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ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES
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Pest Risk Analysis for
Baccharis halimifolia

September 2013

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This risk assessment follows the EPPO Standard PM 5/3(5) Decision-support scheme for quarantine pests (available at <http://archives.eppo.int/EPPOStandards/prah.htm>) and uses the terminology defined in ISPM 5 *Glossary of Phytosanitary Terms* (available at <https://www.ippc.int/index.php>).

This document was first elaborated by an Expert Working Group and then reviewed by the Panel on Invasive Alien Plants and if relevant other EPPO bodies. It was finally approved by the Council in September 2013.

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Male flowers of *B. halimifolia*.
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Female inflorescence of *B. halimifolia*.
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B. halimifolia fruiting along a river course in the Domaine de la Palissade in Camargue (FR). © Sarah Brunel, EPPO



Seeds of *B. halimifolia*.
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Pest Risk Analysis for *Baccharis halimifolia*

This PRA follows the EPPO Decision-support scheme for quarantine pests PM 5/3 (5). A preliminary draft was prepared by Mr Guillaume Fried (ANSES, FR). This document has been reviewed by an Expert Working Group that met in the Laboratoire de la santé des végétaux, Montpellier, France, on 2012-10-16/19.

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Invasion in the saltmarshes of the Domaine de la Palissade, Camargue (FR)
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Stage 1: Initiation

1.01 - Give the reason for performing the PRA

Identification of a single pest

Baccharis halimifolia causes major environmental damage in France, Italy and Spain, while its distribution in the EPPO region is still restricted to Belgium, France, Spain and the UK. This species has been identified as an invasive alien plant which represents a priority for Pest Risk Analysis according to the EPPO Prioritization process for invasive alien plants (EPPO, 2012a).

1.02a - Name of the pest

Baccharis halimifolia L.

1.02b - Indicate the type of the pest

Non parasitic plant

1.02d - Indicate the taxonomic position

Reign: Plantae; Family: Asteraceae; Genus: *Baccharis*; Species: *Baccharis halimifolia* L.
Nomenclatural synonym: *Baccharis cuneifolia* Moench [1794, Meth.: 574] [nom. illeg.]

1.03 - Clearly define the PRA area

EPPO Region (see map at www.eppo.int).

1.04 - Does a relevant earlier PRA exist?

No

A risk assessment has been prepared for Australia in 2003 (Randall, 2003) with the Weed Risk Assessment (WRA) tool (Pheloung *et al.*, 1999). A score of 19 has been obtained which led to rejection of the proposal to import this species. Based on their WRA scores, species are placed into the following categories: Accept (not likely to be a pest; WRA score < 1), Reject (likely to be a pest; WRA score > 6), or Evaluate (requires further evaluation; WRA score = 1-6).

However, this risk assessment is not entirely valid since it has been performed in another risk area outside the PRA area. In addition, the Australian Weed Risk Assessment is a pre-border assessment tool that follows a different scheme of assessing risk.

1.06 - Specify all or suitable habitats (for non-parasitic plants). Indicate the ones which are present in the PRA area.

Recorded habitats in its native range

In its native range, *B. halimifolia* has been recorded in the following plant communities (Van Deelen, 1991) according to the Kuchler classification (Kuchler, 1964):

- K078 Southern cordgrass prairie
- K080 Marl – everglades
- K090 Live oak - sea oats

Initiation

- K091 Cypress savanna
- K092 Everglades
- K105 Mangrove
- K112 Southern mixed forest
- K113 Southern floodplain forest
- K114 Pocosin
- K116 Subtropical pine forest

Ervin (2009) reports that in the USA, the species has spread outside its historic range, in association with human disturbance of natural habitats. It then colonized highways or power line rights-of-way, managed lands (largely pine plantations) and forest edges. Erwin (2009) suggests that climate may be the most influential variable in determining potential range expansion of *B. halimifolia*.

Recorded habitats in its exotic range

The following list summarizes the main habitats in which *B. halimifolia* is known to occur in the EPPO region according to the EUNIS habitat classification (See EEA Website):

- A2.5: Coastal saltmarshes and saline reedbeds
- B1.43: Mediterraneo-Atlantic fixed grey dunes
- B1.8: Moist and wet dune slacks
- B3.3: Rock cliffs, ledges and shores, with angiosperms
- C3.2: Water-fringing reedbeds and tall helophytes other than canes
- D5.2: Beds of large sedges normally without free-standing water
- E3.1: Mediterranean tall humid grassland
- E3.4: Moist or wet eutrophic and mesotrophic grassland
- F4.234: Northern [*Erica vagans*] heaths
- F9.3: Southern riparian galleries and thickets
- G1.13: Southern [*Alnus*] and [*Betula*] galleries
- J4.2: Road networks
- J4.3: Rail networks
- J4.5: Hard-surfaced areas of ports
- J4.6: Pavements and recreation areas
- J5: Highly artificial man-made waters and associated structures
- X03: Brackish coastal lagoons.

1.07 - Specify the pest distribution for a pest initiated PRA, or the distribution of the pests identified in 2b for pathway initiated PRA

Native distribution:

North America: Canada (Nova Scotia), Mexico (Mexico, Nuevo Leon, San Luis Potosi, Tamaulipas, Veracruz; Flora of North America Website), the USA (Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Louisiana, Maryland, Massachusetts, Mississippi, New Jersey, New York, North Carolina, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Texas, Virginia, West Virginia; Flora of North America Website).

Caribbean: Bahamas (Correl & Correl, 1982), Cuba (USDA-ARS Website; Weber, 2003).

Note: In Canada, *B. halimifolia* reaches its northern limit range and it is considered as an extremely rare Atlantic coastal plain species, occurring only in Tusket River estuary and its

vicinity. Official conservation programmes are being implemented in this area (Nova Scotia Website, Species at Risk Conservation Fund 2009 Approved Projects).

Exotic distribution:

Oceania: Australia (Queensland, New South-Wales), New-Zealand (South Island).

Note: in New Zealand, according to Webb *et al.* (1988), the species was recorded as locally established on Banks Peninsula (Canterbury) only: Evans Pass, Lyttelton, Victoria Park and Barrys Bay. There are approximately 40 known sites that are monitored and consist mostly of old scattered plants on the Porthills area near Sumner. The aim of the management actions where the species is present is eradication (Lynne Huggins, Department of Conservation, New Zealand, pers. comm., 2012). *B. halimifolia* has been declared an unwanted organism under the New Zealand Biosecurity Act 1993, which makes it illegal to knowingly release, spread, display or sell, breed, propagate or otherwise distribute plants or part thereof.

In Australia, the species is considered noxious and is regulated in Queensland and New South Wales (as well as in Northern Territory where it is not recorded as present) (Weeds Australia Database <http://www.weeds.org.au/noxious.htm>).

Asia: Georgia (in Abkhazia, on the eastern coast of the Black Sea) (Westman *et al.*, 1975; Kikodze *et al.*, 2010).

EPPO Region: Belgium (Verloove, 2008), France (Thellung, 1916; Muller, 2004), Italy (Zanetti, 1997; Arrigoni & Viegi, 2011), Spain (Allorge, 1941), and the UK (Clement & Foster, 1994).

Note: the species had been recorded in the Netherlands but is not known to be present anymore in this country (van Valkenburg *et al.*, 2013). The plant is also recorded as planted in the Atatürk arboretum in Istanbul, but has so far not been recorded in the wild (IOBM, 2012).

Detail of the distribution of *B. halimifolia* in EPPO countries:

In Belgium: *B. halimifolia* was intentionally introduced as a windbreak in coastal dunes during the first half of the 20th century (e.g., in Raversijde in 1924). It was then recorded as a casual escaped species in the port of Oostende in 1948 (Lambinon, 1957). In the past decades, it has been increasingly planted as an ornamental plant in public parks in coastal areas. It is now naturalized in numerous, widely scattered localities along the Belgian coast, mostly centered between Adinkerke and Oostduinkerke, around Blankenberge and between Zeebrugge and Knokke (Verloove, 2011).

In France: in its Flora *Les quatre flores de France*, Fournier (1936) indicated that *B. halimifolia* had been introduced in France in 1683. Lamarck (1817) indicated that the plant was cultivated in the Jardin du Roi in Paris where it has probably been cultivated since at least 1753 (AME & CBNMP, 2003). During the second half of the 19th century, it was widely recommended as an ornamental garden plant in numerous nursery catalogues and horticultural books. For example, Langlois (1877) states in his book *Le nouveau jardinier fleuriste* that *B. halimifolia* should be planted as a hedge. *B. halimifolia* probably naturalized from the very early twentieth century in the Basque Country in France. In the *addition and corrections* to the three volumes of his *Flore illustrée de la France*, Coste (1906) indicated that it was already completely naturalized in the Gironde and Basse-Pyrénées departments. At the same

time, Thellung (1916) collected *B. halimifolia* on the beach of Biarritz in 1907 and considered that the plant was naturalized. A few years later, it was also recorded as abundant in a pine forest along railways between Pornic and Paimboeuf in the South of Brittany (Anonymous, 1916). In the 1950s, it was already considered as spreading fast: Jovet (1947) describes the situation, stating that *B. halimifolia* 'is now very common in the South-West', especially abundant all around the Arcachon bassin (Gujan, between Andernos and Arès, around Pitchourlin). In some locations, for example in the Courant d'Huchet, *B. halimifolia* forms 'impenetrable thickets'. At the same time in Brittany, it was also invasive, for example in Carnac where it colonized *Juncus maritimus* marshes.

In the middle of the 1970s, it was considered as completely naturalized along the French Atlantic coast (Jovet & de Vilmorin, 1975) and occurred in nine departments: Ile-et-Vilaine, Côtes-d'Armor, Finistère, Morbihan, Loire-Atlantique, Vendée, Gironde, Landes and Pyrénées-Atlantiques.

During the 1980s, the first records of *B. halimifolia* were reported along the Mediterranean coast, in the Roussillon (Amigo, 1983). In the Camargue, an age estimation of individuals by counting growth rings dated colonization to the early 1980s (Charpentier *et al.*, 2006). *B. halimifolia* was recorded more recently along the Languedoc coast (Salabert & Gastesoleil, 1991).

Recently it also appeared on the shores of the North Sea in Pas-de-Calais (62) in the estuary of the Slack (Ambleteuse) and Wimereux (Benoît Toussaint, Conservatoire Botanique National de Bailleul, pers. comm., 2012).

In Italy: Its presence has been recorded in the Veneto region (Zanetti, 1997; Pizzo & Buffa, 2009; Minelli, 2009) and in the Tuscany region (Coaro, 1987; Arrigoni & Viegi, 2011), in both cases in coastal areas. According to Zanetti (1997) the species has been introduced in Veneto in the forest plantations along the coastal wetlands, especially in the delta area of the river Piave and river Po. Recently, the management plan of the site SIC ZPS IT3270023 – Delta del Po (Directive Habitat 92/43/EEC) has mentioned the need for eradication and control actions for some invasive alien plants, including *B. halimifolia*. In 2010, in the Veneto region its presence has been recorded as well inside the nature reserve (riserva naturale) Valle Averte, which is a Site of Community Interest (SIC IT3250030) according to Tomé (2010). In the Tuscany region, the taxon is considered invasive. Near Livorno, it is recorded as massively present in the vicinity of *Salicornia* spp. communities (Coaro, 1987).

In Spain: *B. halimifolia* was first reported in Spain in 1941 in Lekeitio in the Basque Country (Allorge, 1941). It is currently widely naturalized on the Atlantic Coast of the Basque Country and of Cantabria. It occurs in almost all estuaries of the Cantabric coast, from the rio of Tina Mayor at the border with Asturias east to Txingudi in Guipuzcoa. In Cantabria it was first recorded in 1958 (Guinea, 1953) in the bay of Santander (Herrera & Campos, 2010). In the Asturias, it was first recorded in 1998, in the marshes of Tina Mayor. A few locations with only some individuals or some scattered thickets are found at other points in Asturias (including Avilés, marshes of the rivers Sella and Navia, the ria of Villaviciosa) but it does not seem to have yet established in Galicia. It is also present to a lesser extent on the Mediterranean coast (country of Baix Ter, Catalonia, Barriocanal *et al.*, 2005).

In Spain, the species is considered as one of the top 20 most invasive species and it is as such listed in the Appendix 1 of the Spanish catalogue of alien plants (Grupo Especialista en Invasiones Biológicas, 2007). A 'Real Decreto' has been approved in November 2011 to regulate the species of this list, on which *B. halimifolia* is registered. The introduction, possession, trade and transport of the species listed is prohibited.

In the UK: there are two records. According to Clement & Foster (1994), it is established on the shore at Mudeford, South Hants (known since 1942) and also known from the shore at Hamworthy, Dorset, where Bowen (2000) in *The Flora of Dorset* says it was recorded as a self-sown plant in 1958.

A third record from Scotland is regarded as dubious by the New Atlas editors (Chris D Preston, Centre for Ecology and Hydrology, pers. comm., 2012).

In the Netherlands: A few individuals had been collected in 2003 in the nature reserve 'Kwade Hoek' (coordinates 51°50.689,3°59.387) and an herbarium sample had been deposited at the Nationaal Herbarium Nederland, Universiteit Leiden branch (L.) by R. van de Meijden. Mr van Valkenburg went in this nature reserve in September 2012 and could not detect *B. halimifolia*, as the vegetation had progressed towards shrubland dominated by *Hippophae rhamnoides* (Elaeagnaceae, native in the Netherlands) (Johan van Valkenburg, Plant Protection Service of the Netherlands, pers. comm., 2012; Van Valkenburg *et al.*, 2013 submitted).

See available distribution maps in Appendix 1.

Caño *et al.* (2012) provide a rough summary of the presence and spread of *B. halimifolia* in Europe in Figure 1. More precise historical data have been assembled in the framework of this PRA and are included in the text.

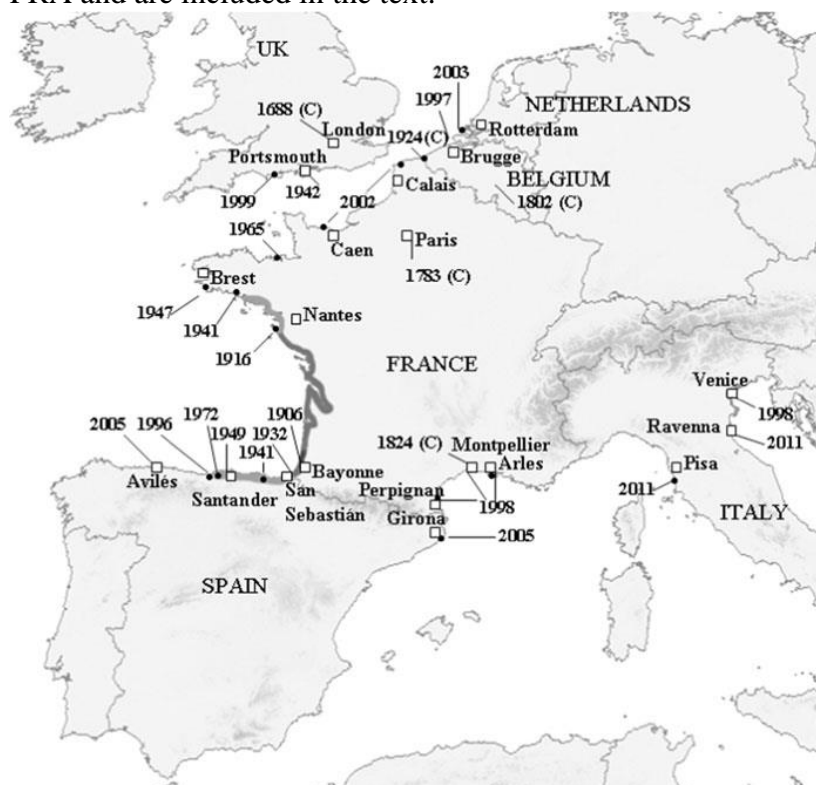


Figure 1: Distribution of *B. halimifolia* in Europe. Shaded area indicates the coastline area where *B. halimifolia* forms a continuum of stable populations across estuaries. First records of *B. halimifolia* cultivation in different countries are indicated by (C).

