Yair *et al*., 2017). The potential for further establishment within such habitats is considered likely, in particular in regions where there is a high level of suitability for establishment. The EWG consider that similar establishment would be likely in the *Mediterranean* regions as defined by the endangered area: Spain, Italy (Southern Sardinia, Sicily), Greece, Turkey, Israel, Jordan, Morocco, Algeria and Tunisia.

Habitats within the endangered area include: various natural and disturbed habitats, including dry plains and semi-arid valleys, degraded pastures, cultivated orchards, summer field crops (cotton and water melon) avocado and date groves, along roadsides, river-banks (including dry riverbeds), in wastelands and other disturbed areas (Jean Marc Dufour-Dror, pers. comm., 2017; Yair *et al.*, 2017).

A high rating of likelihood of establishment has been given for the managed environment with a low rating of uncertainty. The EWG consider that even though the species is absent from EU Member States, a similar score for establishment in such countries as detailed above is appropriate.

Rating of the likelihood of establishment in the managed environment	*Low* ☐	*Moderate* ☐	*High* **X**
Rating of uncertainty	*Low* **X**	*Moderate* ☐	*High* ☐

11. Spread in the PRA area

Natural spread

In Israel, *A. confertiflora* has shown a fast rate of spread since its introduction in 1990 (Israel Ministry of Environmental Protection, 2013). The plant spreads very fast via seeds and to a lesser extent through rhizome spreading locally (pers. obs. Jean-Marc Dufour, 2017; Yair et al., 2017). Dispersal can also occur by flowing water, particularly during floods.

A. confertiflora reproduces from seeds and through vegetative propagation which happens through adaptive buds found on spreading horizontal roots. The species can spread naturally over short distances through creeping roots. The seeds can also be spread over long distances when the hooked spines attach to livestock and wild animals, or can be spread by water, especially during flooding, as the woody burr floats (Australian Government, 2017; Weeds in Australia Website 2017; Southern Tablelands and South Coast Noxious Plants Committee, 2017). However, *A. confertiflora* has not shown significant increase in reported occurrences in Australia, since its first record in 1937 (Atlas).

A. confertiflora spreads by both rhizomes and viable seeds that can germinate after only four days and remain viable for a long period of time. Achenes of *A. confertiflora* in the herbarium (collected by Avinoam Danin in 1990) germinated after 25 years and developed into adult plants. It is not known how long the seeds stay viable in water nor if the seeds germinate immediately or form a seed back.

Human-assisted spread

The plant is spread through human activities when seeds attach to clothing and other fibrous material (e.g. tents). Root fragments may also be spread over long distance as a contaminant of machinery and vehicles, in particular agricultural machinery (Israel Ministry of Environmental Protection, Undated). Seeds may also be spread by grazing animals.

According to the area infested (Israel): The plant has a very short lag phase (5-8 years) and enters the exponential phase within 10 years of introduction (pers. obs. Jean-Marc Dufour, 2017). Once introduced the plant may be widespread within less than 15 years, depending on human density, and hydrography, and suitability of habitat (pers. obs. Jean-Marc Dufour, 2017).

It should be noted that the population of *A. confertiflora* in Israel is effectively an isolated occurrence in the EPPO region. There are no connecting rivers between Israel and surrounding countries except for the Jordan river and there is limited overland (i.e. lorries) trade between Israel and the surrounding countries. Therefore, this can act to reduce the potential of spread of the species within the EPPO region and hence the moderate rating of uncertainty.

It should also be noted that the species has the potential to establish within EU Member States and only only a small number of seeds are needed to potentially produce viable plants. As an individual plant can produce numerous seeds per year just a few number of individuals can lead to extensive populations. See also section 15 (climate change). Note, it is not known how many seeds an individual plant can produce.

Rating of the magnitude of spread in the PRA area	*Low* ☐	*Moderate* ☐	*High* **X**
Rating of uncertainty	*Low*	*Moderate* **X**	*High* ☐

12. Impact in the current area of distribution

12.01 Impacts on biodiversity

Ambrosia confertiflora forms dense stands that can outcompete native plant species (Jean Marc Dufour-Dror, pers. comm., 2017). The plant has the ability to modify the vegetation dynamics (Israel Ministry of Environmental Protection, 2013). A monoculture can act to suppress understory native plants which results in environmental impacts, in particular in humid habitats, in grasslands and in dry river beds (Jean Marc Dufour-Dror, pers. comm., 2017). In Israel, the plant spreads rapidly in wetlands and thrives along riverbanks where it displaces native species and creates pure stands (Jean Marc Dufour-Dror, pers. comm., 2014). Species that have been shown to be outplaced by *A. confertiflora* in Israel include: *Bolboschoenus maritimus*, *Asparagus palaestinus*, *Polygonum salicifolium*, *Vicia galeata*, *Cyperus fuscus*, *Verbena officinalis*, *Ipomoea sagittata*, *Ranunculus sceleratus*, *Epilobium hirsutum*, *Pulicaria dysenterica* (pers comm. Yaacobi, 2017).

In Australia, there are no known studies that have assessed the impact of the species on biological diversity.

The EWG considers that dense communities can have significant impacts on native species in the EPPO region, however, to-date there are no published replicated scientific studies evaluating impacts. Therefore, the rating of uncertainty is scored high to reflect this.

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

Ecological impacts of other invasive Ambrosia species in the EPPO region

Ambrosia artemisiifolia is an annual herbaceous plant. It thrives in a wide range of open and disturbed habitats, in both native and invasive ranges: along waterways, roadsides and railways, in old fields and industrial or urban wastelands, and in cultivated fields, particularly among maize, sunflower and soya bean. In Europe, in particular in parts of Central, Eastern and Western Europe, *A. artemisiifolia* has become a dominant weed on arable land (Essl et al. 2015).

Yield loss can be substantial, but depends largely on the crop type, the time of emergence of *A. artemisiifolia* relative to the crop and the density of *A. artemisiifolia* infestation. In Europe, the impact of various densities of *A. artemisiifolia* on the yield of sunflower, sugar beet and maize has been documented (see Essl et al. 2015 for references). For example, it has been demonstrated that *A. artemisiifolia* at densities of 5 and 10 plants m^2 caused 21 and 33% yield reduction in sunflower and almost 30% in maize at both densities.

In Europe, *A. artemisiifolia* reveals that it only rarely invades habitats of high nature conservation value. Occurrences in dry grasslands have been documented several times for Central and Eastern European Countries, but these seem mostly to be a consequence of disturbances (e.g. grazing) that have created patches of open soil (Essl et al. 2015). *A. artemisiifolia* has become a major cause of pollen allergy in Europe and its impact is well-documented (Smith et al. 2013).

A. psilostachya is a rhizomatous perennial plant. It occurs principally on sandy soils in disturbed habitats. The species can be found in coastal areas (dunes), along riverbanks, degraded grasslands, ruderal sites (railway tracks, industrial areas) and occasionally on arable land (ANSES 2017).

In agriculture, its occurrence is confined mainly to perennial crops (e.g. orchards). It may become more of a problem in annual crop fields with reduced or no tillage. However, the highest impact is due to it allergenic pollen. In natural area, its impact is considered to be low (ANSES, 2017).

12.02. Impact on ecosystem services

Ecosystem service	**Does the pest impact on this Ecosystem service?** Yes/No	**Short description of impact**	**Reference**
Provisioning	Yes	*Ambrosia confertiflora* is also a serious pest in cultivated fields, citrus groves and orchards in general (Israel Ministry of Environmental Protection, 2013), and in grape (Conabio Website, 2017). It competes for nutrients and interferes with the harvest (Parsons & Cuthbertson 2001). The plant spreads among cultivated fields and mixes with crops which cannot be harvested properly. The fruits can reduce the quality of sheep wool.	Dufour-Dror 2012
Regulating	Yes	Given the high biomass produced, the species will utilise a large amount of water. It also has the potential to affect air quality by producing large amounts of allergenic pollen. There is some evidence that the species has allelopathic effects.	Dufour-Dror 2012, Yair, 2017
Cultural	Yes	Infestations in leisure sites may be problematic because of unpleasant smell of the plant and mainly because of possible dermatitis and allergies caused by the plant	Dufour-Dror, 2012

In Israel, *A. confertiflora* has been shown to significantly impact on ecosystem services though a lot of the data for this is through observations rather than scientific studies. The plant competes for nutrients and can spread among cultivated fields and mixes with crops which cannot be harvested properly (Parsons & Cuthbertson 2001). *A. confertiflora* can impact on organic farming as chemical application in such areas is prohibited. It has caused great damage to *Moringa* spp. fields in the Sharon region (JM Dufour-Dror, pers. comm., 2017). The burrs of the plant contaminate wool and can lower its value (Parsons & Cuthbertson, 2001).

Rating of magnitude of impact on ecosystem services in the current area of distribution	*Low* ☐	*Moderate* ☐	*High* **X**
Rating of uncertainty	*Low*	*Moderate* **X**	*High*

12.03. Socio-economic impact

A. confertiflora is also a serious pest in cultivated fields, citrus groves and orchards in general (Israel Ministry of Environmental Protection, 2013), and in grape (Conabio Website) (Figures 8 & 9). The plant competes for nutrients and can spread among cultivated fields and mixes with crops which cannot be harvested properly (Parsons & Cuthbertson 2001). *A. confertiflora* can impact on organic farming as chemical application in such areas is prohibited. It has caused great damage to *Moringa* spp. fields in the Sharon region (JM Dufour-Dror, pers. comm., 2017). The burrs of the plant contaminate wool and can lower its value (Parsons & Cuthbertson, 2001).