Stage 2: Pest Risk Assessment Section A: Pest categorization

1.08a - Do you want to go to the main Pest Risk Assessment or to continue with the pest categorization?

Yes, go to the main Pest Risk Assessment

There are about 350-450 species in the genus *Baccharis* which can clearly be distinguished from *B. halimifolia* (Sundberg & Bogler, 2006) based on the situation of its buds and flowers, and of its leaf blade; the organism therefore corresponds to a single taxonomic entity that can be differentiated from other species.

The species has a history of being an invasive alien plant.

In its native range *B. halimifolia* is considered as a weed due to 'infestations' on overgrazed rangeland in the Southern United States (Nesom, 2006).

In Australia, *B. halimifolia* is considered as a pest due to its low nutritional value for cattle and its ability to dominate pastures, tree plantations (timber species) and native *Melaleuca* wetlands (Westman *et al.*, 1975; Sims-Chilton & Panetta, 2011). In Queensland, *B. halimifolia* has been declared noxious since 1951 (Sims-Chilton *et al.*, 2010), as a class 2 pest under the *Land Protection (Pest and Stock Route Management) Act 2002*. In New South Wales, *B. halimifolia* is a class 3 pest. In both cases, this means that measures should be taken to control it (Sims-Chilton & Panetta, 2011).

In some countries where it is already established in the EPPO region (Belgium, France, Italy, Spain), *B. halimifolia* is also considered as an invasive alien plant with strong impacts on native vegetation (Invasive Alien Species in Belgium Website; Muller, 2004; Campos *et al.*, 2004; Grupo Especialista en Invasiones Biológicas, 2007).

Dense thickets of *B. halimifolia* can seriously affect species, habitats and ecosystems and their uses. There is a high risk of further spread of *B. halimifolia* in several coastal habitats in EPPO countries where it is already established, and there is a high risk of introduction where it is not already present and conditions (habitats, climate) are suitable.

Stage 2: Pest Risk Assessment Section B: Probability of entry of a pest

2.01a - Describe the relevant pathways and make a note of any obvious pathways that are impossible and record the reasons. Explain your judgement

History of introduction and use of *B. halimifolia*

The first record of *B. halimifolia* in the EPPO region dates back to 1683 in France, where it was introduced for ornamental reasons (Fournier, 1936). There are indications of its cultivation in several botanical gardens; e.g., in 1796 in Paris (Jardin des Plantes), in Montpellier in 1824 (AME & CBNMP, 2003), in Auteuil: *villa des Cyclamens* garden (Pardé, 1902).

From the second half of the 19th century it has also been grown in private gardens: specific indications could be found in the South-West of France (Guillaud, 1887), in Brittany: Carnac, Saint-Quay-Portrieux (Hibon, 1938). Thellung (1916) indicates that the plant is widely cultivated in Provence since its introduction in 1863. In Provence, it has been first introduced in 1863 at Villa Rotschild (Saint-Jean-Cap-Ferret) from Carolina (USA) (Sauvaigo, 1899). A few years later in 1889 it was also recorded in Antibes in *Villa Thuret* garden (Jeannel, 1890). During the 19th century, the cultivation of *B. halimifolia* as an ornamental plant was recommended in several horticultural books (Duhamel du Monceau, 1800; Dupuis & Hérincq, 1884). The plant was particularly used due to its tolerance to salinity, both in soil and in wind spray. It is also widely used as an ornamental plant on roadsides and roundabouts in coastal areas, and is also used on canal shores for stabilization, and more rarely for small game. In addition, the species is also reported to be used as a food supplement for its medicinal value as a cleanser favoring weight loss (Fédération des Conservatoires Botaniques Nationaux, undated).

In Spain, *B. halimifolia* was reported for the first time by Allorge (1941) in the Basque Country (from Lekeitio to Deba) in 1941 (Gobierno Vasco, 2011) and then in Santander by Guinea (1953), more than 100 km away. The Gobierno Vasco (2011) noted that although the species did not seem to be available in nurseries in the Basque Country. However, *B. halimifolia* was found in gardens in Asturias (González Costales, 2007).

In Spain, the species was not found in trade either, except for two internet websites. The species may then have been introduced locally through individuals, but no analyses of the introduction pathway of the species have been conducted. In addition, the species is suspected to have invaded some natural areas in the Spanish Basque Country by natural spread by wind from the French Basque Country (Estela Beteta, Gobierno Vasco, pers. comm., 2012). In the estuary of Txingudi (at the border between the French and Spanish Basque Country), Lozano Valencia & Alagón Cardoso (1995) report that the species has been planted to protect agricultural lands.

In Belgium, it was mentioned for the first time as introduced in 1924. It is thought to have been introduced intentionally in coastal dunes as a windbreak (Verloove, 2011). This plant is now recorded to be used in soil bioengineering systems to stabilize tidal shorelines because of its ability to root from a dormant, unrooted cutting (Invasive Species in Belgium Website).

In Australia, the plant was first introduced for ornamental purposes around 1900 in Queensland. By 1930 it was considered invasive, spreading to neighboring areas, and is now recorded in New South Wales (Sims-Chilton & Panetta, 2011).

Pathway: intentional import as an ornamental and amenity plant

'Ornamental' and 'amenity' are defined according to Lambdon *et al.* (2008):

- Ornamental species are cultivated on a small scale (especially in private gardens).
- Amenity species are cultivated on a large to moderate scale in public places for landscaping purposes (e.g., for soil stabilization or aesthetic enhancement).

Trade for ornamental purposes can occur both via the internet and by direct retail at nurseries. The plant is widely available in garden centres and nurseries in Europe, in France, Germany, the United Kingdom and Italy. The species is still sold in EPPO countries, and is already established in Belgium, France, Italy, Spain and the United Kingdom.

For amenity purposes, municipalities may produce the plants. Figures of production for such purposes are not available, but volumes are considered to be higher than for ornamental use.

Volume, frequency and distribution of imports

As *B. halimifolia* is in trade, the entry of the species is not time-limited as it is available all year long.

The plants may be mainly produced within the EPPO region rather than imported from elsewhere. No import of this species is noted in France, Germany, Italy and the Netherlands (EPPO, 2012b).

The volume of trade of *B. halimifolia* and the situation in Europe and in some EPPO countries is described below:

Europe

According to the PPP Index, 54 nurseries are reported as selling *B. halimifolia* in Europe. As not all nurseries in Europe are registered on the PPP Index, this figure is a possible underestimate of the degree to which the species is in trade.

France

B. halimifolia is easily available in numerous nurseries and garden centers, usually as young plants. The following websites proposing *B. halimifolia* for sale have been identified (links consulted in October 2012); this list is not exhaustive:

- *Plantes & Jardins* garden centers (nurseries spread throughout France): http://www.plantes-et-jardins.com/catalogue/catalogue4.asp?id_variations=5076

- *Jardiland* garden centers (nurseries spread throughout France):

<http://www.jardiland.com/vente-en-ligne/pepiniere/4063-baccharis-halimifolia.html>

- Planfor (nursery situated in the Landes Department): <http://www.planfor.fr/achat,senecon-en-arbre,9017,FR>

- Lepage nursery in Brittany: http://www.pepiniere-bretagne.fr/plantes_arbustes.php?Num_lepage=158 available for 7€

- Pépinière de Chambly (Oise Department):

<http://www.florum.fr/Baccharis-halimifolia/1664/pepdeChambly/information-produit-professionnel.html>

- Lumen Plantes Vivaces (Dordogne Department):

<http://apps.rhs.org.uk/rhsplantfinder/nurseryfinder2.asp?id=1951&d1=10&so=pf&mo=N>

- Brochet-Lanvin Nursery (Marne Department), the website warns about the fact the species may be invasive in some regions:

http://www.pepiniere-brochetlanvin.com/brochetlanvin/1007/boutique/3709/baccharis_halimifolia.htm

Some professionals are aware of the damage caused by *B. halimifolia* and have decided to remove this species from their catalogue, as for example:

- Jardin du Pic Vert (Somme Department) :

http://www.jardindupicvert.com/4daction/w_partner/sene_arbre_haris_halimifolia.4465

- Pépinière Olivier Filippi (Hérault Department): www.jardin-sec.com

Warnings about its invasive behaviour are also given on some gardening websites:

- Jardipedia website: http://www.jardipedia.com/fiche_Baccharis-halimifolia-8198.htm

- Les arbres: <http://www.lesarbres.fr/baccharis.html>

A cultivar obtained by C. Chambolle (F): *Baccharis halimifolia* 'Baccador' cov is also available in the Minier nursery (Maine-et-Loire Department):

<http://www.pepinieres-minier.fr/fichePlante.php?codePlante=13415&route=pepiniere-RetDbis-research>

It is a male clone assumed to be non-invasive.

Germany

The PPP Index lists three retailers in Germany selling the plant.

Italy

Retailers selling *B. halimifolia* could be found in Italy as well:

- Vivai Ferrari (Emilia-Romagna Region): <http://www.vivaiferrari.it/b.html>

- Garden Bedetti Cantu (Lombardia Region):

<http://www.gardenbedetti.com/02.02s.php?luce=67&ref=15&rco=&rin=1&id=2361>

- Florveneto (Veneto Region):

http://www.florveneto.it/pubblico_08/enciclopedia.asp?nome=B&cerca_qua=yzxcv

- Curtolo (Veneto Region): http://www.curtolo.it/mondo_part2003.asp?ID=700

- Vivai Nord (Lombardia Region) : <http://www.vivainord.it/ita/prodotti/arbusti/b.html>

- Vivai Mimosa (Calabria Region) : <http://www.vivaiomimosa.com/catg4b.htm>

- Agriservice Sardegna (Sardegna Region) : www.agriverservicesardegna.it/

Spain

Two French websites selling *B. halimifolia* in Spain could be found:

- Planfor (nursery situated in the Landes Department in France, selling in Spain as well):

http://www.planfor.es/compra_chilca_9017_ES

- Vilmorin (nursery situated in the Maine-et-Loire Department in France, selling in Spain as well): <http://www.vilmorin-semillas-de-arboles.com/semillas/arbustos/entry-13188-baccharis-halimifolia.html>

The United Kingdom

The Royal Horticultural Society reports the following retailers:

- one in Scotland: Linn Botanic Gardens, Helensburgh, Dunbartonshire.

- one in South-West UK: Burncoose Nurseries, Redruth, Cornwall.

- one in Southern UK: East Northdown Farm Nursery, Marget, Kent.

Source: <http://apps.rhs.org.uk/rhsplantfinder/pfregions.asp?ID=1951>

The volume, frequency and distribution of the species in the EPPO region are considered to be sufficient for the species to enter new areas within the region. The uncertainty is low.

Transfer from the pathway to a suitable habitat

Probability of entry

Given its tolerance to salt spray, *B. halimifolia* is deliberately planted in coastal regions in gardens, but also on roundabouts or along roads, along pathways close to shorelines, in places situated nearby the habitats at risk (coastal wetlands of the backshore). From these plantations, the species may spread to semi-natural and natural habitats (i.e. unintended habitats), first along roadsides or disturbed grasslands, then into coastal wetlands (Le Moigne & Magnanon, 2009). The numerous seeds produced, as many as 10 000 to 1 500 000 per plant (Westman *et al.*, 1975; Panetta, 1979a, b, c) are easily dispersed by wind (achenes with pappus) up to hundreds of metres, which facilitates the establishment in unintended habitats (e.g. coastal saltmarshes, cliffs, wetlands, wet grasslands).

In the EPPO region, the probability that *B. halimifolia* would transfer from the pathway to a suitable habitat is variable depending on the proximity of suitable habitats to areas where *B. halimifolia* is planted, but is considered to be high overall, with a low level of uncertainty.

Other pathways which are not considered

Natural spread through seeds being wind dispersed is a possible pathway, and is expected to have occurred between France and Spain. Though, this pathway is considered to be minor in comparison with intentional import of the plant as an ornamental and amenity plant and is therefore not considered further in this analysis.

Unintentional entry of the plant through contaminated vehicles or contaminated soil movements are also relevant pathways. Though, these pathways are also considered to be minor in comparison with intentional import of the plant as an ornamental and amenity plant.

The probability of entry through intentional import as an ornamental and amenity plant is very likely, as the species already entered the EPPO region, and continues to enter. Uncertainty is low

Stage 2: Pest Risk Assessment Section B: Probability of establishment

In a first step, assessors should select the ecological factors that influence the potential for establishment.

Seven factors may influence the limits to the area of potential establishment and the suitability for establishment within this area:

- 1 - Suitable habitats
- 2 - Alternate hosts and other essential species
- 3 - Climatic suitability
- 4 - Other abiotic factors
- 5 - Competition and natural enemies
- 6 - The managed environment
- 7 - Protected cultivation

No.	Factor	Is the factor likely to have an influence on the limits to the area of potential establishment?	Is the factor likely to have an influence on the suitability of the area of potential establishment?	Justification
1	Suitable habitats (see note for Q3.01)	Yes (see 3.01)	Yes (see 3.09)	
2	Alternate hosts and other essential species	No	No	Female flowers of <i>B. halimifolia</i> are wind-pollinated (Krischik & Denno, 1990a; Sims-Chilton & Panetta, 2011), so no other species is needed to complete the life cycle of the plant. The flowers can also be pollinated by generalist pollinators such as bees, but such species are not necessary for the production of seeds. Achenes are attached to a pappus and are therefore readily dispersed by wind and also by water (Sims-Chilton & Panetta, 2011), and no other species is necessary for seed dispersal. In addition, there is no report of mycorrhiza association.
3	Climatic suitability	Yes (see 3.03)	Yes (see 3.11)	
4	Other abiotic factors	No	Yes (see 3.12)	<i>B. halimifolia</i> can be found on a wide range of soil textures and pH (Westman <i>et al.</i> , 1975), although it preferentially grows on moist soils with high organic content, temporarily covered by brackish

Probability of establishment

				<p>water with maximum 33 g/L (Young <i>et al.</i>, 1994; Sims-Chilton & Panetta, 2011; Caño <i>et al.</i>, 2009).</p> <p>Therefore, abiotic conditions other than climate are likely to have an influence on the suitability of the local area for establishment (e.g., establishment would not be possible if salt content would exceed 33g/L) but are unlikely to influence the limits to the area of establishment, as highly favourable conditions can be found in the whole PRA area, this includes the modification by human activities.</p>
5	Competition and natural enemies	No	Yes (see 3.13)	<p>Native plants can have a significant influence on the suitability of the habitat for the establishment of <i>B. halimifolia</i>. Nevertheless, <i>B. halimifolia</i> has already developed dense populations in the EPPO region, e.g. in France (Muller, 2004; Fried, 2012) and Spain (Herrera & Campo, 2010) on the Atlantic coast, despite competition with native plants and presence of natural enemies.</p> <p>Dauphin & Matile-Ferrero (2003) reported that a few species had been found feeding on <i>B. halimifolia</i> in France, but there is no evidence that these species may influence the suitability of the area of potential establishment.</p>
6	The managed environment	Yes (see 3.06)	Yes (see 3.14 / 3.15)	
7	Protected cultivation	No	No	Not relevant for an invasive alien plant.

Host plants and suitable habitats

3.01 - Identify and describe the area where the suitable habitats are present in the PRA area outside protected cultivation.

B. halimifolia can be found in several coastal habitats including salt marshes, coastal swamps, coastal forests, tidal rivers, sandy places (Weber, 2003). It can also colonize disturbed habitats even in places far from the coast. Details are provided for North America (native range), Australia (exotic range) and Europe (exotic range).

North America

In its native range, according to Sundberg & Bogler (2006), *B. halimifolia* occurs in open sandy places, wet fields, marshes, beaches, disturbed sites, roadsides, old fields, from 0 to 100 metres above sea level. It is considered as a common species in upland fringes of coastal saline marshes and back dune habitats (Cronquist, 1980). It is also capable of establishing in disturbed habitats such as fallow fields and hedgerows, as well as inland saline soils (Krischik & Denno 1990b), especially in areas outside its native range, where it is currently expanding (Ervin, 2009).

Associated species: *B. halimifolia* is abundant in swamps dominated by *Melaleuca leucadendron* and along sandy shorelines consisting of *Casuarina equisetifolia* (Westman *et al.*, 1975). It is commonly associated with *Iva frutescens* (McCaffrey & Dueser 1990, Tolliver *et al.*, 1997) and *Myrica cerifera* (McCaffrey & Dueser 1990, Tolliver *et al.*, 1997, Wang *et al.*, 2006), both perennial shrubs that are found along the east coast of North America. In a vegetation survey in the Kissimmee River floodplain (south-central Florida), *B. halimifolia* was found to dominate the community along with *Paspalum notatum*, *Rubus cuneifolius*, *Myrica cerifera* and *Thelypteris interrupta* (Toth, 2005).

Australia

It is found in similar habitats in its introduced range. In Australia, *B. halimifolia* established within a wide variety of plant communities, from dry *Eucalyptus* forests to native tea-tree (*Melaleuca quinquenervia*) swamps (Westman *et al.*, 1975). It is particularly suited to moist gullies, salt marsh areas and wetlands. It also does well on high, cleared slopes (Anonymous, 2007a).

As in its native range, *B. halimifolia* is also found in disturbed habitats, including cleared unused land, cleared slopes (Anonymous, 2007a), tropical pastures (Westman *et al.*, 1975) or exotic pine plantations, e.g. *Pinus elliottii* (Panetta, 1979a, b). Westman *et al.* (1975) observed that irrigation channels and coastal canals provide favourable man-made habitats for the species.

The most common native plant neighbours include *Imperata cylindrica*, *Themeda australis*, *Paspalum dilatatum* (alien), *Pteridium esculentum*, *Tristania conferta*, *Melaleuca quinquenervia* and *Eucalyptus intermedia* (Sims-Chilton & Panetta, 2011). In subtropical pastures it is found together with alien species such as *Setaria sphacelata*, *Melinis minutiflora*, *Phaseolus atropurpureus*, *Desmodium intortum* and *Glycine javanica* (Panetta, 1977).

Europe

On the Atlantic coast of Europe, *B. halimifolia* is known to escape from cultivation (private gardens, hedges, roundabouts and central reservations of road) and to establish first in artificial habitats: along roadsides [J4.2 according to EUNIS habitat classification, EEA, Undated], along canals and irrigation channels [J5], in agricultural, industrial or on old saltworks wastelands (Le Moigne & Magnanon, 2009), in hard-surfaced areas of ports [J4.5] and in pavements and recreation areas [J4.6] from which it can invade coastal wetlands [A2.5, B1.8], tall humid grasslands [E3.1] and open woodlands (Muller, 2004; Le Moigne et Magnanon, 2009). Although preferentially in wetlands, it is also found in drier habitats such as heathlands with *Ulex europaeus* or in the upper beach area (Anonymous, 2007b).

In the Basque Country (France and Spain), in association to subhalophilous saltmarshes (Campos *et al.*, 2004), it also invades coastal cliffs: in halochasmophytic communities of *Crithmo–Armerion* or in aerohaline heathlands with *Dactylido–Ulicion* communities [B3.3 according to the EUNIS habitat classification]. As in Mediterranean areas, the species is

found in saltmarshes with *Juncus maritimus* and *Juncus acutus* [A2.522], water-fringing reedbeds with *Phragmites australis* [C3.2], and Tamarisk thickets [F9.3]. It is also found in communities of *Elymus pycnanthus* (A2.514) and humid prairies of *Calthion palustris* [E3.41] (Herrera *et al.*, 2010), as well as in marshes with *Cladium mariscus* (Zendoia *et al.*, 2006). *B. halimifolia* is also reported to establish in woodland estuarine communities such as *Alnus glutinosa* [G1.131], and can colonize sparsely the halophilous communities of the lower marsh zone dominated by *Sarcocornia fruticosa* [X03] (Caño *et al.*, 2012). In France as well (e.g. in the Domaine de la Palissade), some individuals of *B. halimifolia* are growing in *Sarcocornia* communities, although these are the less invaded communities due to higher salt concentration.

In Mediterranean France, it grows mainly along roadsides [J4.2 according to EUNIS habitat In the Mediterranean areas (Camargue and littoral area of Languedoc-Roussillon region), it colonizes especially Mediterranean saltmarshes with *Juncus maritimus* and *Juncus acutus* [A2.522], water-fringing reedbeds with *Phragmites australis* [C3.2], Tamarisk thickets [F9.3] (Guillaume Fried, Anses, pers. obs., 2012) and marshes with *Cladium mariscus* and *Schoenus nigricans* [D5.2]. In the Crau, the species is particularly invasive at the junction of marshes with *Cladium mariscus* and Mediterranean tall humid grassland of the *Molinio-Holoschoenion* [E3.1] (Marc Thibault, Tour du Valat, pers. comm., 2012). It is also reported in Mediterraneo-Atlantic fixed grey dunes [B1.43]. A study conducted in coastal saltmarshes of Camargue and Pyrénées-Orientales (Fried *et al.*, 2013) showed that the most common species associated with *B. halimifolia* were *Juncus maritimus*, *Phragmites australis*, *Elytrigia elongata* subsp. *scirpea*, *Althaea officinalis*, *Sonchus maritimus* subsp. *maritimus* and *Juncus acutus*. Caño *et al.* (2012) also report that communities dominated with *Elytrigia aetherica* are affected.

In the Crau, the species is particularly invasive at the junction of marshes with *Cladium mariscus* and Mediterranean tall humid grassland of the *Molinio-Holoschoenion* (Marc Thibault, Tour du Valat, pers. comm., 2012).

As in France and Spain, in Belgium *B. halimifolia* grows in a wide range of coastal habitats, including the upper fringes of irregularly flooded tidal fresh and brackish marshes, dunes and open woods (Rappé *et al.*, 2004). In Belgium, *B. halimifolia* colonizes man-made as well as natural habitats: cracks in pavement, quays and walls, sea dunes and beaches, saltmarshes and open woods (Verloove, 2011; Rappé *et al.*, 2004).

The species occurs in an endangered Natura 2000 habitat: Atlantic salt meadows (*Glaucopuccinellietalia maritimae*) [A2.5] (Invasive Alien Species in Belgium Website). It is also recorded in *Erica vagans* heaths (Estela Beteta, Gobierno Vasco, pers. comm., 2012).

The following list summarizes the main habitats in which *B. halimifolia* is known in the EPPO region according to the EUNIS habitats classification:

- A2.5: Coastal saltmarshes and saline reedbeds
- B1.43: Mediterraneo-Atlantic fixed grey dunes
- B1.8: Moist and wet dune slacks
- B3.3: Rock cliffs, ledges and shores, with angiosperms
- C3.2: Water-fringing reedbeds and tall helophytes other than canes
- D5.2: Beds of large sedges normally without free-standing water
- E3.1: Mediterranean tall humid grassland
- E3.4: Moist or wet eutrophic and mesotrophic grassland
- F4.234: Northern [*Erica vagans*] heaths

- F9.3: Southern riparian galleries and thickets
- G1.13: Southern [*Alnus*] and [*Betula*] galleries
- J4.2: Road networks
- J4.3: Rail networks
- J4.5 : Hard-surfaced areas of ports
- J4.6 : Pavements and recreation areas
- J5: Highly artificial man-made waters and associated structures
- X03: Brackish coastal lagoons.

Caño *et al.* (2012) indicate that the habitats most often replaced by monospecific stands of *B. halimifolia* are wet meadows and *Juncus maritimus* communities, as shown on Figure 2:

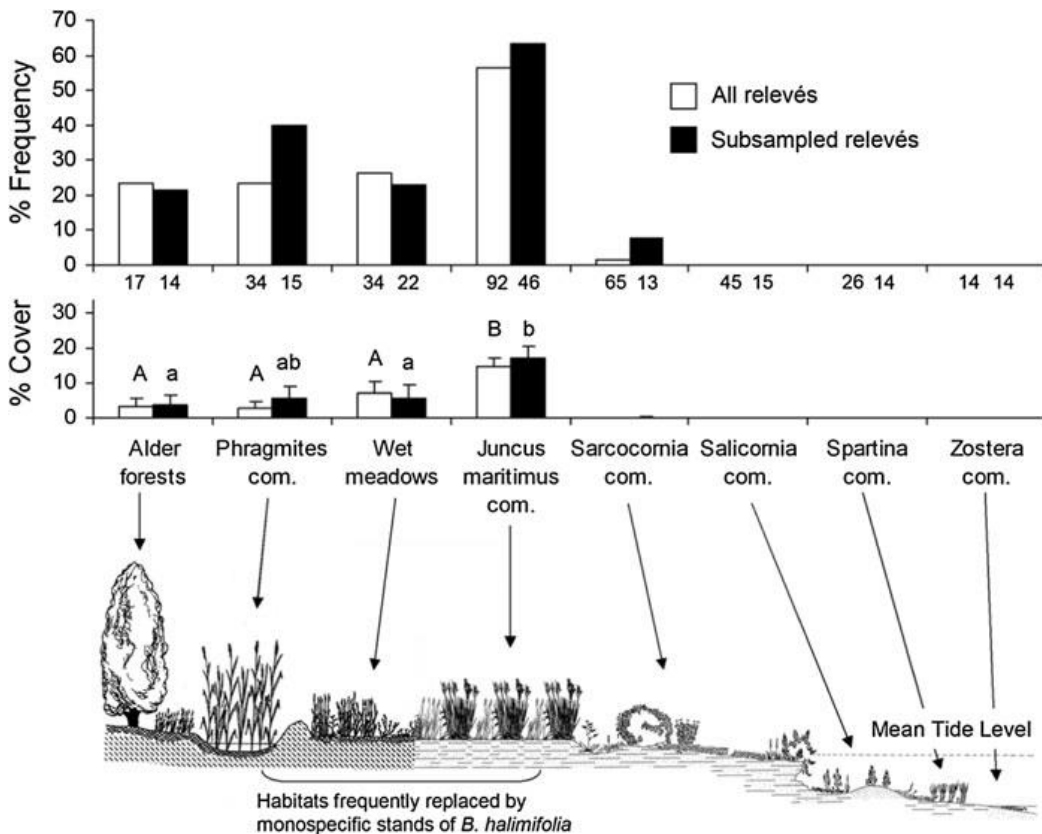


Figure 2 from Caño *et al.* (2012): Frequency of presence and mean cover (\pm SE) of *B. halimifolia* in estuarine communities in Northern Spain based on 327 floristic relevés (white bars) and on 153 relevés after stratified subsampling by 191 km grid (black bars). Numbers below bars indicate the total number of relevés per community type used to calculate the frequency and cover of *B. halimifolia*. Different letters above bars represent significant differences among habitats according to nonparametric mean comparisons. Upper-case indicates differences when considering all the relevés and lower-case when considering the subsampled relevés.

The suitable habitats for *B. halimifolia* are distributed along the coasts of European and Mediterranean countries, and estuaries are particularly suitable (e.g. in France in the Rhône, Gironde and Loire Estuaries, in Spain in Galicia, in Italy, etc.).

Moreover, anthropogenic habitats (e.g. road networks, rail networks and wasteland) suitable for the establishment of the species are widespread and distributed all over the EPPO region.

Alternate hosts and other essential species

/

Climatic suitability

3.03 - Does all the area identified as being suitable for establishment in previous question(s) have a suitable climate for establishment?

No.

B. halimifolia has already established in several EPPO countries (especially in France and in Spain, but also in Belgium, in the United Kingdom and in Italy) and it is particularly widespread on the Atlantic Coast from northern Spain to south Brittany in France (See 1.07 for detailed references).

According to the World Map of Köppen-Geiger Climate Classification (Kottek *et al.*, 2006), *B. halimifolia* occurs mainly in Cfa climate type (warm temperate climate, fully humid with hot summer) as well as in Aw climate type (equatorial, winter dry) in Florida. In Australia, it also occurs in both Cfa and Cfb climate types (Oceanic climate).

The largest part of the EPPO region is under Cfb, Csa (Hot-summer Mediterranean climate) and Csb (Warm-summer Mediterranean climate) climate types, and are therefore suitable for the establishment of *B. halimifolia*.

Sims-Chilton *et al.* (2010) elaborated a CLIMEX climatic projection for *B. halimifolia* for the world. This is presented in Appendix 2.

According to the CLIMEX map, where conditions are assumed suitable (i.e., EI>20) and according to the proportion of Cfa and Cfb climate types in the PRA area, the EWG considered that the climatic conditions over the whole EPPO region are moderately similar with overall similarities between 25 and 75%.

Other abiotic factors

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Competition and natural enemies

/

The managed environment

3.06 - Is all the area identified as being suitable for establishment in previous questions likely to remain unchanged despite the management of the environment?

No.

B. halimifolia has a number of biological characteristics adapted to pioneer stages in succession (Westman *et al.*, 1975). It is able to invade open microsites in habitats where native vegetation has been periodically disturbed by fire, flooding or animal activities (Panetta, 1977).

The management of roadsides (e.g., mowing) or any soil disturbances altering the native vegetation cover and creating bare soil will favour *B. halimifolia* in infested areas because of the promotion of seed germination upon exposure to light (Westman *et al.*, 1975; Anonymous, 2007a).

Management will therefore rather increase the suitable area of *B. halimifolia*. As an example, in its native range, the current range expansion of *B. halimifolia*, from its original distribution restricted to coastal areas to the inner lands, occurs along disturbed habitats: highways, power line right-of-way, pine plantations, etc. (Ervin, 2009).

Protected Cultivation

/

3.08 - By combining the cumulative responses to previous questions with the response to question 3.07, identify the part of the PRA area where the presence of host plants or suitable habitats and other factors favour the establishment of the pest.

The EWG considered that the suitable areas follow a gradient for temperature and moisture, going from Northern Spain and South-Western France being the most suitable areas, and northern Europe and the Mediterranean being less suitable.

According to both climatic requirements and habitat preferences, the following coastal areas would be most at risk from the plant:

- the **Atlantic coast**, from north of Morocco to Scotland (including France, Ireland, Portugal, Spain, the United Kingdom);
- the **Mediterranean Basin** (the Southern Mediterranean coast may be too dry for the species to thrive) ;
- the eastern part of the **Black Sea**.

Uncertainty remains on the ability of the species to thrive under colder and arid climates, and the following areas are considered to be less suitable:

- the **North Sea coast** (including Belgium, the Netherlands, Germany) ;
- from Denmark to Poland, and in the south of Sweden on the **Baltic Sea coast**.
- **arid areas**.

The climate would also make *B. halimifolia* able to establish in subcoastal land; however it would be restricted to disturbed habitats and it would have less environmental impact than on coastal habitats.

Host plants and suitable habitats

3.09 - How likely is the distribution of suitable habitats in the area of potential establishment to favour establishment?

Likely

Level of uncertainty: medium

Natural and semi natural habitats colonized by *B. halimifolia* such as saltmarshes and coastal dunes (see answer 3.07 for details) are very suitable for the species. These habitats are restricted to the coastal areas.

Moreover, anthropogenic habitats are widespread across the area suitable for the establishment of the species. These habitats remain less suitable than coastal ones.