Infestations in recreational sites may be problematic because of unpleasant smell of the plant and mainly because of possible dermatitis and allergies caused by the plant (though not clearly established so far). In addition, the monocultures can prevent access to sites and rivers. The plant also invades gardens and parks and is reported to disrupt their maintenance (Israel Ministry of Environmental Protection, Undated).

As with the other *Ambrosia* species, *A. confertiflora* produces a large amount of pollen considered to be severely allergenic (Yair, 2017), causing hay fever and contact dermatitis in susceptible people (Parsons & Cuthbertson, 2001).

Control costs have been calculated from Israel. Using Imazapyr at a 2.5 to 5% diluted in about 400 L/ha will equate to 500 to 1000 euro/ha, excluding labour. Other herbicides like mixture of glyphosate + 2,4D can cost 50 euro/ha but are considered less effective.

Rating of magnitude of socio-economic impact in the current area of distribution	*Low* ☐	*Moderate* ☐	*High* X
Rating of uncertainty	*Low*	*Moderate* X	*High*

13. Potential impact in the PRA area

Will impacts be largely the same as in the current area of distribution? **Yes (in part)**

Given the similarity in both land use and climate between the EPPO Mediterranean region and Israel, compared to that with Australia, the EWG expect the impacts will be of a similar magnitude to those in Israel.

The EWG considers the magnitude of impacts will be similar to that in the current area of distribution, and uncertainty will remain high for all categories (impact on biodiversity, impact on ecosystem services and socio-economic impact). This is mainly due to the fact that impacts have not been measured in the PRA area.

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

The text within this section relates equally to EU Member States and non-EU Member States in the EPPO region.

13.1. Potential impacts on biodiversity in the PRA area

In the PRA area, *A. confertiflora* has the potential to impact on native plant species due to its ability to form monocultures. Areas particularly under threat may include temporary river beds in the Mediterranean region (EUNIS C1.6B). These habitats are frequently invaded in Israel.

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

13.2. Potential impact on ecosystem services in the PRA area

Impacts on ecosystem services include impacts on crop yield and cultural impacts where the species can degrade recreational sites where *A. confertiflora* is able to reach the levels of abundance required for these impacts to be displayed. If the species invades countries where it is currently absent in the endangered area (Spain, Italy (Southern Sardinia, Sicily), Cyprus, Greece, Jordan, Turkey, Morocco, Algeria and Tunisia), similar impacts could be seen as in Israel (EWG opinion).

Rating of magnitude of impact on ecosystem services in the area of potential establishment	*Low* ☐	*Moderate* ☐	*High* **X**
Rating of uncertainty	*Low*	*Moderate* ☐	*High* **X**

13.03 Potential socio-economic impact in the PRA area

Based on experience elsewhere in Israel, management is likely to be both expensive and difficult (EWG opinion). The potential economic impact of *A. confertiflora* in the EPPO region could be significant if the species spreads and establishes in further areas (EWG opinion). There are no indigenous host specific natural enemies in the EPPO region to regulate the pest species, and in many EPPO countries herbicide application in or around water bodies is highly regulated or not permitted.

Rating of magnitude of socio-economic impact in the area of potential establishment	*Low* ☐	*Moderate* ☐	*High* **X**
Rating of uncertainty	*Low*	*Moderate* ☐	*High* **X**

14. Identification of the endangered area

Ambrosia confertiflora is capable of establishing in the Mediterranean biogeographical regions including the EU countries where the species has a high suitability: Spain, Italy (Southern Sardinia, Sicily), Greece, Cyprus and the wider EPPO region countries: Israel, Jordan, Turkey, Morocco, Algeria and Tunisia. A small region in Russia, close to the Georgian border also shows suitability (see appendix 1). The EWG considers that the endangered area will be the regions which show high suitability (see appendix 1). Therefore, the endangered area is EU countries: Spain, Southern Sardinia, Sicily, Greece, and the wider EPPO region: Turkey, Israel, Jordan, Morocco, Algeria and Tunisia.

Habitats within the endangered area include: various natural and disturbed habitats, including dry plains and semi-arid valleys, degraded pastures, cultivated orchards, summer field crops (cotton and water melon) avocado and date groves, along roadsides, river-banks (including dry riverbeds), in wastelands and other disturbed areas (Jean Marc Dufour-Dror, pers. comm., 2017).

15. Climate change

With climate change, it is predicted that *Ambrosia confertiflora* will be capable of establishing in the Mediterranean biogeographical region. The countries where the species has a high suitability include: Spain, Southern France, Southern Sardinia, Sicily, Greece, Bulgaria, Romania, Hungary, Ukraine, Turkey, Israel, Jordan, Russia, Morocco, Algeria and Tunisia (see appendix 1).

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

Climate projection: RCP: 8.5 (2070)

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

*Temperature **(yes)***	*Precipitation **(no)***	*$C0_2$ levels **(no)***
*Sea level rise **(no)***	*Salinity **(no)***	*Nitrogen deposition **(no)***
*Acidification **(no)***	*Land use change **(no)***	*Other (please specify)*

15.3. Consider the influence of projected climate change scenarios on the pest.

Are the **pathways** likely to change due to climate change? **(If yes, provide a new rating for likelihood and uncertainty)**	**Reference**
The pathways are unlikely to change as a result of climate change but uncertainty will increase from low to moderate. Contaminant of livestock: Low with moderate uncertainty Contaminant of animal feed mixture: Low with moderate uncertainty Contaminant of machinery and equipment: Low with moderate uncertainty Contaminant of travelers: Low with moderate uncertainty	EWG opinion
Is the **likelihood of establishment** likely to change due to climate change? **(If yes, provide a new rating for likelihood and uncertainty)**	**Reference**
Practically, the potential invasion of *Ambrosia confertiflora* in the EPPO region, if introduced to other countries than Israel and the West Bank, would take place over a short time span, and climate change is likely increase the area for establishment. More extreme weather events are likely, including flooding, which will act to increase the establishment of the species. Likelihood of establishment in natural areas: High with high uncertainty Likelihood of establishment in managed areas: High with high uncertainty	EWG opinion
Is the magnitude of **spread** likely to change due to climate change? **(If yes, provide a new rating for the magnitude of spread and uncertainty)**	**Reference**
Yes, spread is likely to change as a larger area will be available for the colonisation of the species. More extreme weather events are likely, including flooding, which will act to increase the spread capacity of the species. Spread: High with high uncertainty	EWG opinion
Will **impacts** in the PRA area change due to climate change? **(If yes, provide a new rating of magnitude of impact and uncertainty for biodiversity, ecosystem services and socio-economic impacts separately)**	**Reference**
Impacts within the EPPO region may be experienced at a wider scale, but impacts overall will not change. **Impacts (EPPO region)**	EWG opinion

Biodiversity: High with high uncertainty Ecosystem services: High with high uncertainty Socio-economic: High with high uncertainty	

16. Overall assessment of risk

Ambrosia confertiflora poses a high risk to the Mediterranean biogeographical region with a high uncertainty. The natural habitats at risk are both natural wetlands, natural drylands with non-forest vegetation structures. Cultivated habitat is also at risk. The likelihood of direct introduction from Israel is unclear, presumably similar to that of *Parthenium hysterophorus*. If introduced, the impacts would be similar to these experienced in Israel presently.

The fact that no trade and commercial activities exist between the infested area (Israel) and the rest of the EPPO region via land (except for Jordan), may reduce the proliferation risk of *Ambrosia confertiflora* (i.e. potentially infested products cannot be exported from Israel via Lebanon or Syria due to the permanent and lasting state of war existing between these countries).

Pathways for entry:

Contaminant of livestock

Likelihood of entry	Low X	Moderate	High
Likelihood of uncertainty	Low	Moderate	High X

Contaminant of animal feed mixture

Likelihood of entry	Low X	Moderate	High
Likelihood of uncertainty	Low	Moderate	High X

Contaminant of machinery and equipment

Likelihood of entry	Low X	Moderate	High
Likelihood of uncertainty	Low	Moderate	High X

Contaminant of travelers

Likelihood of entry	Low X	Moderate	High
Likelihood of uncertainty	Low	Moderate	High X

Likelihood of establishment in the natural 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

Likelihood of establishment in managed environment in the PRA area

Rating of the likelihood of establishment in the managed environment	Low	Moderate	High x
Rating of uncertainty	Low x	Moderate	High

Spread in the PRA area

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

Impacts

Impacts on biodiversity and the environment

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

Impacts on ecosystem services

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

Socio-economic impacts

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

Impacts in the PRA area

Will impacts be largely the same as in the current area of distribution? **Yes (in part)**

Potential impacts on biodiversity in the PRA area

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

Potential impact on ecosystem services in the PRA area

Rating of magnitude of impact on ecosystem services in the area of potential establishment	*Low* ☐	*Moderate* ☐	*High* **X**
Rating of uncertainty	*Low*	*Moderate* ☐	*High* **X**

Potential socio-economic impact in the PRA area

Rating of magnitude of socio-economic impact in the area of potential establishment	*Low* ☐	*Moderate* ☐	*High* **X**
Rating of uncertainty	*Low*	*Moderate* ☐	*High* **X**

Stage 3. Pest risk management

17. Phytosanitary measures

The results of this PRA show that *Ambrosia confertiflora* poses a high risk to the endangered area (Mediterranean biogeographical region) with a high uncertainty.