Overall, the distribution of suitable habitats is likely to favor the establishment of *B. halimifolia* in the climatically suitable area.

Alternate hosts and other essential species

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Climatic suitability

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

Moderately similar

Level of uncertainty: high

B. halimifolia has already established in several EPPO countries (especially in France and in Spain, but also in Belgium, in the United Kingdom and in Italy) and it is particularly widespread on the Atlantic coast from northern Spain to south Brittany in France (See 1.07 for detailed references).

In its native area, *B. halimifolia* is found from Florida, which has a humid subtropical to tropical climate, to areas such as Massachusetts, which has snowfall in winter (USDA-ARS Website). It covers five plant hardiness zones from 9 to 6 with mean annual minimum temperatures of -17.8°C/-23.3°C in the latter zone (Erwin, 2009). The species is considered to be resistant to -15°C (Huxley, 1992 in Muller, 2004).

In Australia, it has been shown that, to complete its life cycle and produce seeds, *B. halimifolia* requires a long warm summer and an annual precipitation of more than 900 mm, mainly occurring in summer (Westman *et al.* 1975). It is assumed to grow more vigorously under subtropical conditions and to be particularly invasive in the wetter parts of Australia (Sims-Chilton *et al.*, 2010).

Westman *et al.* (1975) found that optimal germination occurs between 15-20°C with cold pre-treatment at 5°C. This shows the temperate to subtropical range of the species.

As a late flowering and fruiting species, it is not known how the date of first frost and duration of freezing in winter could limit its extension northwards in Europe. Self-sown individuals are recorded in Belgium up to Knokke-Heist in the north at latitude N51°20'. In the Netherlands, a few individuals had been observed on sand dunes in 'Kwade Hoek' in 2003, but did not persist. The hypotheses are that the species did not persist because the winters were too cold, or that competition with native communities of *Hyppophae rhamnoides* (Johan van Valkenburg, Plant Protection Service of the Netherlands, pers. comm., 2012; Van Valkenburg *et al.*, 2013 submitted) excluded it.

The potential distribution of *B. halimifolia* was projected with the software CLIMEX using the parameters of a previous study undertaken by Sims-Chilton *et al.* (2010). A Maxent and a GBIF Niche Model projection have also been undertaken. The Maxent projection identifies a very limited endangered area which may be an underestimate. The CLIMEX and GBIF Niche Model projection maps are concordant, although the EWG considered that the CLIMEX projection maps provided by Sims-Chilton *et al.* (2010) may overestimate the potential range of the species in the EPPO region, particularly in northern countries. Uncertainties remain on the cold and drought resistance of the species (see Appendix 2 for more details).

According to both climatic requirements and habitat preferences, the following coastal areas would be most at risk from the plant:

- the **Atlantic coast**, from north of Morocco to Scotland (including France, Ireland, Portugal, Spain, the United Kingdom);
- the **Mediterranean Basin**: Albania, Bosnia & Herzegovina, Bulgaria, Croatia, Cyprus, Former Yugoslav Republic of Macedonia, France (Mediterranean part), Greece, Italy,

Montenegro, Romania, Serbia, Slovenia, Slovakia, Spain (Mediterranean part), Turkey (Mediterranean part). The Southern Mediterranean coast may be too dry for the species to thrive, but may still be at risk: Algeria, Israel, Jordan, Morocco, Tunisia.

- the eastern part of the **Black Sea**: Georgia, Turkey, Russia.

Uncertainty remains on the ability of the species to thrive under colder and arid climates, and the following areas are considered to be less suitable but may still be at risk:

- the **North Sea coast** (including Belgium, the Netherlands, Germany) ;

- from Denmark to Poland, and in the south of Sweden on the **Baltic sea coast**.

- **temperate areas**: Austria, Azerbaijan, the Czech Republic, Denmark, Germany, Hungary, Lithuania, Moldova, the Netherlands, Poland, Serbia, Slovakia, Switzerland, Ukraine as well the Scandinavian and Baltic coasts of Finland, Norway and Sweden.

- **arid areas**: Azerbaijan, Israel, Jordan.

Other abiotic factors

3.12 - Based on the area suitable for establishment already identified, how similar are other abiotic factors that would affect pest establishment to those in the current area of distribution?

Completely similar

Level of uncertainty: low

B. halimifolia can be found on a wide range of soil types. For example, in Australia, it is recorded from dry infertile forest soils to rich volcanic loams and low-lying clay soils with high moisture content (Winders 1937, cited in Sims-Chilton & Panetta, 2011).

Indications on the nature of soils on which *B. halimifolia* has been found are found in the literature and are summarized below:

Soil moisture: *B. halimifolia* grows most typically in moist soils with high organic content (Sims-Chilton & Panetta, 2011). However, in Spain, *B. halimifolia* was also associated with high elevations and coarse sand, and fewer plants were found at high soil moisture, silt content and conductivity (Onaindia *et al.*, 2001, cited in Sims-Chilton & Panetta, 2011). This is in contrast to the positive associations with moisture referred to in other studies (Westman *et al.*, 1975; Boldt, 1987).

Soil pH: the plant is observed on soils with pH values in the A horizon ranging from 3.6 to 9 (Westman *et al.*, 1975). These results were obtained from 22 sites in Florida (pH= 5-9) and 14 sites in Queensland (pH=3.6-8.2).

Soil nutrients: based on 14 sites in Queensland where the species is present, Kjeldahl nitrogen ranges from 560 to 5500 ppm where the plant was recorded, while available phosphorus ranges from 4 to 73 ppm (mean:15 +/- 5) (Westman *et al.*, 1975).

Salinity: In both its native and exotic ranges, it is often found in soil covered by water with salinity ranging from 0 to 3.6% (from chlorinities of 0.0-1.98 % according to Westman *et al.*, 1975). It is documented that in the Basque Country it can invade halophytic reedbeds and subhalophytic rush communities with a salinity range between 4 g/L and 33 g/L, which mean salinities comprised between 4 and 33% (Caño *et al.*, 2009). Caño *et al.* (unpublished data) assessed the growth of individuals of *B. halimifolia* in low, medium and high salinity

communities. They identified that *B. halimifolia* shoots grew from May to December in the low and medium salinity communities but in the high salinity community shoots showed almost no growth from early August.

These soil conditions are totally similar in the native and exotic ranges.

Competition and natural enemies

3.13 - Based on the area suitable for establishment already identified, how likely is it that establishment will occur despite competition from existing species, and/or despite natural enemies already present?

Very likely

Level of uncertainty: low

B. halimifolia has already developed dense populations in the EPPO region, e.g. in France (Muller, 2004; Fried, 2012) and Spain on the Atlantic coast (Campos *et al.*, 2004; Campos & Herrera, 2009), despite competition with native plants and predation by natural enemies.

Competition with native plants during establishment

In its native range, *B. halimifolia* is a good competitor. For instance, in New Jersey, USA, *B. halimifolia* was successfully used (with *Myrica cerifera* and *Iva frutescens*) to help inhibit the spread of the invasive *Phragmites australis* in brackish marshes (Wang *et al.*, 2006).

B. halimifolia shows a degree of shade-tolerance during establishment (Panetta, 1977). However, the relative lateness of stem growth indicates that seedlings are not able to rapidly escape shade conditions in the field (Panetta, 1977).

In Australia, compared to other tropical pasture species, *B. halimifolia* is at disadvantage in terms of establishment (lower seed weight and lower relative seedling growth rate).

During early development (before the 5-leaf stage), heavy shade can affect root and leaf allocation and root establishment, leading to seedling mortality (Panetta, 1977). However, the critical factor for *B. halimifolia* establishment will not be the available photon flux but rather drought and/or lack of nutrients resulting from competition with established plants.

In Mediterranean coastal wetlands, *B. halimifolia* is able to grow and outcompete native vegetation in saltmarshes dominated by *Juncus maritimus*, *Spartina versicolor* or *Elytrigia* spp., but areas where dense stands of *Phragmites australis* dominate are more rarely colonized (Guillaume Fried, Anses, pers. obs., 2012). Locally not all plant communities are suitable for *B. halimifolia* establishment. Lozano Valencia & Alagón Cardoso (1995) report that in the Bidasoa islands in Spain, elevated areas are the most suitable for the establishment of *B. halimifolia*. In these places, *B. halimifolia* has been observed in competition with *Phragmites australis*, and managed to establish and to spread. Caño *et al.* (2012) report that although estuarine alder forests are also vulnerable to colonization by *B. halimifolia*, competition with other shrub or trees (e.g. *Alnus glutinosa*, *Salix atrocinerea*) seems to prevent species persistence in the long term (JA Campos, the University of the Basque Country, pers. obs., 2012).

In the Netherlands, a few individuals had been recorded in 2003 in 'Kwade Hoek' on sand dunes, but did not persist. Competition by the native *Hippophae rhamnoides* was hypothesized as a potential reason for this decline (Johan van Valkenburg, Plant Protection

Organization of the Netherlands, pers. comm., 2012; Van Valkenburg *et al.*, 2013 submitted).

Overall, the EWG considered that it is moderately likely that establishment of *B. halimifolia* would occur despite competition with other species, depending on the situation. At the germination stage, the species takes advantage of open areas and disturbances (including micro-disturbances) and is dependant on such situations, but once established, it is able to outcompete other species.

Natural enemies

Several natural enemies have been identified in France (Fried *et al.*, 2013):

a) mealybugs:

- *Ceroplastes sinensis* (Hemiptera : Coccidae) has been first identified on *B. halimifolia* in Gironde (Dauphin & Matile Ferrero, 2003) and more recently in the Pyrénées-Orientales (Fried *et al.*, 2013);

- *Saissetia oleae* (Hemiptera : Coccidae) which leads to the development of fungi (sooty mold) has also been observed on *B. halimifolia* in Camargue and on the Atlantic coast (Dauphin & Matile Ferrero, 2003).

b) aphids:

- *Aphis fabae* (Hemiptera: Aphididae), which is a very polyphagous species recorded on *B. halimifolia* in Camargue and in the Pyrénées-Orientales (Fried *et al.*, 2013);

- *Aphis spiraecola* (Hemiptera: Aphididae), which is a moderately polyphagous species recorded on *B. halimifolia* in the Pyrénées-Orientales (Fried *et al.*, 2013).

Dauphin & Matile Ferrero (2003) also state the presence of an undetermined Agromyzidae larva on *B. halimifolia* in Gironde.

Despite the fact these natural enemies are polyphagous species, and even if the two mealybugs (especially *Ceroplastes sinensis*) lead locally to significant damage, including the death of young shrubs (Fried *et al.*, 2013), they did not prevent the establishment of *B. halimifolia* in France.

In the Basque Country, *B. halimifolia* is also attacked by Coccidae, wax scales and sooty mold although their exact identity has not been determined. Scale insects were present on new shoots from August to December and scale excreted honeydew supported the growth of sooty mold during fall. Male individuals showed more scale insects per shoot and higher levels of fungi infection than female individuals. However, the impact of wax scale insects and sooty mold on *B. halimifolia* individuals remains unknown (Caño *et al.*, in review).

Westman *et al.* (1975) observed a low level of consumption by herbivores both in the introduced and native ranges, which make biological control dubious according to these authors.

Westman *et al.* (1975) found that the absolute level of consumption of *B. halimifolia* is low even in its native range (1.95% foliar loss). However, from the 174 phytophagous insects found on *B. halimifolia* in its native range (Palmer & Bennett, 1988), 13 have been released and six have established in Australia.

Despite some effectiveness, biological control has not been completely successful in Australia (Sims-Chilton *et al.*, 2009).

Overall, it is likely that establishment of *B. halimifolia* would occur despite both competition

and attack by natural enemies.

The managed environment

3.14 - How favourable for establishment is the managed environment in the area of potential establishment?

Highly favourable

Level of uncertainty: low

B. halimifolia has the ability to invade habitats where native vegetation is periodically disturbed by fire, flooding or animal activity (Panetta, 1977).

The EWG considered that the managed environment is highly favourable in semi-natural habitats (e.g. saltmarshes and estuaries) since several current management actions are assumed to favour the establishment of *B. halimifolia*:

- by developing irrigation channels and canals, which are favourable habitats for *B. halimifolia* (Westman *et al.*, 1975), human infrastructure can enhance the spread of *B. halimifolia*.
- water management with the introduction of fresh water as in Camargue (and probably in other coastal areas) influences soil water balance in such a way that it favours establishment due to less brackish water;
- artificial fire regimes (sometimes used to control *B. halimifolia*) have a positive influence on the germination success of this species (Panetta, 1977);
- construction activities and management along roadsides have a positive influence on *B. halimifolia* establishment (see Ervin, 2009);
- in conditions of disturbed soils, the plant was highly invasive in Australia (Ensbey, 2009);
- in pastures under conditions of over- or under-grazing, in recently cleared areas and forestry plantations, or in fertilized areas, the species was particularly invasive in Australia (Ensbey, 2009);
- disturbances may also favour the invasion of *B. halimifolia* over native species. According to Connor & Wilson (1968) quoted by Westman *et al.* (1975), the relative dominance of *B. halimifolia* in swamp vegetation increased following fertilizer application.

In anthropogenic habitats such as roadsides, frequent management practices (i.e. roadside mowing twice a year) would disfavor the species.

Overall, the EWG considered that the managed environment is highly favorable to the establishment of *B. halimifolia*.

3.15 - How likely is the pest to establish despite existing pest management practice?

Very likely

Level of uncertainty: medium

B. halimifolia colonizes mainly natural or semi-natural habitats in natural areas usually subject to no regular pest management practices. Some management practices, such as the removal of invasive alien plants, may leave bare soil and would favor the establishment of *B. halimifolia*. Such management practices are to be considered on a case by case basis, and such control actions have been reported in France (e.g. Domaine de la Palissade in Camargue) and Spain (Life project in the Basque Country). Minimizing disturbances would even lower the

possibilities of establishment of the species.

The EWG rated the probability of establishment of *B. halimifolia* despite existing pest management practices as very likely.

Protected Cultivation

/

3.17 - How likely are the reproductive strategy of the pest and the duration of its life cycle to aid establishment?

Very likely

Level of uncertainty: low

The reproductive strategy of *B. halimifolia* has some characteristics that will aid its establishment:

- the ability to grow very fast, up to 30 to 40 cm per year (Herrera & Campos, 2010);
- although it is a woody shrub, it is able to flower after 2 years (Panetta, 1979b). An efficiency of pollination mechanisms with fertility rates of 90% has been observed (Panetta, 1979b);
- the ability to produce many seeds - estimations range between 10 000 (Auld, 1970) to 1 500 000 per year for a healthy adult plant growing in full sunlight (Westman *et al.*, 1975) - well dispersed by wind, potentially over long distances, increases the probability of reaching suitable areas for establishment;
- the ability to germinate rapidly when conditions are favorable: field observations (Westman *et al.*, 1975) showed that most of the seeds germinate within one month after seed set;
- the seed bank is expected to persist at least 2 years (Panetta, 1979a);
- the ability to sprout new shoots from the base, following disturbance (fire, management) (Westman *et al.*, 1975).

However, some characteristics are also detrimental:

- *B. halimifolia* is a small-seeded species and consequently has only moderate seedling growth potential (Panetta, 1977);
- slow growth during the establishment phase of seedlings may lead to extended periods of drought susceptibility;
- shade has been found to have a significant impact on seedling growth, particularly during the first 11 weeks (Panetta, 1977);
- high insolation is necessary for initiating flower production (Panetta, 1979b);
- this is a dioecious species, meaning that a colonizing female must be within the pollen shadow of a male in order to produce seeds.

3.18 - Is the pest highly adaptable?