Pathways identified in the PRA

Possible pathways *(in order of importance)*	Measures identified
Contaminant of animal feed mixtures*	Grain has been produced in a pest-free area (PRA) Or Pest-free place of production/production site consist in the following combination of measures: visual inspection at the place of production, specified treatment of the crop, inspection of the commodity. Or Cleaning and treatment of grain lot to remove *Ambrosia confertiflora* seeds, AND Cleaning and treatment of ships and containers.
Contaminant of machinery and equipment	ISPM 41 'International movement of used vehicles, machinery and equipment' should be implemented
Contaminant of travellers, their clothes and shoes	Publicity awareness campaigns should be initiated to enhance public awareness on pest risks especially at key international travel hubs.
Contaminant of livestock	Strengthen boarder control for inspection of livestock. Provide inspectors with identification material for all plant parts.

* Contaminant of animal feed mixtures refers to grain

International measures
Ambrosia confertiflora should be recommended for regulation within the endangered area. With this, the import into and movement within countries in the endangered area, of plants labeled or otherwise identified as *Ambrosia confertiflora* should be prohibited. *Ambrosia confertiflora* should be banned from sale within the endangered area,

National measures
Ambrosia confertiflora 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 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 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. 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 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

Ambrosia confertiflora is not effectively controlled by cultural practices. In fact, cultural practices can make the infestation worse by spreading pieces of the perennial root and stimulating development of root buds.

Mechanical control
Mechanical control can even exacerbate the intensity of the invasion, as the plant regenerates very quickly after mowing (Jean Marc Dufour-Dror, pers. comm., 2017). Uprooting may only be effective against very young plants as otherwise, the root remains in the soil and the plant regenerates.

Chemical control
Herbicides such as glyphosate, triclopyr, and fluroxypyr are not very effective as the plant recovers quickly after the spraying. However, these herbicides are not registered for use in wetlands and

riparian habitats. Though, herbicides have been recorded as providing satisfying results in controlling A. confertiflora in pastures in Australia. A recent unpublished experiment in Israel suggests imazapyr is effective in killing mature specimens of the burr ragweed. Targeted chemical control with Imazapyr © 5% in water is effective. Better results are obtained if applied 3 weeks after low cut, i.e. spraying regenerating shoots. It may require returning control. Imazapyr is registered for use in wetlands (Jean Marc Dufour-Dror, pers. comm., 2017).

Manipulation of the habitat
An unpublished study conducted in Israel showed that natural vegetation restoration along river banks with *Arundo donax* and *Arundo mediterranea* (Poaceae) successfully prevented *A. confertiflora* re-establishment in previously infested areas (Jean Marc Dufour-Dror, pers. comm., 2017).

Biological control
No biological control agents have been tested for specificity against this species. However, the *Lepidoptera Epiblema strenuana* is present in the country but shows no significant impact on its host (Yaacoby and Seplyarsky, 2011).

As there are no occurrences of *A. confertiflora* in the EU, in the natural environment, implementation costs for Member States would be relatively low. The cost of inaction could significantly increase potential costs in the future as any management programme would have to take place on a larger scale and this would reduce the cost-effectiveness of any measures.

18. Uncertainty
The main uncertainty associated with this PRA includes the lack of published material on impacts.

In addition, for the modelling:

Modelling the potential distributions of range-expanding species is always difficult and uncertain. Other variables potentially affecting the distribution of the species, such as edaphic variables, were not
included in the model.

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 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.
- Additional data sources to GBIF were used, which may have been from regions without GBIF records.

19. Remarks
NA

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Appendix 1: Projection of climatic suitability for *Ambrosia confertiflora* establishment

Aim

To project the suitability for potential establishment of *Ambrosia confertiflora* 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) and aggregated to a 0.25 x 0.25 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 minimum temperature of the coldest month (Bio6 °C) reflecting exposure to frost. As a perennial plant, harsh frosts might limit over winter survival.
- Mean temperature of the warmest quarter (Bio10 °C) reflecting the growing season thermal regime.

Cool temperatures might limit reproductive output.

- Climatic moisture index (CMI, ratio of mean annual precipitation, Bio12, to potential evapotranspiration, PET) reflecting plant moisture regimes. Monthly PETs were estimated from the WorldClim monthly temperature data and solar radiation using the simple method of Zomer *et al.* (2008) which is based on the Hargreaves evapotranspiration equation (Hargreaves, 1994). *A. confertiflora* occurs in arid environments and might be restricted by excessive moisture.
- Precipitation seasonality (Bio15) was included as it is suggested that *A. confertiflora* might prefer 'Mediterranean' type climates with pronounced seasonality in precipitation regimes.
- Precipitation of the driest quarter (Bio17, mm) was included as a further measure of potential 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) 4.5 and 8.5 were also obtained. For both scenarios, 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).

RCP 4.5 is a moderate climate change scenario in which CO_2 concentrations increase to approximately 575 ppm by the 2070s and then stabilise, resulting in a modelled global temperature rise of 1.8 C by 2100. RCP8.5 is the most extreme of the RCP scenarios, and may therefore represent the worst case scenario for reasonably anticipated climate change. In RCP8.5 atmospheric CO_2 concentrations increase to approximately 850 ppm by the 2070s, resulting in a modelled global mean temperature rise of 3.7 °C by 2100.

In the models we also included the following habitat variable:

- Human influence index as *A. confertiflora*, like many invasive species, is likely to associate with anthropogenically disturbed habitats. 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.

Species occurrence data were obtained from:

- Global Biodiversity Information Facility (GBIF)
- USDA Biodiversity Information Serving Our Nation (BISON)
- Berkeley Ecoinformatics Engine
- iNaturalist
- Tropicos
- Calflora
- Consortium of California Herbaria
- Atlas of Living Australia
- BioNet Atlas of New South Wales Wildlife
- Queensland Herbarium Records System (HERBRECS)
- Personal record databases of member of the EPPO Expert Working Group

We scrutinised occurrence records from regions where the species is not known to be well established and removed any that appeared to be dubious or planted specimens (e.g. plantations, botanic gardens) or where the georeferencing was too imprecise (e.g. records referenced to a country or island centroid) or outside of the coverage of the predictor layers (e.g. small island or coastal occurrences). The remaining records were gridded at a 0.25 x 0.25 degree resolution for modelling (Figure 1a). In total 551 grid cells contained records of *A. confertiflora*.

Additionally, the recording density of vascular plants (phylum Tracheopthyta) on GBIF was obtained as a proxy for spatial recording effort bias (Figure 1b).

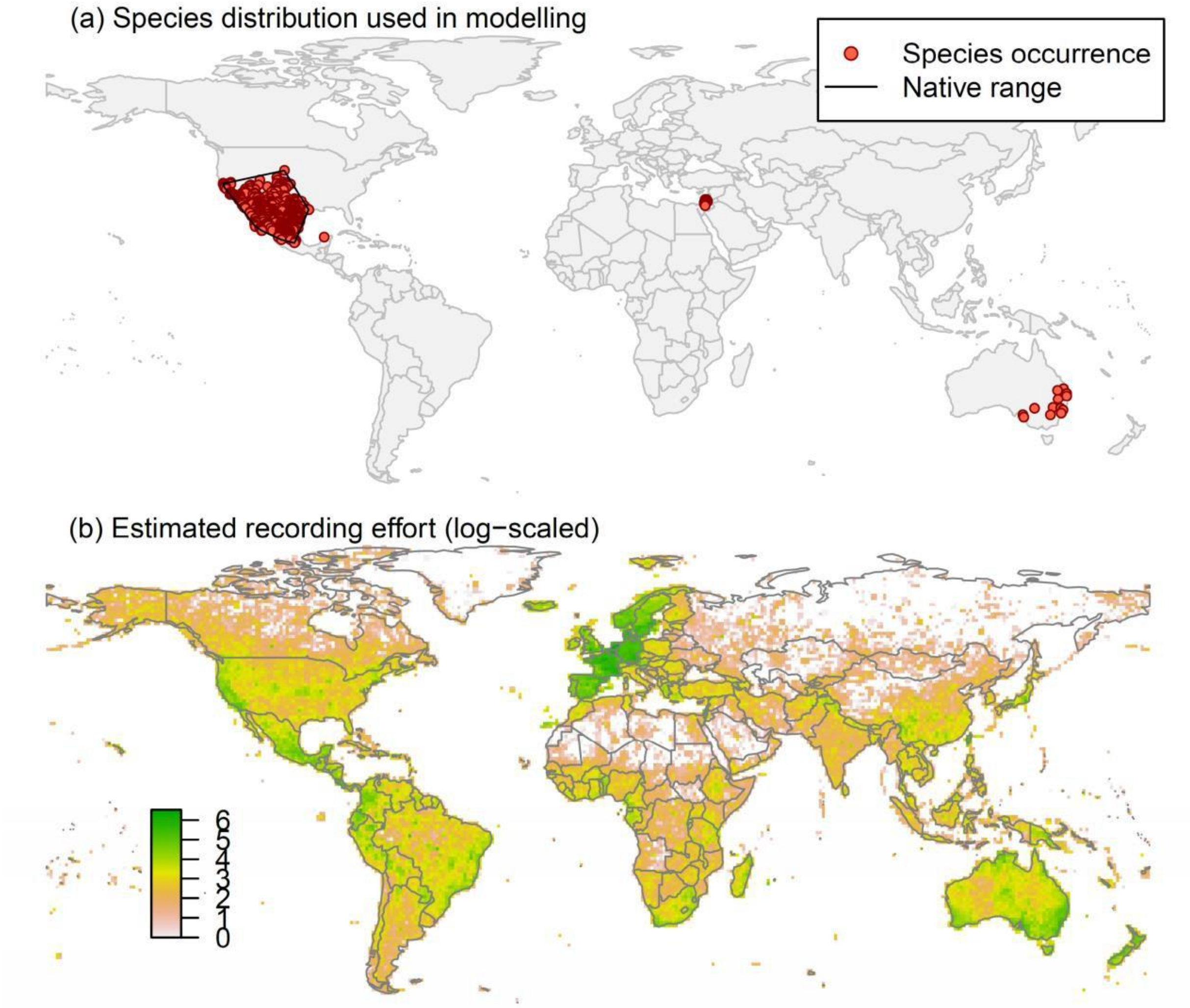


Figure 1. (a) Occurrence records obtained for *Ambrosia confertiflora* and used in the modelling, showing the native range and (b) a proxy for recording effort – the number of Tracheophyta records held by the Global Biodiversity Information Facility, displayed on a $\log_{10}$ scale.

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 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 area accessible by native *A. confertiflora* populations (see Fig. 1a), in which the species is likely to have had sufficient time to disperse to all locations. The native range was defined as the North American mainland occurrences, excluding the outlier in Yucatan, eastern Mexico, which we assumed was an introduction. The accessible region was defined as a 300 km buffer around the minimum convex polygon bounding all native occurrences; AND

- A relatively small 30 km buffer around all non-native occurrences, encompassing regions likely to have had 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 Figure 2).

Absence from these regions is considered to be irrespective of dispersal constraints. No ecophysiological information about *A. confertiflora* was available, so we used the distribution data to quantify maximum exposure to factors likely to determine the native range margins and limit occurrence in Europe. The following rules for unsuitability were applied, where thresholds represent approximately the 1^{st} or 99^{th} percentile for conditions at the occurrence locations:

- Mean minimum temperature of the coldest month (Bio6) < -11 °C.
- Mean temperature of the warmest quarter (Bio10) < 16 °C.
- Climatic moisture index (CMI) > 0.8.
- Precipitation seasonality (Bio15) < 0.25.
- Precipitation of driest quarter (Bio17) < 200 mm.

To sample as much of the background environment as possible, without overloading the models with too many pseudo-absences, ten background samples of 10,000 randomly chosen grid cells were obtained (Figure 2). To account for recording effort bias, sampling of background grid cells was weighted in proportion to the Tracheophyte recording density (Figure 1b).

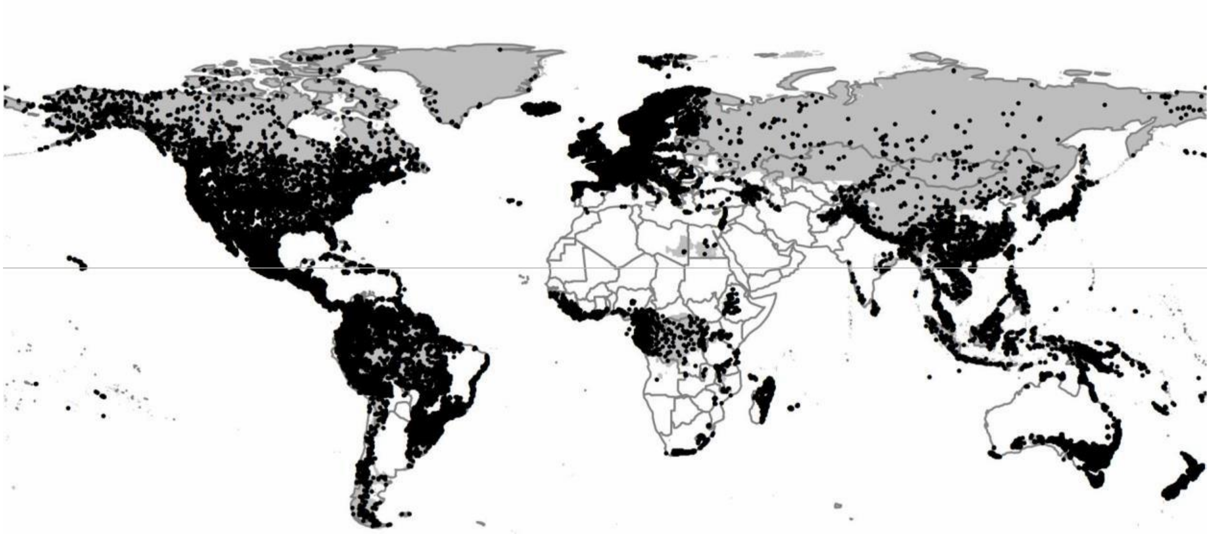


Figure 2. Randomly selected background grid cells used in the modelling of *Ambrosia confertiflora*, mapped as red points. Points are sampled from the native range, a small buffer around non-native occurrences and from areas expected to be highly unsuitable for the species (grey background region), and weighted by a proxy for plant recording effort (Figure 1b).

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) and rescaled using logistic regression:

- Generalised linear model (GLM)
- Generalised boosting model (GBM)
- Generalised additive model (GAM) with a maximum of four degrees of freedom per effect.
- 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. Normalised variable 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.

An ensemble model was created by first rejecting poorly performing algorithms with relatively extreme low AUC values and then averaging the predictions of the remaining algorithms, weighted by their AUC. To identify poorly performing algorithms, AUC values were converted into modified z-scores based on their difference to the median and the median absolute deviation across all algorithms (Iglewicz & Hoaglin, 1993). Algorithms with $z < -2$ were rejected. In this way, ensemble projections were made for each dataset and then averaged to give an overall suitability.

Global model projections were made for the current climate and for the two climate change scenarios, avoiding model extrapolation beyond the ranges of the input varaibles. The optimal threshold for partitioning the ensemble predictions into suitable and unsuitable regions was determined using the 'minimum ROC distance' method. This finds the threshold where the Receiver-Operator Curve (ROC) is closest to its top left corner, i.e. the point where the false positive rate (one minus specificity) is zero and true positive rate (sensitivity) is one.

Limiting factor maps were produced following Elith et al. (2010). For this, projections were made separately with each individual variable fixed at a near-optimal value. These were chosen as the median values at the occurrence grid cells. Then, the most strongly limiting factors were identified as the one resulting in the highest increase in suitability in each grid cell. Partial response plots were also produced by predicting suitability across the range of each predictor, with other variables held at near-optimal values.

Results

The ensemble model suggested that suitability for *A. confertiflora* was most strongly determined by moisture availability, precipitation seasonality, summer and winter temperature and precipitation of the driest quarter (Table 1). From Figure 3, suitability was strongly restricted by excessive moisture lack of precipitation seasonality, low summer temperature and either low or very high winter temperature. For all predictors, there was substantial variation in the partial response plots between algorithms (Figure 3).

Global projection of the model in current climatic conditions indicates that the native and known invaded records generally fell within regions predicted to have high suitability (Figure 4). The model predicts potential for substantial further expansion of the currently-invaded non-native ranges in Australia and the Middle East, as well as potential establishment in currently uninvaded parts of the world such as southern Africa, western South America (Figure 4).

The model predicts a restricted region of suitability in Europe and the Mediterranean region (Figure 5). *A. confertiflora* may be capable of establishing in southern Iberia, more arid parts of southern Italy, eastern Greece, central Turkey and throughout most of north Africa and the Middle East. The model predicts that establishment in the rest of Europe will mainly be prevented by excessive moisture availability, though in some places precipitation seasonality was the most important constraint (Figure 6).

By the 2070s, under the moderate RCP4.5 and extreme RCP8.5 climate change scenarios, the currently suitable regions of Europe are predicted to expand (Figures 7 and 8). Additionally, newly suitable areas appear in the more arid parts of continental eastern Europe (e.g. Bulgaria, Romania, Ukraine and Russia).

In terms of Biogeographical Regions (Bundesamt fur Naturschutz (BfN), 2003), those predicted to be most suitable for *A. confertiflora* establishment in the current climate are Macaronesia, Anatolian and Mediterranean (Figure 9). In the evaluated climate change scenarios, predicted suitability was substantially increased in all of these regions except Macaronesia. Other regions increasing in suitability under climate change include Steppic and Black Sea (Figure 9).

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

Algorithm	Predictive AUC	In the ensemble	Variable importance					
			Minimum temperature of coldest month	Mean temperature of warmest quarter	Precipitation seasonality	Precipitation of driest quarter	Climatic moisture index	Human influence index
ANN	0.9749	yes	13%	11%	22%	8%	45%	2%
GLM	0.9746	yes	9%	7%	27%	8%	49%	0%
GAM	0.9743	yes	8%	7%	28%	10%	46%	1%
MARS	0.9741	yes	10%	4%	23%	8%	55%	0%
GBM	0.9722	yes	8%	15%	22%	0%	55%	0%
RF	0.9690	yes	4%	18%	13%	9%	54%	2%
Maxent	0.9686	yes	8%	14%	24%	9%	45%	1%
FDA	0.9640	yes	8%	10%	17%	8%	57%	0%
MEMLR	0.9523	no	2%	0%	12%	3%	83%	1%
CTA	0.9378	no	5%	16%	23%	1%	54%	0%
Ensemble	0.9764		8%	11%	22%	7%	51%	1%