No, moderately adaptable or less

Level of uncertainty: high

B. halimifolia is present in two different Köppen-Geiger climate zones (Cfa, Cfb, Aw, Csa), including humid sub-tropical to tropical climate in Florida and temperate areas with winter snowfall such as in Massachusetts (Sims-Chilton & Panetta, 2011).

The EWG considered that *B. halifimifolia* has some characteristics of plasticity which are detailed below:

Leaves

Its relative adaptability can be seen through the leaf life span; while it exhibits a semi-deciduous growth habit in the northernmost portions of its North-American range, it may retain its leaves year-round throughout most of its global distribution, in particular in Australia (Sims-Chilton & Panetta, 2011). The leaf drop varies highly among individuals within sites, depending on edaphic conditions. Under high salinity conditions, the percentage of leaf drop is higher during the fall than in less saline soils. The leaf drop can also vary between females and males trees (Caño *et al.*, in review). In addition, the specific leaf area (leaf mass: leaf area ratio) is very plastic. Specific leaf area is reduced in more halophilous communities, which may be an adaptive response to salinity (Caño *et al.*, in review). Plasticity of morphological or ecophysiological traits may indeed be one of the main underlying mechanisms for the relative tolerance to salinity in *B. halimifolia*.

Seeds

B. halimifolia has two categories of seeds: (1) seeds which respond to temperature fluctuations in the absence of light and (2) seeds which germinate under fluctuating temperature and intermittent light (Panetta, 1979c). Seeds buried at depths in excess of 5 cm are probably dormant.

B. halimifolia can produce seeds at various degrees of shade and under light intensity as low as 3% of open light (Westman *et al.*, 1975), even if the yield of viable seed is reduced (See also page 1062 in Panetta, 1979b).

B. halimifolia demonstrates high plasticity regarding salinity and flooding. In Urdaibai, it invades reedbeds where the salinity of the water table ranges between 4 and 33 g of NaCl per litre of water.

However, in the laboratory it was shown that low concentrations of salt of about 2 g/L in the irrigation water can decrease the germination probability to about 20% and concentrations higher than 10 g/L seem to inhibit germination (Caño *et al.*, 2009). This suggests that for *B. halimifolia* to colonize the most halophytic communities, recruitment must happen with specific tide, rainfall, temperature and soil conditions that result in lowest salinity values. The research also shows that although *B. halimifolia* can survive in most halophytic and flooded reedbeds, its capability to invade these environments is limited.

Though, the species has not developed subspecies, is not reported to have developed resistance to numerous plant protection products, and has not increased its number of habitats in its alien range. The EWG therefore considered that the pest is not highly adaptable.

3.19 - How widely has the pest established in new areas outside its original area of distribution?

Widely

Level of uncertainty: low

B. halimifolia has been introduced and established in two different realms (Palearctic, Australasia), and it is therefore considered as widely established in new areas outside its original area of distribution.

3.20 - The overall probability of establishment should be described.

Probability of establishment

Very high

Level of uncertainty: low

B. halimifolia has already established in five countries in the EPPO region (Belgium, France, Italy, Spain, and the United Kingdom); the probability of establishment in the EPPO region is therefore considered as very high, with a low level of uncertainty. This is in line with the outcomes of the CAPRA visualizer presented in Figure 3.

According to climatic prediction and habitat suitability, additional countries are at risk, and the EWG considered the probability of establishment in further countries as moderate, with a medium level of uncertainty.

Figures 3 and 4 are the results of the CAPRA visualizer for establishment as well as the Matrix model.

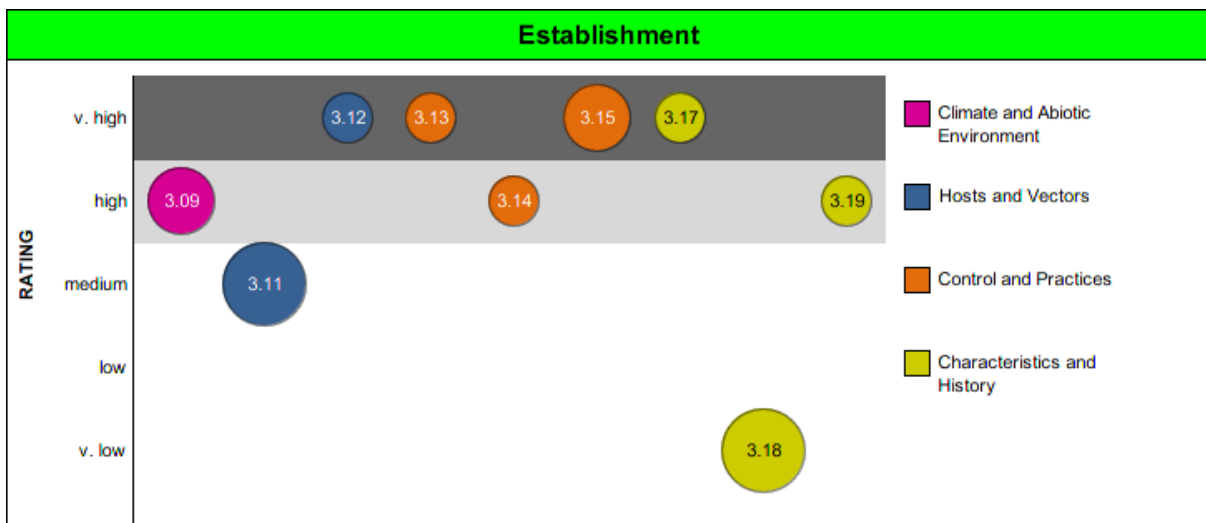


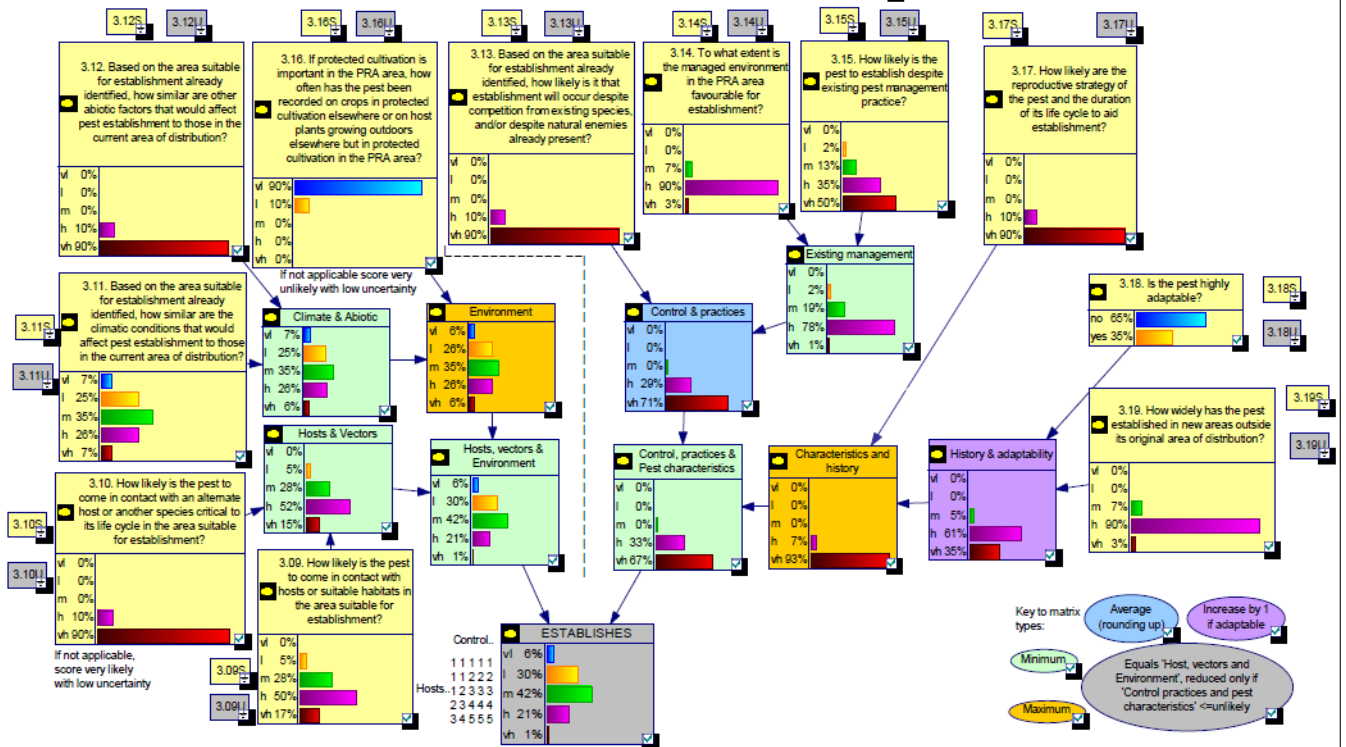
Figure 3: Result of the CAPRA visualizer (visualization of the ratings and uncertainty for each question) for the establishment of *Baccharis halimifolia* in the EPPO region.

Probability of establishment

Pest establishment. Pratique Version 7 2012-03-28

1. choose an uncertainty distribution==>>> Uncertainty distribution

2. choose scores S & Uncertainties U



This model structure has some new elements that are untested. 1. The eradication question, 3.17 is now aggregated with 3.18 using an average matrix as both relate to the characteristics of the pest. 2. Adaption, 3.19 is aggregated with 3.20 as both relate to aspects of whether the pest has, or is likely to, adapt to new environments; this uses a newly defined node, necessitated by the use for a yes/no question for adaptability; the outcome is increased by one category if adaptability is yes. 3. The transients question, 3.21 is included for completeness but is not linked to the rating of establishment. 4. Uncertainty in the yes/no questions 3.19 & 3.21 is incorporated with an arbitrary distribution between 'yes' and 'no' which is more even the greater the uncertainty; the response 'yes' with low, medium & high uncertainty is assumed to correspond to 95, 85 and 66% yes (and the remainder no). 5. For the 5-category variables, the pre-defined Beta uncertainty distribution is the same as that used in IRIS. As an alternative a truncated normal distribution may be selected. In broad terms, a Beta distribution gives more weight to the centre of the distribution and the truncated normal, more weight to the tails of the distribution JH 11/11/2010

Figure 4: Results of the Matrix model in CAPRA for the risk of establishment of *Baccharis halimifolia* in the EPPO region.

Stage 2: Pest Risk Assessment Section B: Conclusion of introduction

c1 - Conclusion on the probability of introduction.

B. halimifolia is currently traded as an ornamental and amenity plant; its probability of entry in the EPPO region is therefore considered as very high with a low uncertainty.

B. halimifolia is already established in five countries of the PRA area (Belgium, France, Italy, Spain, the United Kingdom); the probability of establishment is therefore considered as very high with a low uncertainty.

It has the potential to establish in additional countries (Western Coast, Mediterranean basin, etc). Its biological characteristics and the environment, as well as management practices (fire, road management) are favorable for its establishment.

As a consequence, the probability of introduction of *B. halimifolia* in the EPPO region is considered as very high with a low uncertainty.

Combinations of scores according to the genie matrices developed with the open source software Genie (software based on Bayesian networks to provide combination rules and summary ratings to visualize the answers chosen by the assessor and the result of their combination) are shown in Figure 5:

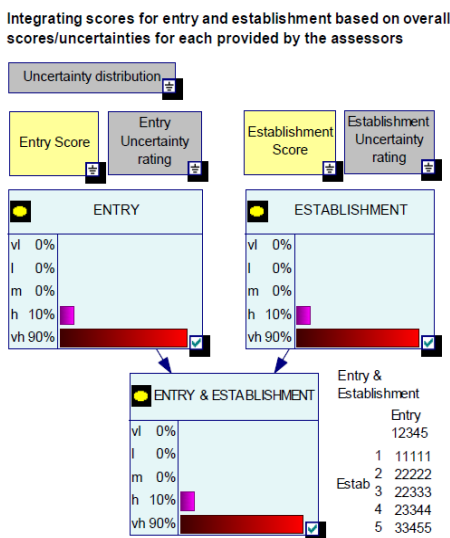


Figure 5: Matrix model in CAPRA combining entry and establishment for *Baccharis halimifolia* in the EPPO region.

Stage 2: Pest Risk Assessment Section B: Probability of spread

4.01 - What is the most likely rate of spread by natural means (in the PRA area)?

Moderate rate of spread

Level of uncertainty: medium

B. halimifolia is known as one of the most prolific plants, with estimates of seed production ranging between 10 000 (Auld, 1970) to 1 500 000 (Westman *et al.*, 1975) seeds per plant per year. Panetta (1979b) estimated that the reproductive output of a *Baccharis halimifolia* population growing within a pine stand prior to canopy closure was 376 000 achenes/m². Even in shaded conditions (Sarlon 92% shade cloth), seed production remains still considerable, with about 20 000 achenes produced per m² (Panetta, 1979b).

Seeds are very small, their mass is approximately 0.11 mg (Panetta, 1977) and they are crowned by a pappus and are therefore readily dispersed by wind (Boldt, 1987) but also by water (Panetta, 1977).

Most seeds fall within a few metres of the parent bush (Anonymous, 2007a), but records showed that seeds can drift up to 140 m from a 2 m high plant (Diatloff, 1964), while wind updrafts can carry seeds many kilometers (Anonymous, 2007a). According to Westman *et al.* (1975), some remote populations were apparently separated by at least 2-3 miles (3.2-4.8 km). Some isolated populations found during a survey in the Camargue were separated by more than 5 km (Charpentier *et al.*, 2006).

B. halimifolia is suspected to be continually entering the Spanish Basque Country from wind dispersed achenes produced in the French Basque Country and *vice versa* (Estela Beteta, Gobierno Vasco, pers. comm., 2012).

According to the high number of seeds produced and their dispersal by wind, the EWG considered *B. halimifolia* as a plant with long distance dispersal capacity. Though applying the generic scoring system (1 to 10 km spread per year) only results in a moderate natural spread rate. As no exact measurements have been undertaken on the rate of spread by natural means of the species, the uncertainty is considered to be medium.

4.02 - What is the most likely rate of spread by human assistance (in the PRA area)?

Very high rate of spread

Level of uncertainty: medium

B. halimifolia is often planted in coastal areas along roads or roundabouts, making it easier to reach unintended habitats such as coastal wetlands.

The more the species is traded, the higher is the probability of escape from cultivation and the creation of new populations. The species is traded in EPPO countries; selling websites are provided under question 2.01a.

The EWG considered that further human mediated pathways that have not been quantified may spread the plant: vehicles, contaminated soil movement, etc. The rate of spread by human assistance was therefore considered as very high. As such factors have been studied in details and cannot be quantified; the level of uncertainty is ranked as medium.

4.03 - Describe the overall rate of spread

Very high rate of spread

Level of uncertainty: medium

Caño *et al.* (2012) report that in 90 years, *B. halimifolia* has invaded all the estuaries along 300 km of coastline in Northern Spain. In the Urdaibai Biosphere Reserve (Basque Country, Spain), the invaded area has increased from 54 ha in 1996 to 128 ha in 2000 and to 288 ha in 2005. In addition, according to Prieto (2006) *B. halimifolia* has totally replaced subhalophilous plant communities and forms monospecific impenetrable stands in 88 ha.

Considering the moderate natural spread capacity of *B. halimifolia* and the very high assisted dispersal by human activities, the overall probability of spread is very high, uncertainty is medium.

4.04 - What is your best estimate of the time needed for the pest to reach its maximum extent in the PRA area?

Level of uncertainty: high

The EWG considered that as human mediated spread through the use of the species as an ornamental and amenity plant is very high, the time needed to reach the maximum extent in the EPPO region will be highly dependent on the future use and intensity of trade of the plant. Since this essential element is unknown, the time needed to reach the maximum extent in the EPPO region cannot be estimated.

4.05 - Based on your responses to questions 4.01, 4.02, and 4.04 while taking into account any current presence of the pest, what proportion of the area of potential establishment do you expect to have been invaded by the organism after 5 years?