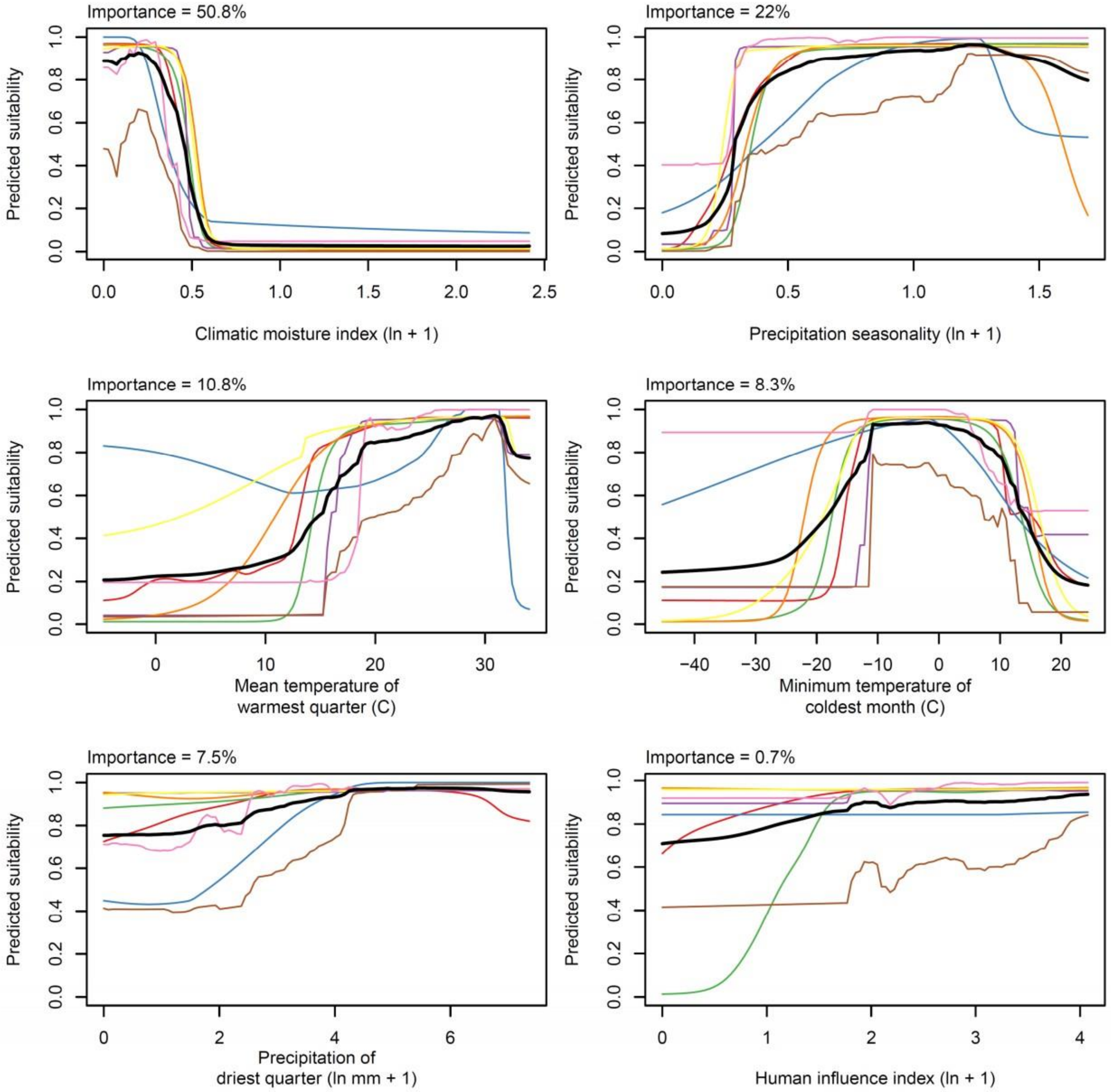


Figure 3. Partial response plots from the fitted models, ordered from most to least important. Thin coloured lines show responses from the algorithms in the ensemble, while the thick black line is their ensemble. In each plot, other model variables are held at their median value in the training data.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

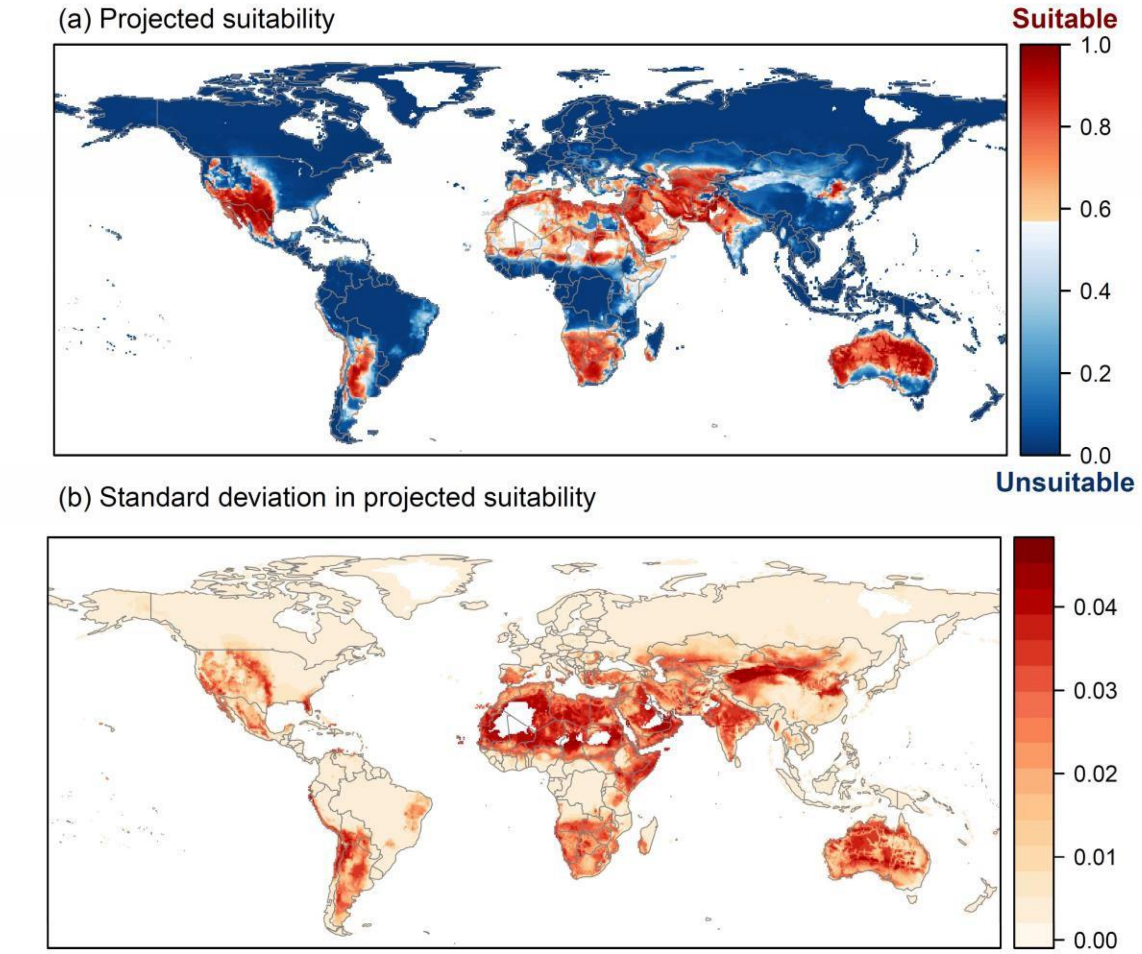


Figure 4. (a) Projected global suitability for *Ambrosia confertiflora* establishment in the current climate. For visualisation, the projection has been aggregated to a 0.5 x 0.5 degree resolution, by taking the maximum suitability of constituent higher resolution grid cells. Red shading indicates suitability. White areas have climatic conditions outside the range of the training data so were excluded from the projection. (b) Uncertainty in the suitability projections, expressed as the standard deviation of projections from different algorithms in the ensemble model.

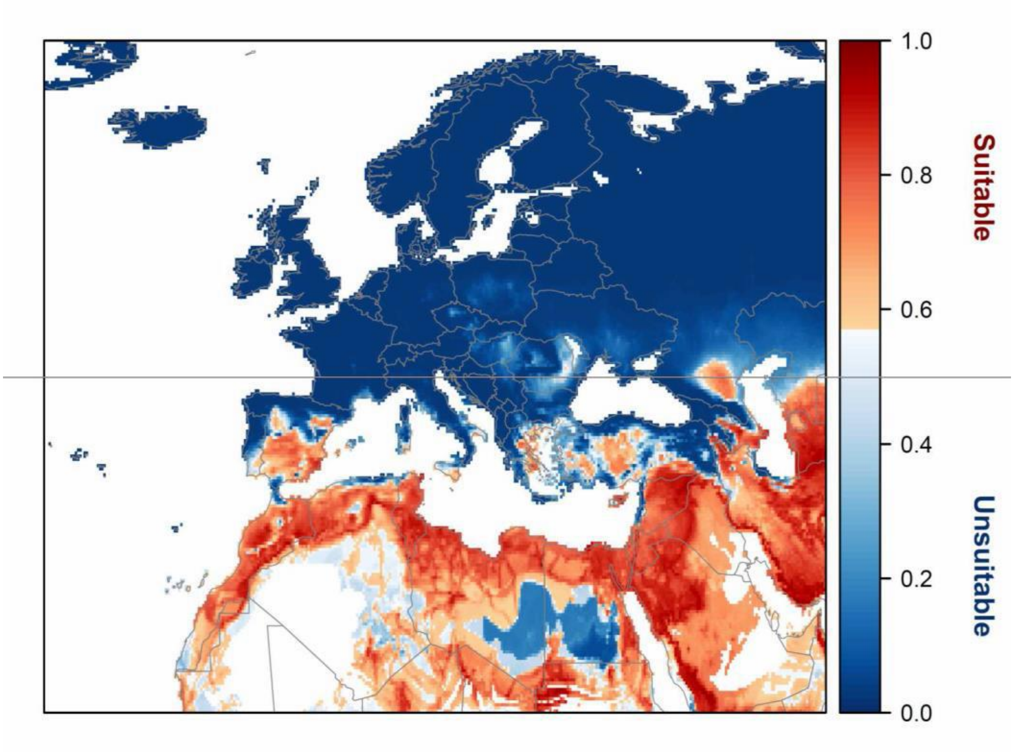


Figure 5. Projected current suitability for *Ambrosia confertiflora* establishment in Europe and the Mediterranean region. The white areas have climatic conditions outside the range of the training data so were excluded from the projection.

Figure 6. Limiting factor map for *Ambrosia confertiflora* establishment in Europe and the Mediterranean region in the current climate. Shading shows the predictor variable most strongly limiting projected suitability.

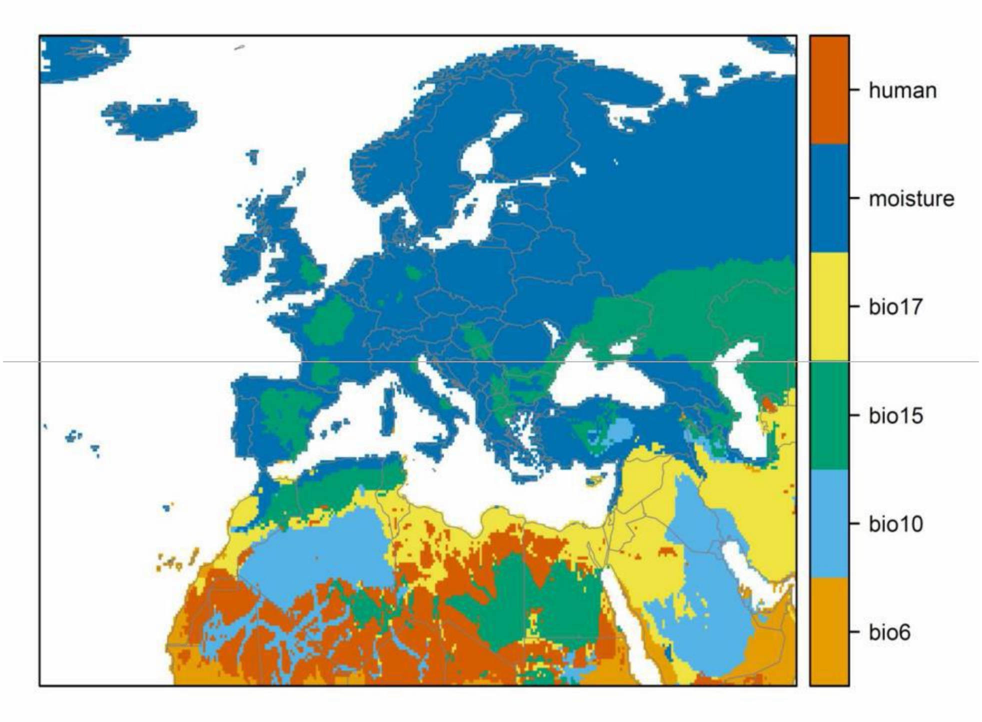


fIgure 6. Limiting factor map for *Ambrosia confertiflora* establishment in Europe and the Mediterranean region in the current climate. Shading shows the predictor variable most strongly limiting projected suitability.

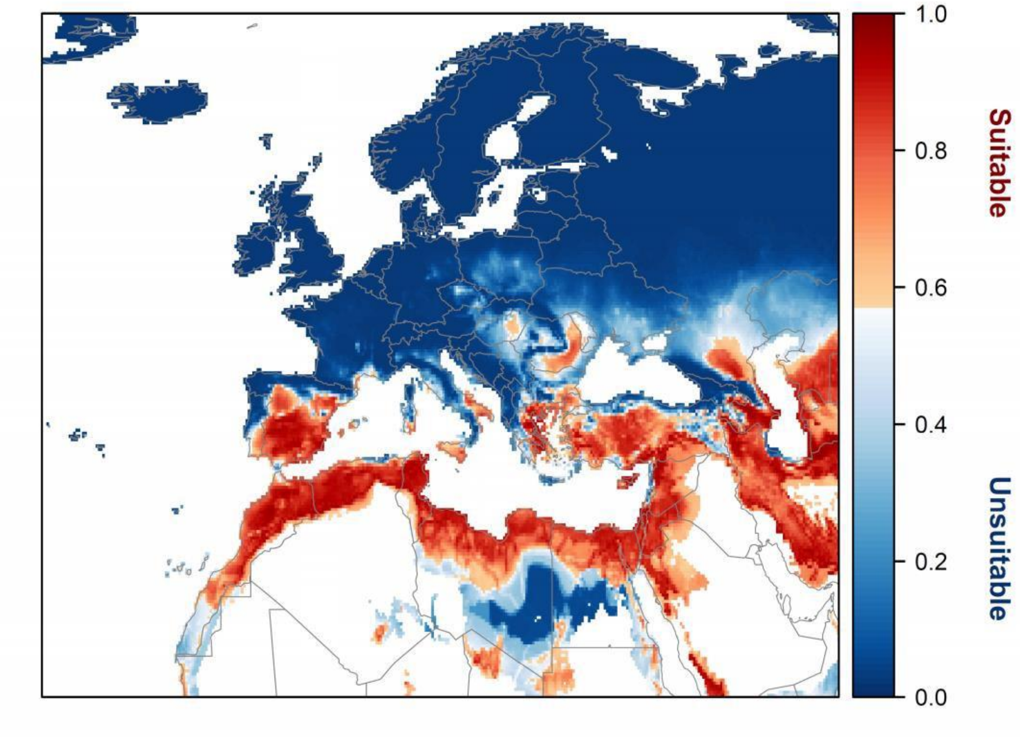


Figure 7. Projected suitability for *Ambrosia confertiflora* establishment in Europe and the Mediterranean region in the 2070s under climate change scenario RCP4.5, equivalent to Figure 5.

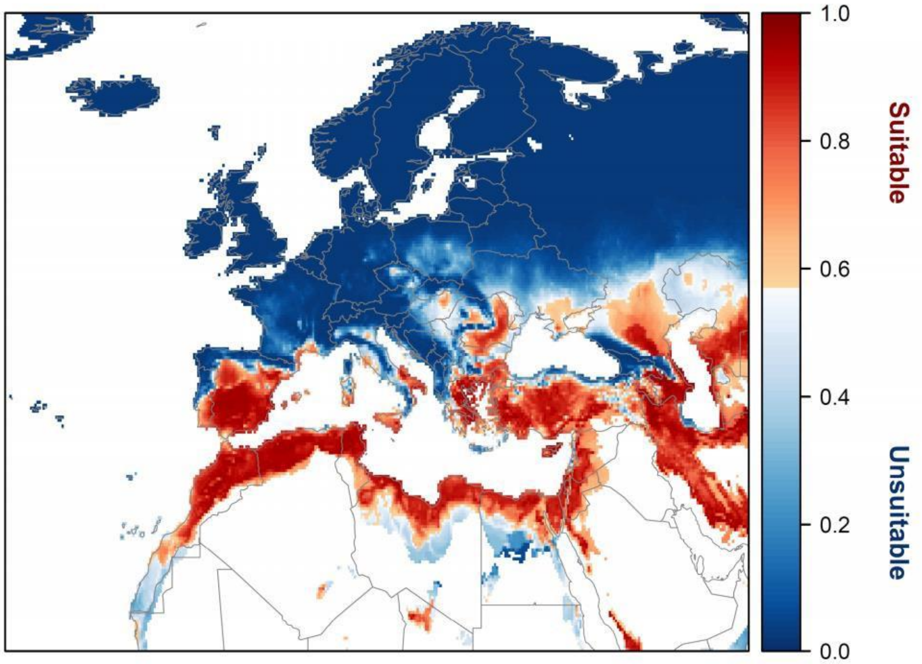
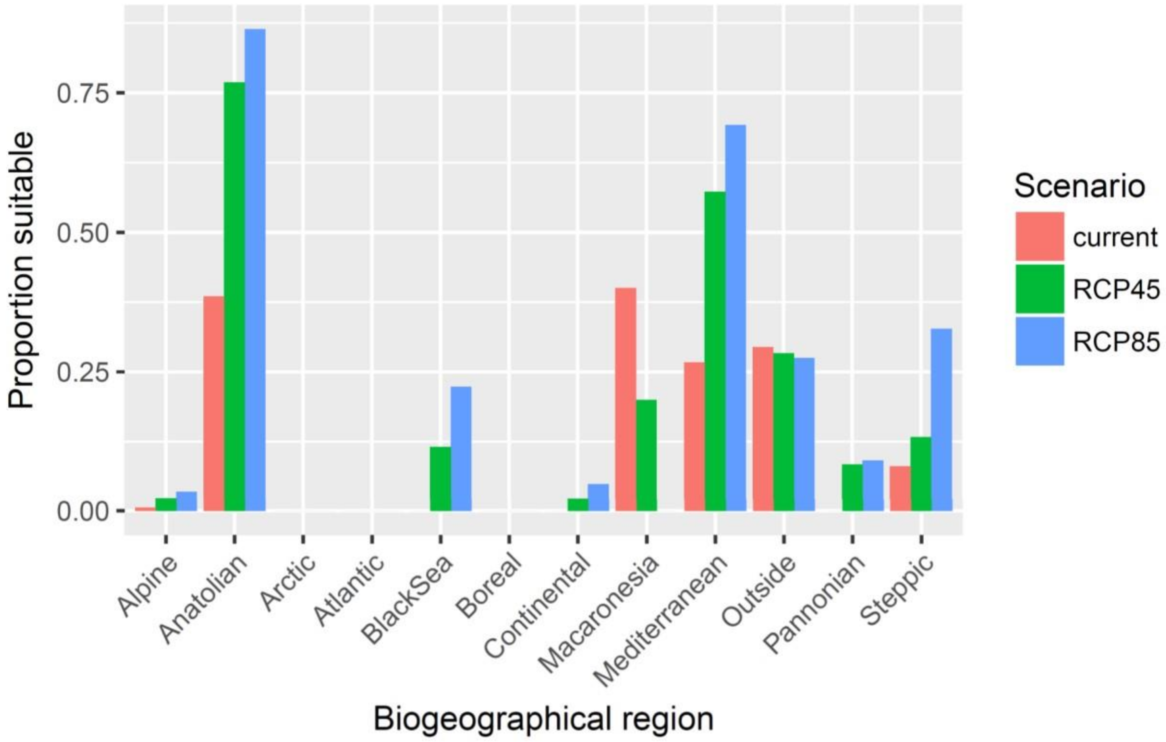


Figure 8. Projected suitability for *Ambrosia confertiflora* establishment in Europe and the Mediterranean region in the 2070s under climate change scenario RCP8.5, equivalent to Figure 5.