Level of uncertainty: high

Since the future use and intensity of trade of the species in the next 5 years cannot be estimated, the proportion to be colonized in the next 5 years cannot be estimated.

The area of potential establishment is quite large, and the EWG considered that currently only a very small proportion is colonized, and extrapolated that within the next 5 years, this situation is not expected to change significantly.

Stage 2: Pest Risk Assessment Section B: Eradication, containment of the pest and transient populations

5.01 - Based on its biological characteristics, how likely is it that the pest could survive eradication programmes in the area of potential establishment?

Likely

Level of uncertainty: low

If detected very early, young plants (<2 years) could be controlled prior to reproduction. Older infestations imply a production of seeds and possibly the formation of a seed bank, requiring repeated monitoring surveys.

In any case, if control activities result in bare soils, this can promote seed germination.

Although the species is conspicuous and can be easily recognized, it may colonize remote and impenetrable habitats, rendering its detection unlikely in many circumstances.

The EWG concluded that eradication would only be a possibility for isolated and small infestations where sustained resourcing could be anticipated. No successful case of eradication has been reported. It is therefore likely that the species would survive an eradication programme, with a low level of uncertainty.

5.02 - Based on its biological characteristics, how likely is it that the pest will not be contained in case of an outbreak within the PRA area?

Likely

Level of uncertainty: medium

High seed production, effective dispersal by wind and the promotion of germination upon exposure to light make management and containment difficult (Westman *et al.*, 1975).

Even though containment on a local scale may be difficult to achieve, containment over larger scales may be feasible, if prevention of the trade of the plant is involved.

One of the most effective control methods would be the use of herbicides (2,4-D, dicamba plus MCPA, glyphosate, picloram plus 2,4-D, and tryclopyr, (Weber, 2003), but these are not allowed in all situations where the plant occurs (e.g. protected sites), and active substances may be phased out in the future.

If detected at an early stage, containment is more likely to be achieved.

The EWG concluded that it is likely that the pest will not be contained in the case of an outbreak in the EPPO region, the level of uncertainty is medium as there is of information on attempted and successful containment programs.

5.03 - Are transient populations likely to occur in the PRA area through natural migration or entry through man's activities (including intentional release into the environment) or spread from established populations?

Yes

Level of uncertainty: medium

There is very little evidence of transience in populations of *B. halimifolia*. The few individuals that did not persist in the Netherlands may be one such example. The plant may enter through human activities (e.g. release of the plant in the environment) but may not be able to thrive subsequently.

Even if transient populations could occur, the EWG considered that such populations would be unlikely to affect the overall impacts of *B. halimifolia* in the EPPO region.

Stage 2: Pest Risk Assessment Section B: Assessment of potential economic consequences

6.01 - How great a negative effect does the pest have on crop yield and/or quality of cultivated plants or on control costs within its current area of distribution?

Moderate

Level of uncertainty: low

Impact on pastures

In its native range, *B. halimifolia* is considered a weed due to 'infestation' on overgrazed rangeland in the Southern United States (Nesom, 2006).

In Australia, *B. halimifolia* is a pest of pastures, where thick stands can inhibit the movement of stock and reduce the productivity of grazed areas (Ensbey, 2001, cited in Sims-Chilton & Panetta, 2011).

It has little nutritional value for livestock. There are very few records of livestock poisoning due to the cardiotoxic glucosides found in the leaves of the plant (Boldt, 1987, cited in Sims-Chilton & Panetta, 2011). This is probably due to the low palatability of the plant: *B. halimifolia* is generally grazed only when grass is scarce (Everist, 1974). Other studies have shown no poisoning effects. For example, White (1936) fed *B. halimifolia* to two heifers (*Bos taurus*) for 13 days. The animals appeared emaciated, but no symptoms of poisoning were evident.

In France and Spain, there are currently no records of impacts on pastures.

Control costs

In the 1970s, the cost of a control programme with herbicides (2,4-D and 2,4,5-T) in Queensland was estimated to exceed \$500 000 per year (Westman, 1975). This figure largely concerns pastures, but owing to legal obligation to control this weed, other land uses would also be involved.

In France and Spain, there are no reported impacts on pastures, but control programmes are being undertaken for environmental conservation purposes.

In France in Loire-Atlantique (44), a containment action on a population of 124 trees (spread over 49 locations) was estimated to cost 3064 euros (Commission Syndicale de Grand Brière Mottière, 2007).

In the Basque Country a Life+ project has been implemented to suppress *B. halimifolia* from three estuaries (Urdaibai, Txingudi and Lea) (LIFE project Website). During 2011, control works were carried out in Urdaibai, based on two methodologies:

- manual pulling out: for specimens lower than 50-75 cm, completely digging out the root system;
- using herbicide: adult and resprouting specimens are cut one by one, and brushed with an herbicide (glyphosate 36%) diluted in oil in a proportion of 50%.

In 2011, 298,08 ha were treated, with a total cost of 630 000 €. These are the values of the cost per hectare:

First treatment (139,69 ha in total) :

- high density areas: 2 896 €/ha ;
- low density areas: 2 282 €/ha.

Further treatments (158,39 ha in total) :

- manual pulling out: 1 804 €/ha ;
- use of herbicides: 1 410 €/ha.

In 2012 more elimination works were carried out, with a total cost of 207 000 €:

First treatment (21,50 ha in total) :

- high density areas: 2 795 €/ha ;
- low density areas: 3 011 €/ha.

Further treatments (82,93 ha in total) :

- manual pulling out: 3 249 €/ha ;
- use of herbicides: 811 €/ha.

6.02 - How great a negative effect is the pest likely to have on crop yield and/or quality of cultivated plants in the PRA area without any control measures?

Minimal

Level of uncertainty: low

Impacts on crop yields and/or quality are restricted to loss of grazing areas in coastal wetlands, but there are currently no reported impacts in France and Spain, and it is extrapolated that there shall be minimal impacts in the endangered area.

6.03 - How great a negative effect is the pest likely to have on yield and/or quality of cultivated plants in the PRA area without any additional control measures?

Minimal

Level of uncertainty: low

As stated under question 6.02 there are currently no reported impacts in France and Spain on crops and crop yields in the absence of control measures; there shall be minimal impacts without any additional control measures.

6.04 - How great a negative effect is the pest likely to have on yield and/or quality of cultivated plants in the PRA area when all potential measures legally available to the producer are applied, without phytosanitary measures?

Minimal

Level of uncertainty: low

As stated under question 6.02 there are currently no reported impacts in France and Spain on crops and crop yields in the absence of control measures; there shall be minimal impacts when all available measures are applied, without phytosanitary measures.

6.05 - How great an increase in production costs (including control costs) is likely to be caused by the pest in the PRA area in the absence of phytosanitary measures?

Moderate

Level of uncertainty: medium

Control costs would be similar to those already spent in infested parts in countries where *B. halimifolia* occurs (see Q. 6.01).

6.06 - Based on the total market, i.e. the size of the domestic market plus any export market, for the plants and plant product(s) at risk, what will be the likely impact of a loss in export markets, e.g. as a result of trading partners imposing export bans from the PRA area?

Minimal

Level of uncertainty: low

This question is not relevant for *B. halimifolia*. There will be no loss in export market of plants or plant products.

6.07 - To what extent will direct impacts be borne by producers?

Minimal extent

Level of uncertainty: low

This question is not relevant for *B. halimifolia*.

In this section, the different questions will help the assessor to rate the environmental impact within the current area of distribution of the pest (Q6.08).

This information is used as an indicator for determining the potential environmental impact in the PRA area (Q6.09).

6.08.0A - Do you consider that the question on the environmental impact caused by the pest within its current area of invasion can be answered?

Yes

Data on impacts are available in several invaded countries, in particular in France and Spain.

Negative impact on native biodiversity

6.08.01 - To what extent does the plant cause a decline in native species populations and changes in communities of native species?

High extent

Level of uncertainty: low

The species forms dense monospecific stands that are persistent: each shrub can live up to 25 years. Therefore, the species can have detrimental impacts on native populations and communities.

In Australia, *B. halimifolia* is a major pest of native *Melaleuca* wetlands (Westman *et al.*, 1975) where it forms a thick understorey and suppresses growth of native sedges (Anonymous, 2007a in Sims-Chilton & Panetta, 2011).

In France, Muller (2004) reports that *B. halimifolia* can outcompete other plants. Once established, the shrub blocks the light to other species, modifying micro-climatic conditions, leading to a regression of herbaceous species.

A recent study conducted in France (Pierre, 2012; Fried *et al.*, 2013), has measured the impact of *B. halimifolia* on native plant communities of Mediterranean *Juncus maritimus* and *Juncus acutus* saltmarshes (A2.522 according to the EUNIS classification). On average, at the plot scale (4 m²), *B. halimifolia* reduced species richness by 42% while the Jaccard dissimilarity index¹ indicated a difference of 0.64 in species composition. At the habitat scale, total species richness was significantly reduced by 39% from 36 to 22 species (permutation-test on cumulative species richness curves).

The abundance of all other life forms (therophytes, geophytes and hemicyptophytes) is reduced under *B. halimifolia* patches, except for the chamaephytes (e.g. *Halimione portulacoides*, *Sarcocornia fruticosa*, *Inula crithmoides*).

B. halimifolia causes especially a decrease in cover of native *Juncus maritimus*, *Elytrigia elongata*, *Dorycnium herbaceum*, *Phragmites australis*, *Limonium narbonense* and *Sonchus maritimus*. When the cover of *B. halimifolia* exceeds 80%, the total cover of native species begins to decrease more rapidly.

In the Rhone Valley, *B. halimifolia* is also reported to invade *Cladium mariscus* communities, where it becomes dominant; this habitat is listed as a priority in the Directive 92/43/EEC (Anne Charpentier, Montpellier University, pers. comm., 2012).

A study conducted in Morbihan (Brittany, France) on the insects associated with *B. halimifolia* (Mallard, 2008) showed that insect species richness and abundance was reduced on *B. halimifolia* compared to native shrubs (*Prunus spinosa*, *Ulex europaeus*) and trees (*Quercus robur*, *Salix atrocinerea*).

A particularly strong reduction in phytophagous insects was observed, and Lepidoptera were the most impacted.

In the Spanish Basque Country, Caño *et al.* (2012) report that *Juncus maritimus*, *Elytrigia atherica* and *Phragmites australis* communities are the most affected. The average *B. halimifolia* cover in invaded sea rush communities in Northern Spain estuaries ranged from 32.2% (\pm 4.91SE) in low salinity rush patches to 3.6% (\pm 2.41SE) in high salinity rush patches. *B. halimifolia* reduced the native species cover, the estuarine native species cover, the native species richness and the estuarine species richness in invaded rush communities (Caño *et al.*, in review).

Another important consequence of *B. halimifolia* invasion in rush communities is the reduction of the area occupied by the herbaceous-subshrub layer. The average percent of herbaceous-subshrub layer replaced by the shrub layer in invaded plots came close to 9% in the high salinity patches and to 24% in the low salinity sites (Caño *et al.*, in review).

In addition, 'the development of monospecific *Baccharis halimifolia* communities prevents the growth of the heliophilous species typical of saltmarshes and has reduced the populations of species growing in these habitats such as *Glaux maritima*, *Cochlearia aestuaria*, *Dryopteris carthusiana* (Caño *et al.*, 2012) and *Matricaria maritime* subsp. *maritima*. The latter one is included within the category 'danger of extinction' in the 'Basque Catalogue of Threatened Species of the Wild and Marine Fauna and Flora' (Campos *et al.*, 2004) (See question 6.08.07 for further details on protected habitats). *Cochlearia aestuaria*, *Dryopteris carthusiana* var. and *Matricaria maritime* subsp. *maritima* are all threatened species in the Basque Country according to Prieto Fernández *et al.* (2007).

¹ this index ranges from 0, no difference between two communities to 1 where all species are different between the two communities.

Modifications in communities of invertebrates and vertebrates are expected but there are no available data on this topic yet. Galarza & Hidalgo (2005-2006) report that the stands of *B. halimifolia* have an impact on bird populations associated with invaded habitats. The plant is considered to reduce the attractiveness and use of the habitats for nesting, roosting and feeding.

See question 6.08.08 for further details on species and their status of protection.

6.08.02 - To what extent does the plant hybridize with native species?

Low extent

Level of uncertainty: low

Baccharis is a genus of about 400 species mostly found in the New World tropics and warm-temperate regions. In its native range, *B. halimifolia* has been recorded as having hybridized with *B. neglecta* and *B. angustifolia* in Arkansas, Louisiana, and East Texas. In Florida, *B. halimifolia* is known to hybridize with *B. angustifolia* (Flora of North America Website).

With no native *Baccharis* species in the EPPO region, the risk of hybridization with a native species is nil.

Alteration of ecosystem patterns and processes

6.08.03 - To what extent does the plant cause physical modifications of habitats (e.g. changes to the hydrology, significant increase of water turbidity, light interception, alteration of river banks, changes in fire regime, etc.)?

Medium extent

Level of uncertainty: high

Fire regime

Leaves and wood of *B. halimifolia* secrete an inflammable resin (Bean, 1981), thus dense thickets of *B. halimifolia* could increase fire frequency in invaded habitats (Muller, 2004), but this has not been observed yet.

Sedimentation

Campos & Herrera (2009) report that the root system and large litter production of the species cause changes in sedimentation. In this sense, these authors considered that *B. halimifolia* is a 'transformer' species, i.e. an invasive alien plant that causes changes in the character, condition, form and nature of the invaded ecosystems.

Lozano Valencia & Alagón Cardoso (1995) also report modifications in productivity and in nutrient cycling, including rates of erosion and sedimentation of the affected estuaries. No measurements have been undertaken to support these statements but the authors observed that the soils of the areas massively colonized by *B. halimifolia* have a higher percentage of sand.

Light interception

Dense thickets of *B. halimifolia* also reduce the light available for herbaceous species, which is especially detrimental to heliophilous species (Campos *et al.*, 2004).

6.08.04 - To what extent does the plant cause changes to nutrient cycling and availability (e.g. significant changes in nutrient pools in topsoils or in water)?

Medium extent

Level of uncertainty: high

No studies have been conducted on the impact of *B. halimifolia* on nutrient cycling. The EWG considered that as *B. halimifolia* is a productive shrub that forms large monospecific stands, it is likely to affect nutrient cycling.

6.08.05 - To what extent does the plant cause modifications of natural successions (e.g. acceleration or temporary freezing of successions)?

Medium extent

Level of uncertainty: medium

In Mediterranean salt marshes, native *Tamarix* spp. are usually restricted to humid depressions and are not able to establish in the drier parts of salt marshes where *B. hamilifolia* is the only shrub, therefore changing the natural succession by adding a new vegetation layer (Fried *et al.*, 2013).

In the Spanish Basque Country (Campos *et al.*, 2004), invasion by *B. halimifolia* causes a marked change in the structure and physiognomy of the invaded community (a 'transformer' species, *sensu* Richardson *et al.*, 2000).

The stands of *B. halimifolia* stabilize the soils and transform the substrate by producing humus that changes the composition of soils. This effect limits the development of species related to marshes, the colonized area remaining suitable for halophyte species (Lozano Valencia & Alagón Cardoso, 1995).

In sites invaded by *B. halimifolia* in the Spanish Basque Country, an 'invasional meltdown' was noted, with an increase in the areas covered by two other invasive alien plants: *Lonicera japonica* and *Aster squamatus* (Caño *et al.*, 2009).

The impact of *B. halimifolia* on plant communities (including life form changes) may be also explained by the fact that its presence may favor small herbivores (e.g. rabbits), themselves reducing the herbaceous cover (observed for the close related species *B. pilulifera* by Hobbs & Mooney (1986).