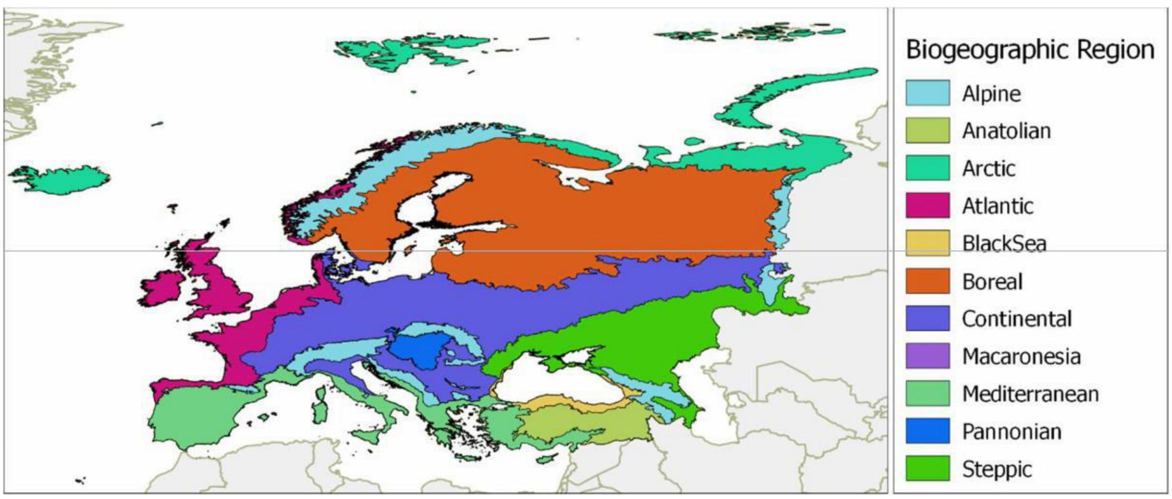


Figure 8. Variation in projected suitability among Biogeographical regions of Europe (Bundesamt fur Naturschutz (BfN), 2003). The bar plots show the proportion of grid cells in each region classified as suitable in the current climate and projected climate for the 2070s under emissions scenarios RCP4.5 and RCP8.5. The coverage of each region is shown in the map below.

Caveats to the modelling

Modelling the potential distributions of range-expanding species is always difficult and uncertain. Other variables potentially affecting the distribution of the species, such as edaphic variables, were not included in the model.

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.
- Additional data sources to GBIF were used, which may have been from regions without GBIF records.

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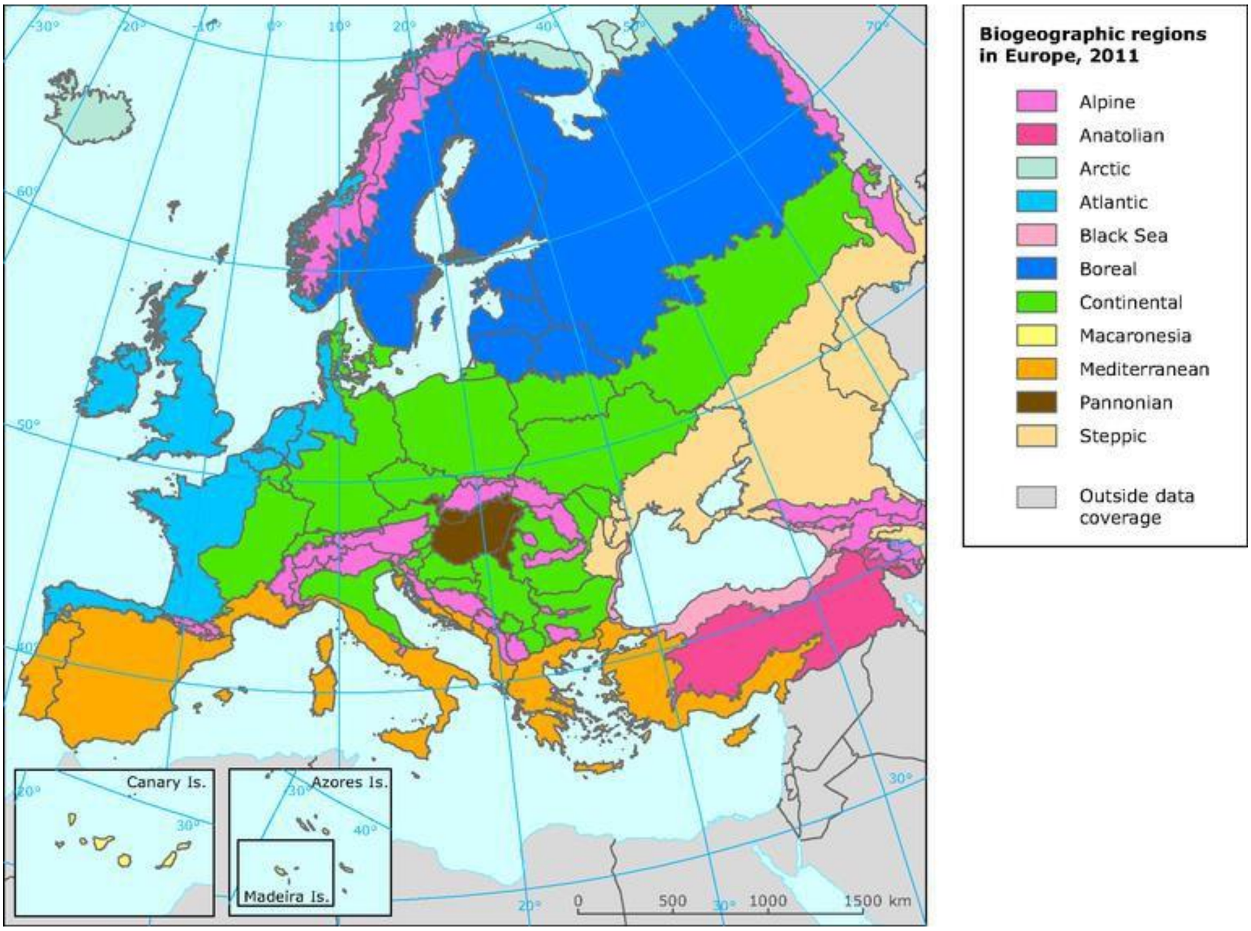
Appendix 2 Biogeographical regions



Appendix 3. Relevant illustrative pictures (for information)

Figure 1: Emerging plant of *Ambrosia confertiflora*.

Figure 2: Habitus of *Ambrosia confertiflora*.

Figure 3: Flowering *Ambrosia confertiflora*

Figure 4: Male (above) and female (below) flowers of *Ambrosia confertiflora.*

Figure 5: Infestation of a wadi bed in Israel.

Figure 6: Infestation of the bank of the Alexander River in Israel

Figure 7: Infestation of a roadside in Israel.

Figure 8: Infestation of arable land in Israel.

Appendix 4: Distribution summary for EU Member States and Biogeographical regions

Member States:

	Recorded	Established (currently)	Established (future)	Invasive (currently)
Austria	–	–	-	–
Belgium	–	–	-	–
Bulgaria	-	-	YES	–
Croatia	–	–	-	
Cyprus	–	–	YES	–
Czech Republic	-	–	-	–
Denmark	–	–	-	–
Estonia	–	–	-	–
Finland	–	–	-	–
France	-	-	YES	-
Germany	-	–	-	–
Greece	–	–	YES	–
Hungary	-	-	YES	-
Ireland	–	–	-	–
Italy	-	-	YES	-
Latvia	–	–	-	–
Lithuania	–	–	-	–
Luxembourg	–	–	-	–
Malta	–	–	-	–
Netherlands	–	–	-	–
Poland	-	–	-	–
Portugal	–	–	YES	-
Romania	-	–	YES	–
Slovakia	-	–	-	–
Slovenia	-	–	-	–
Spain	–	–	YES	–
Sweden	–	–	-	–
United Kingdom	–	–	-	–

Biogeographical regions

	Recorded	Established (currently)	Established (future)	Invasive (currently)
Alpine	–	–	-	–
Atlantic	–	-	-	–
Black Sea	–	–	-	–
Boreal	–	–	YES	–
Continental	–	–	-	–
Mediterranean	-	-	YES	-
Pannonian	-	-	YES	-
Steppic	-	–	-	-