6.08.06 - To what extent does the plant disrupt trophic and mutualistic interactions (e.g. through the alteration of pollinator visitations - leading to a decrease in the reproductive success of native species-, allelopathic interactions, strong reduction of phytophagous or saprophagous communities, etc.)?

Low extent

Level of uncertainty: high

There is no record on the disruption of trophic and mutualistic interactions. The EWG therefore ranked this question as low impact with high uncertainty.

Conservation impacts

6.08.07 - To what extent does the plant occur in habitats of high conservation value (includes all officially protected nature conservation habitats)?

High extent

Level of uncertainty: low

Invasive populations of *B. halimifolia* often occur in threatened habitats listed on the Annex I of the EC *Habitats Directive* (Directive 92/43/EEC) in France and Spain, according to Gobierno Vasco (2011) as well as in Belgium (Tim Adriaens, Institute for Nature and Forest Research, INBO, pers. comm., 2012):

1230: Vegetated sea cliffs of the Atlantic and Baltic Coasts

1330: Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)

1410: Mediterranean salt meadows (*Juncetalia maritimi*)

1420: Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)

2110: Embryonic shifting dunes

2120: Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes')

2190: Humid dune slacks

2210: *Crucianellion maritimae* fixed beach dunes

3130: Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isaëto-Nanojuncetea*

4040: Dry Atlantic coastal heathes with *Erica vagans*

6420: Mediterranean tall humid grasslands of the *Molinio-Holoschoenion*

7210: Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*

92D0: Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Serucinegion tinctoriae*).

Atlantic salt meadows (1330) occupy an estimated area of 89 938 ha in Europe (in Denmark 29 583 ha, in France 26.367 ha, in Germany 20 269 ha, in the United Kingdom 19 986 ha, in Ireland 3 416 ha, in Spain 2.108 ha, etc.), of which 77.83% is in Natura 2000 sites (Doody, 2008).

Invasive populations occur in protected areas as in the Parc Naturel Regional de Camargue (Southern France). *B. halimifolia* also causes a decrease in the cover of *Erica vagans* heath, which is a habitat listed as a priority in the Directive 92/43/EEC (Estela Beteta, Gobierno Vasco, pers. comm., 2012), and within the Natura 2000 European networks (see the Natura 2000 viewer, which is a web-based tool allowing selection of habitats, and to visualize Natura 2000 in Europe hosting these habitats as well as EU Life projects related at <http://natura2000.eea.europa.eu/#annexICode=na>).

A non-exhaustive list of Natura 2000 sites where *B. halifolia* occurs in Spain and France is the following:

- ES 2130003 – Ría del Barbadun
- ES 2130011 – Río Artibai
- ES 2130010 – Río Lea
- ES 2130007 – Zonas Litorales y marismas de Urdaibai
- ES 0000144 – Ría de Urdaibai (UNESCO Biosphere reserve)
- ES 2120004 – Urolako Itsasadarra - Ría de Urola
- ES 2120009 – Inurritza
- ES 2120010 – Oriako Itsasadarra - Ría del Oria
- ES 2120017 – Jaizkibel
- ES 2120014 – Uliá
- ES 2120018 – Txingudi-Bidasoa
- ES 0000243 – Txingudi
- FR53 00027 – Gavres-Quiberon

- FR5300059 – Rivière Laïta, Pointe du Talud, Etangs du Loc'h et de Lannec
- FR5310094 – Rade de Lorient
- FR 9112005 – Complexe lagunaire de Salses-Leucate
- FR 9112017 – Etang de Mauguio
- FR 9101406 – Petite Camargue
- BE 2500001 (1-33) – Duingebieden inclusief Ijzermunding en Zwin.

6.08.08 - To what extent does the plant threaten rare or vulnerable species (includes all species classified as rare, vulnerable or endangered in official national or regional lists within the PRA area)?

Medium extent

Level of uncertainty: high

In the Spanish Basque Country, *B. halimifolia* is thought to have reduced the populations of *Matricaria maritima* (Campos *et al.*, 2004), which is included within the category 'danger of extinction' in the 'Basque Catalogue of Threatened Species of the Wild and Marine Fauna and Flora', however no measurements of such decline are available.

Some of the estuarine species present in invaded rush marshes such as *Salicornia* spp., *Limonium humile*, *Sarcocornia perennis*, *Cochlearia aestuaria* or *Frankenia laevis* are already endangered at the regional level (Uribe-Echebarría & Campos 2006).

The recent study conducted in Mediterranean saltmarshes (Pierre, 2012; Fried *et al.*, 2013) in France did not reveal a significant impact on rare species. However, dense stands of *B. halimifolia* occur in areas where species of conservation value occur : *Cynanchum acutum* (Article 1 of the Liste des espèces végétales protégées en region Provence-Alpes-Côte-d'Azur http://inpn.mnhn.fr/espece/cd_nom/93777/tab/statut?lg=en, *Iris spuria* subsp. *maritima* (registered to the article 1 of the Liste des espèces végétales protégées en région Poitou-Charentes and Pays-de-la-Loire http://inpn.mnhn.fr/espece/cd_nom/136863/tab/statut), etc.

Caño *et al.* (2009) also report modifications in communities of invertebrates and vertebrates, but no further detail is provided. Galarza & Hidalgo (2005-2006) report that the stands of *B. halimifolia* have an impact on bird populations associated with invaded habitats. The plant is considered to reduce the attractiveness and use of the habitats for nesting, roosting and feeding. *B. halimifolia* is suspected to threaten *Acrocephalus arundinaceus* (registered on the Annexe 2 of the Bonn and the Bern Conventions, and registered on the National Catalogue of threatened species in Spain, as well as in France, and considered as nearly threatened according to the IUCN Red List <http://www.conservation-nature.fr/statut-Acrocephalus%20arundinaceus.html>) and *Emberiza schoeniclus* (registered on the Annex 2 of the Bern Convention, and listed on article 1 and 5 in France, but which is considered as a minor concern both in France, and according to the IUCN Red List <http://www.conservation-nature.fr/statut-Emberiza%20schoeniclus.html>).

6.08 - How important is the environmental impact caused by the pest within its current area of invasion?

Major

Level of uncertainty: medium

According to the guidance, environmental impact is major since two high scores and at least

one medium score were obtained in each categories. The level of uncertainty is medium. This outcome is illustrated through the CAPRA matrix on the environmental impact in Figure 6: Q5.08 sub-questions

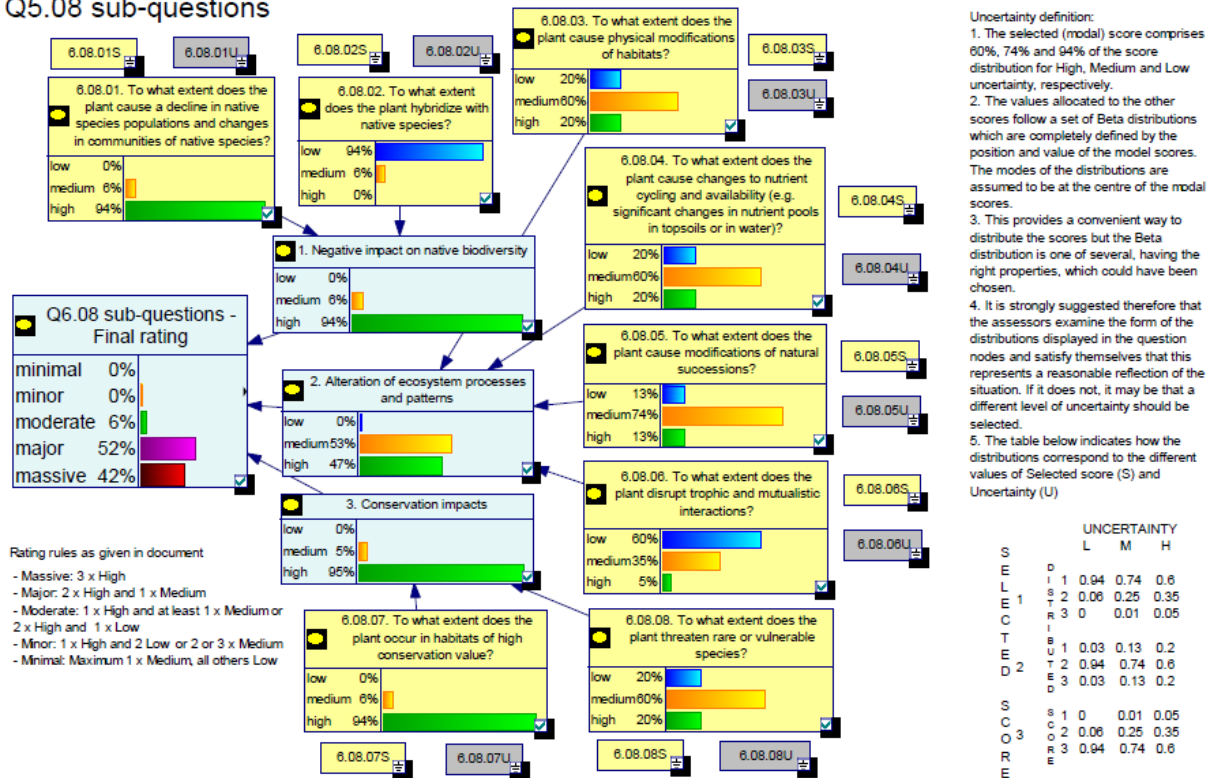


Figure 6: CAPRA Matrix of the overall environmental impact of *B. halimifolia*.

6.09.0a - Taking into account the responses to the relevant questions (on hosts and habitats, climatic conditions, abiotic factors, management methods) in the establishment section, are the conditions in the PRA area sufficiently similar to those in the area of invasion to expect a similar level of impact?

Yes

Level of uncertainty: medium

B. halimifolia already has major impacts in the EPPO region (France and Spain). In the Mediterranean area up to the North of France, impacts will probably be similar.

There are, however, some uncertainties about its behaviour in northern Europe. Indeed, in northern North America, the plant becomes considerably scarce and only a few scattered populations exist in Canada.

6.09.0b - Does the same native species or community, or the same threatened ecosystem services, occur in the PRA area and, if not, is it known whether the native species or communities, or ecosystem service in the PRA area are similarly and significantly susceptible?

Yes

Level of uncertainty: low

The same types of coastal habitats (e.g. wetlands, saltmarshes and heathlands) occur in the endangered area.

6.09 - How important is the environmental impact likely to be in the PRA area?

Major

Level of uncertainty: medium

Since the same types of habitats occur (e.g. coastal saltmarshes, coastal cliffs), the same environmental impacts (i.e major) are assumed to occur in the endangered area.

6.10 - How important is social damage caused by the pest within its current area of distribution?

Moderate

Level of uncertainty: high

Mosquitoes

Establishment of *B. halimifolia* occurs in areas favorable to mosquitoes. Dense thickets of *B. halimifolia* protect mosquito larvae from insecticide treatments and impede access for mosquito control (Bouterin & Canonge, 1999 in Muller, 2004).

Hay fever

B. halimifolia is also reported to cause hay fever-type allergies (Moss, 1967, cited in Panetta, 1979b; De Loach *et al.*, 1986) caused by airborne pollen and seed ‘fluff’ (Anonymous, 2007a). Green *et al.* (2011) performed a survey on the pollen present in the air in Brisbane. They found that in March and April, the highest concentrations of Asteraceae pollen were predominantly derived from *B. halimifolia*. *B. halimifolia* pollen is reported to be severely allergenic (Pollen library Website, <http://www.pollenlibrary.com/>) and to cause symptoms in *Ambrosia artemisiifolia*-sensitive persons (The Asthma and Allergy Foundation of America Website, <http://www.aafa.org/>).

Increased risks of fires

The resin is considered to make *B. halimifolia* highly flammable. Its establishment in fallow lands may increase the fire hazard and threaten security (on industrial sites for instance) (Muller, 2004; Invasive Species in Belgium Website, <http://ias.biodiversity.be/>). However, this has never been observed and such impact is highly uncertain.

Additional difficulties is salt harvest

In Brittany the species was responsible for slowing salt production (by diminishing wind and the evaporation of water), which resulted in economic losses. The species also limits the access to the salt production areas (Observatoire Biodiversité Bretagne Website, <http://www.observatoire-biodiversite-bretagne.fr/>). In addition, the huge number of seeds of *B. halimifolia* increases the insoluble part in the salt production (David, 1999 in Muller, 2004).

6.11 - How important is the social damage likely to be in the PRA area?

Moderate

Level of uncertainty: high

Social impact is assumed to be the same wherever the species grows in suitable conditions in

the endangered area (See 6.10).

As the responses to question 6.04 and 6.05 were "major" or "massive" or any of the responses to questions 6.06, 6.09 and 6.11 is "major" or "massive" or "very likely" or "certain", and the answers given to these questions do not have a high level of uncertainty, questions 6.12 to 6.14 are skipped.

6.15a - Describe the overall economic impact (*sensus stricto*, i.e. excluding environmental impacts)

Moderate

Level of uncertainty: low

B. halimifolia is expensive to control, but it is to be noted that control programmes were undertaken for conservation purposes, as the species has quite a low impact on pastures. The overall economic impact (*sensus stricto*, i.e. excluding environmental impacts) is therefore considered as moderate, with a low uncertainty.

6.15b - With reference to the area of potential establishment identified in Q3.08, identify the area which is at highest risk from economic, environmental and social impacts. Summarize the impact and indicate how these may change in future.

Major

Level of uncertainty: medium

B. halimifolia has major environmental impacts as it threatens native communities and protected habitats.

The habitats in which *B. halimifolia* is found to occur (e.g. saltmarshes, cliffs, wetlands, wet grasslands, etc.) in climatically suitable areas, i.e. the Atlantic and Mediterranean areas are the most at risk.

Anthropogenic habitats in the climatically suitable area are at lower risk, as the impacts in such habitats are lower.

It also has moderate social impacts through provoking pollen allergies and impeding the management of mosquitoes, and is also reported to provoke allergies.

Stage 2: Pest Risk Assessment Section B: Degree of uncertainty and Conclusion of the pest risk assessment

c2 - Degree of uncertainty: list sources of uncertainty

The EWG noted the following uncertainties:

- the trade and use extent of the plant;
- the ability of the species to persist in cold and dry conditions;
- seed longevity ;
- the future rate of spread;
- the impacts at the species level (e.g. on birds);
- the degree of allergenicity.

c3 - Conclusion of the pest risk assessment

The EWG considered that *B. halimifolia* causes major environmental impacts in invaded native communities and protected habitats and potential moderate social impacts through allergies.

As a consequence, *B. halimifolia* qualifies as a quarantine pest.

Stage 3: Pest Risk Management

A decision has to be made to determine whether the risk from any pest/pathway combination is an acceptable risk. This decision will be based on the relationship between the level of risk identified in the pest risk assessment stage (i.e. the combination of the probability of introduction and the potential economic impact) and the importance/desirability of the trade that carries the risk of introduction of the pest.

7.01 - Is the risk identified in the Pest Risk Assessment stage for all pest/pathway combinations an acceptable risk?

No

High spread probability and major environmental impacts are considered a non-acceptable risk.

7.02 - Is natural spread one of the pathways?

Yes

Natural spread through wind- and water-dispersed seeds may occur between non EPPO countries and EPPO countries (e.g. from Georgia to Russia) and between EPPO countries where the species occurs and those where it does not occur (e.g. from Spain to Portugal). *B. halimifolia* is suspected to have entered the Spanish Basque Country through wind dispersal from the French Basque Country.

7.03 - Is the pest already entering the PRA area by natural spread or likely to enter in the immediate future?

The answer to question 4.01 was: **moderate rate of spread**

No

The EWG considered that it is unlikely that additional entries of *B. halimifolia* to the EPPO region would occur in the immediate future.

7.06 - Is the pathway that is being considered a commodity of plants and plant products?