Appendix 5

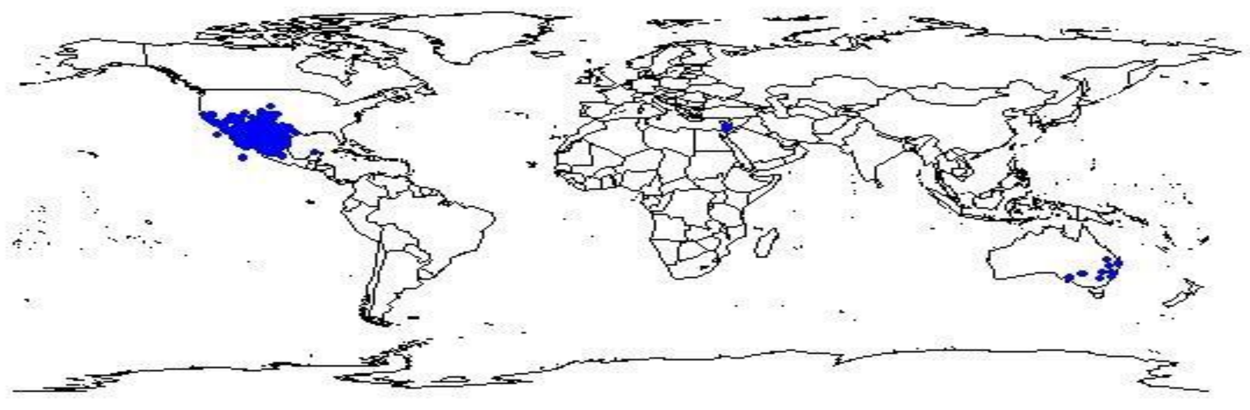


Figure 1. Distribution maps for world map

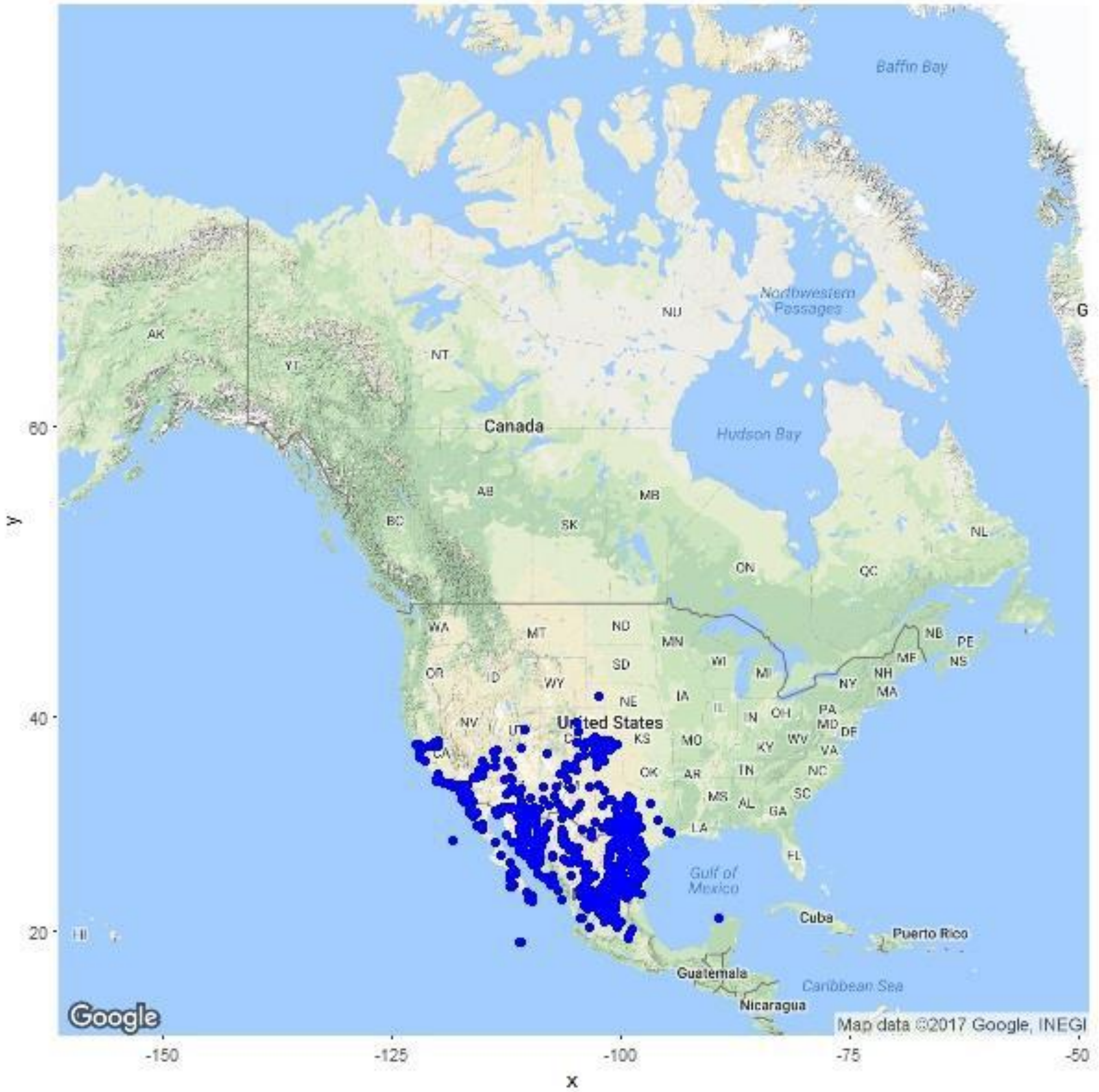


Figure 2. Distribution map of *Ambrosia confertiflora* occurrences in North America

Figure 3. Distribution map of *Ambrosia confertiflora* occurrences in Israel

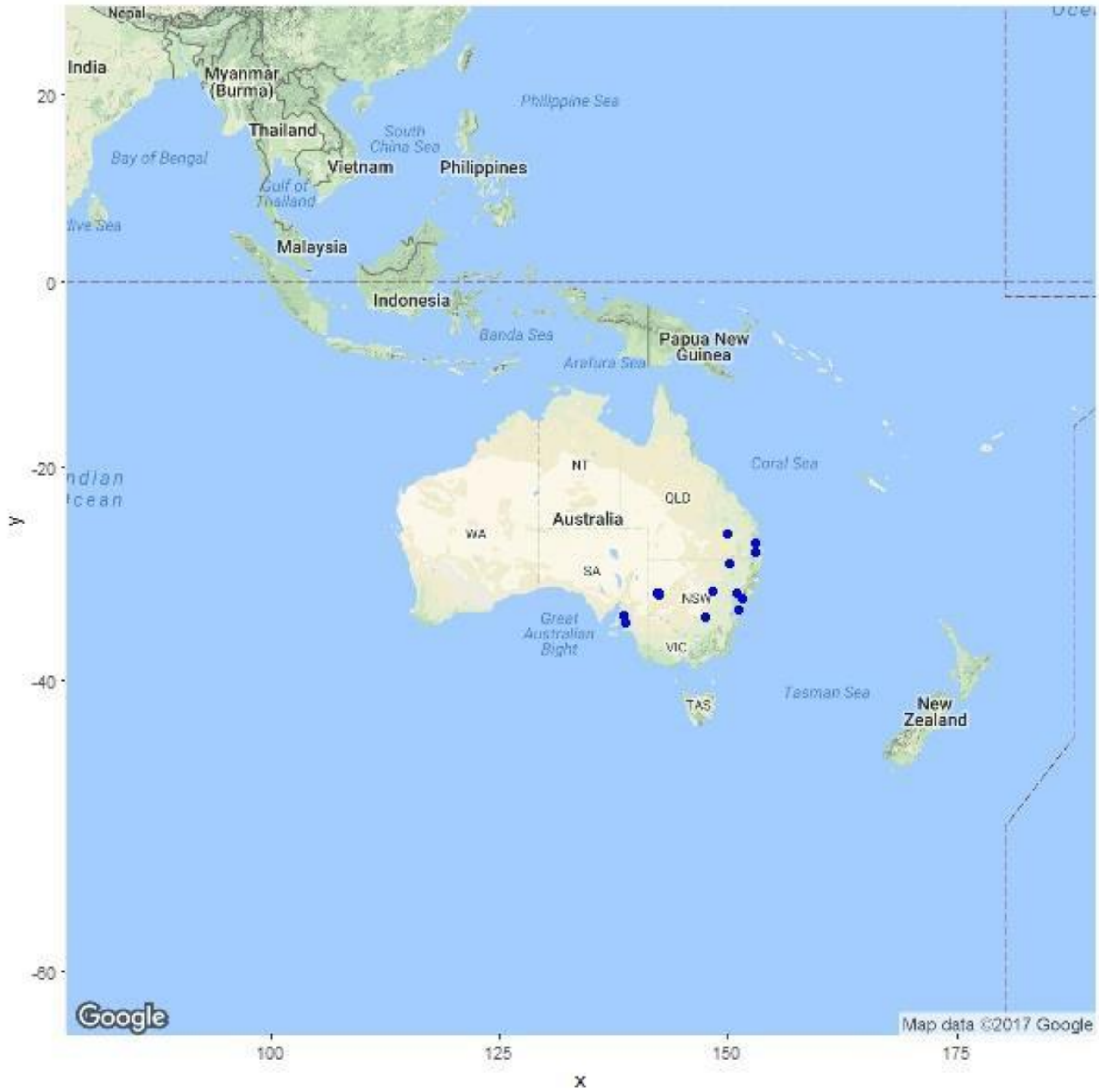


Figure 4. Distribution map of *Ambrosia confertiflora* occurrences in Australia