Yes

The pathway is the intentional import of a plant for ornamental and amenity purposes.

7.09 - If the pest is a plant, is it the commodity itself?

Yes

B. halimifolia is the commodity traded as an ornamental and amenity plant.

7.30 - Have any measures been identified during the present analysis that will reduce the risk of introduction of the pest?

No

Level of uncertainty: Medium

Possible measure: Prohibition of the import, selling, planting, holding, movement, causing to grow in the wild of the plant.

7.31 - Does each of the individual measures identified reduce the risk to an acceptable level?

Yes

Level of uncertainty: low

When *B. halimifolia* is not yet established in a country, prohibition of import may be sufficient, but this needs to be combined with surveillance and action plans for early intervention in case the plant is detected.

In countries where the species is only in cultivation, it is likely to spread to unintended habitats, and prohibition of selling, planting, holding, movement, and causing to grow in the wild should be combined with surveillance and action plans for early intervention in case the plant is detected in unintended habitats.

In countries where the species is already established in the wild, the plant is likely to spread from existing populations present both in gardens and in unintended habitats. Prohibition of selling, planting, holding, movement, and causing to grow in the wild should be combined with surveillance and action plans for early intervention in case the plant is detected in unintended habitats, as well as containment and control measures.

7.32 - For those measures that do not reduce the risk to an acceptable level, can two or more measures be combined to reduce the risk to an acceptable level?

Yes

Level of uncertainty: low

National measures

Prohibition of selling, planting, holding, movement, and causing to grow in the wild of the plant in the EPPO region is necessary. Moreover, the plant has to be surveyed and eradicated or contained or controlled where it occurs. In addition, public awareness campaigns to prevent spread from existing garden populations, or from arboreta and botanic gardens in countries at high risk are necessary.

If these measures are not implemented by all countries, they will not be effective since the species could spread from one country to another (along coastal shorelines, as is suspected for the entry of the species in the Spanish Basque Country through wind and water dispersal from the French Basque Country, and as could happen from Spain to Portugal).

National measures have to be combined with international measures, and international coordination of management of the species between countries is necessary.

International measures

Prohibition of import into and within the EPPO region and within the countries of plants labeled as *B. halimifolia* and all other synonyms and misapplied names in use, as well as subspecies.

The combination of measures is:

At the international level: prohibition of import of the species, with the listing of the species as

a quarantine pest.

At the national level:

Prohibition of selling, planting, holding, movement, and causing to grow in the wild of the plant, combined with:

- management plans for early warning;
- obligation to report findings;
- eradication and containment plans;
- public awareness campaigns.

7.34 - Estimate to what extent the measures (or combination of measures) being considered interfere with international trade.

Level of uncertainty: low

The estimated value of the species to the trade is low and interference of the prohibition of the species with trade is considered as low. Several nurseries and garden centers in France have voluntarily removed *B. halimifolia* from sale due to its known invasiveness. This surely proves that sale of the species is not a major economic issue.

Non-invasive substitution plants may be used for the same ornamental and amenity purposes. In France, recommendations in accordance with nursery professionals suggest that *Atriplex halimus*, native from the Mediterranean basin, may be used as a wind break as it is resistant to drought and salt spray. The exotics *Leucophyllum frutescens* and *Xanthoceras sorbifolia* may be used for ornamental purposes (AME & CBNMP, 2003).

7.35 - Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.

Level of uncertainty: medium

Prohibition of the import, selling, planting, movement, causing to grow in the wild

Considering the high costs to control the plant, compared to the benefit its trade generates, the prohibition of the import, selling, planting, movement, and causing to grow in the wild is very cost-effective.

The removal of this species from the trade would not have a significant impact on the retailers as it is not a high volume product.

Nurseries are not familiar with such legislation, nor is the public, but this case could raise general awareness and have beneficial impacts. Non-invasive substitution plants could be proposed. For instance substitution plants have been proposed in France and Belgium (AME & CBNMP, 2003; Alter IAS Website).

Prohibition of holding of the species

Concerning the removal of the species as a cultivated plant (i.e. in gardens and in municipalities, along roads and in roundabouts), detection may be undertaken during the fruiting period. As the species is not a popular ornamental, this removal would only concern a very low number of locations, with minimal social consequences.

When the species has spread to unintended habitats, the prohibition of holding will result in an obligation to eradicate, contain or control the species, which measures may only be feasible in the first stages of infestation.

Containment and control of the species in unintended habitats

Surveillance and delimitation surveys, in addition to control measures, will be necessary to prevent the species from spreading further.

Control of dense populations of the species in unintended habitats is very difficult, and the coordination of all stakeholders may be difficult to achieve, particularly in countries where there are numerous occurrences of the species (e.g. France and Spain).

Some management measures may have detrimental environmental consequences. The use of systemic herbicides in the natural environment would affect the ecosystem, in particular when sprays occur at large scales. Leaving a bare soil after the removal of *B. halimifolia* could enhance the establishment of other invasive alien plants. Good practices for the management of *B. halimifolia* should therefore be followed to minimize undesirable environmental consequences. The Restoration of Habitats of Community Interest in Estuaries of the Basque Country Life project undertaken in the Spanish Basque Country has such aim (LIFE project Website).

7.36 - Have measures (or combination of measures) been identified that reduce the risk for this pathway, and do not unduly interfere with international trade, are cost-effective and have no undesirable social or environmental consequences?

Yes

Prohibition of selling, planting, holding, movement, and causing to grow in the wild of the plant, combined with management plans for early warning, eradication and containment, and public awareness.

7.41 - Consider the relative importance of the pathways identified in the conclusion to the entry section of the pest risk assessment

Intentional import of the plant for ornamental and amenity purposes: high probability, with low uncertainty.

Other pathways such as natural spread, unintentional introduction as a contaminant of vehicles and soil are minor compared to intentional import.

7.42 - 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.

7.43 - 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).

7.44 - If there are no measures that reduce the risk for a pathway, or if the only effective measures unduly interfere with international trade (e.g. prohibition), are not cost-

effective or have undesirable social or environmental consequences, the conclusion of the pest risk management stage may be that introduction cannot be prevented. In the case of pest with a high natural spread capacity, regional communication and collaboration is important.

**7.45 - Summarize the conclusions of the Pest Risk Management stage.
List all potential management options and indicate their effectiveness.
Uncertainties should be identified.**

International measures

Prohibition of import and trade in the EPPO region and within the countries will effectively prevent further introductions into and within the EPPO region.

National measures

Prohibition of the import, selling, planting, holding, movement, and causing to grow in the wild, combined with eradication, containment and control of the plant may effectively prevent further establishment and spread within the EPPO region.

The presence of the plant in unintended habitats represents a particular form of holding that could be difficult to manage, i.e. where large infestations occur.

Sterile cultivars of the plant may be proposed in trade, but the effective sterility of such forms must be proven.

Integrated management plans

Integrated management plans are potentially highly effective if coupled with prohibition measures. Uncertainty concerns commitment to long-term implementation and coordination across different stakeholders and countries.

This would require:

- monitoring/surveillance in the countries where it is invasive or present (Belgium, France, Italy, Spain, the United Kingdom), and surveillance in the countries at risk where it is not reported;
- early warning consisting of exchanging information with other countries, and rapid response;
- control of existing populations;
- public awareness: producers and sellers shall be informed of the problem and work should be undertaken with them to explain the prohibition of the species, and inform consumers. Administrative bodies should also be warned that the plant should not be used as an ornamental or amenity species.

Monitoring and review

Performance of these measure(s) should be monitored in countries to ensure that the aim is being achieved. Monitoring of ongoing eradication campaigns and management activities should also be undertaken.

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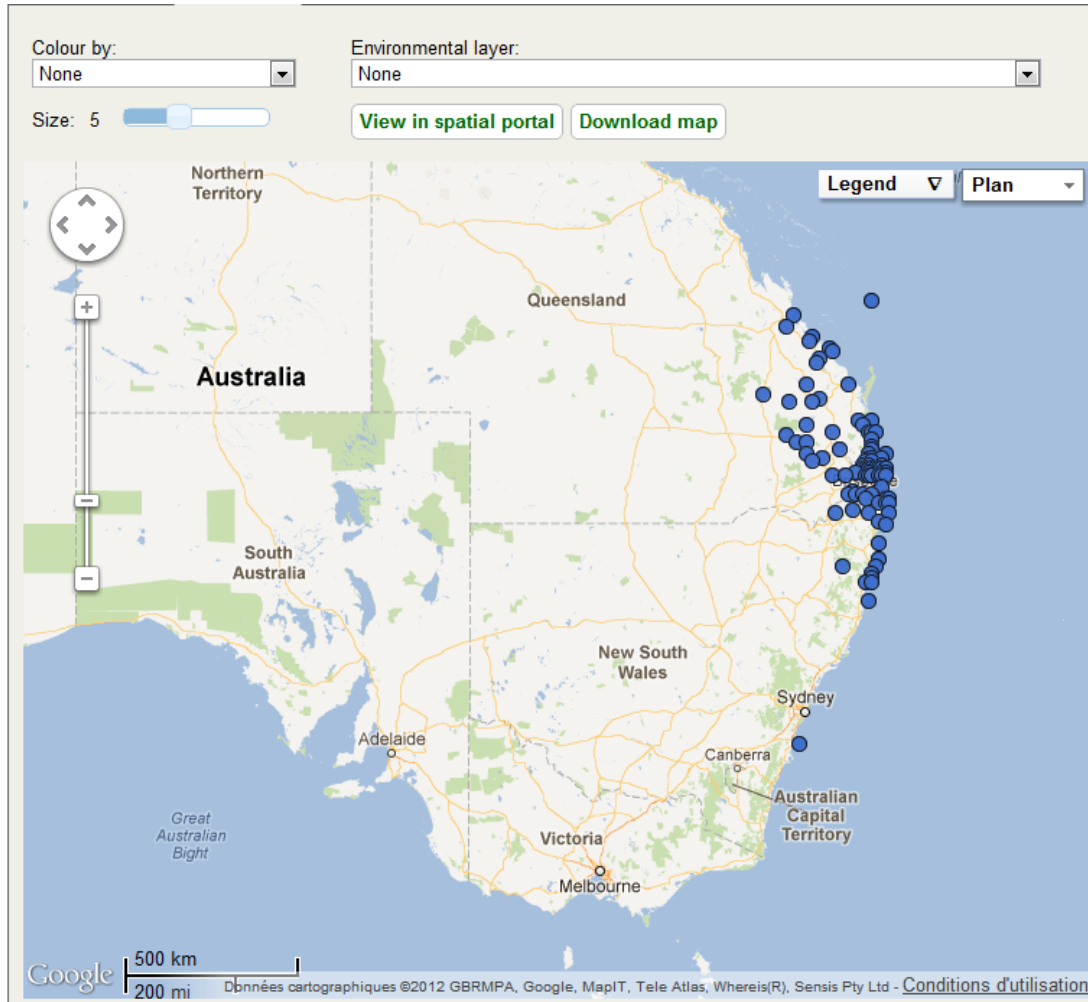
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Appendix 1: Available national distribution maps for *Baccharis halimifolia*

Australia



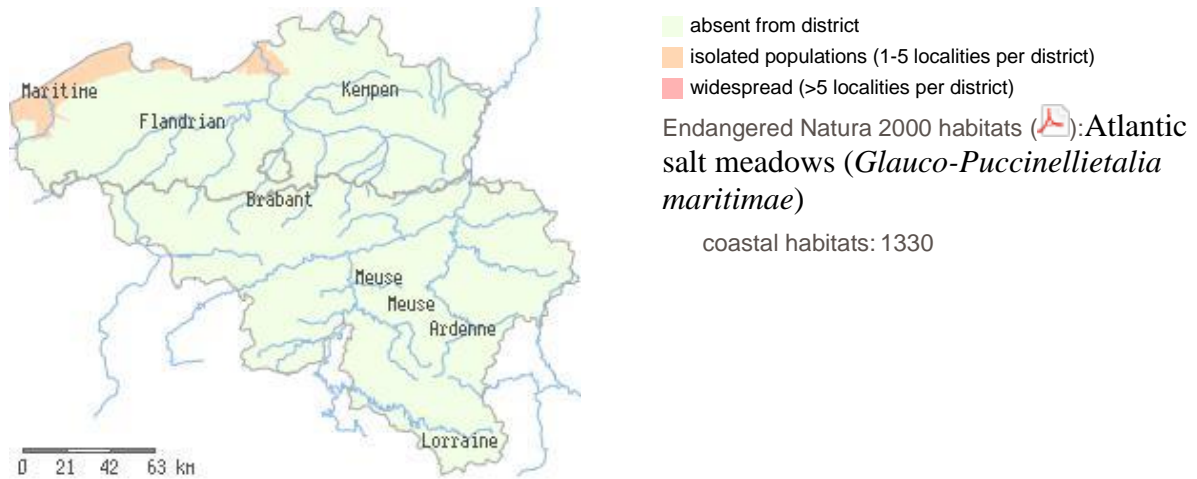
Distribution of *Baccharis halimifolia* in Australia, the occurrences of the species are indicated by blue dots (in Queensland and New South Wales).

Source : Australia's Virtual Herbarium

<http://avh.ala.org.au/occurrences/search?taxa=Baccharis+halimifolia#mapView>

Appendix 1: Available national distribution maps for *Baccharis halimifolia*

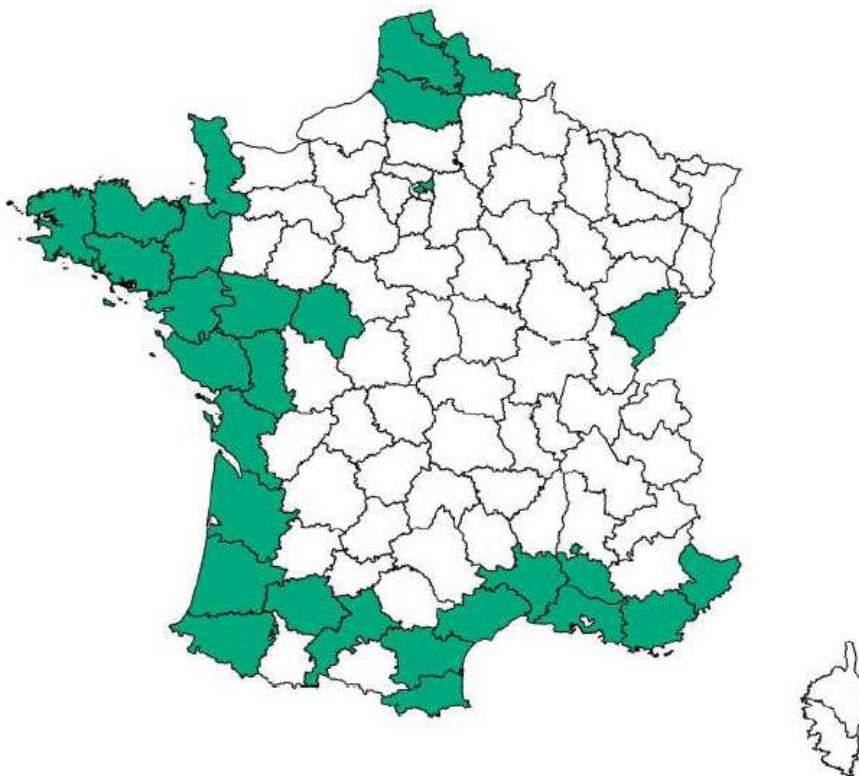
Belgium



Established populations of *Baccharis halimifolia* in Belgium.

Source: Invasive Alien Species in Belgium Website <http://ias.biodiversity.be/species/show/41>

France



Distribution of *Baccharis halimifolia* in France, the species is recorded to occur in the departments indicated in green.

Source: Réseau des CBN, Décembre 2009.

Commission Internationale de suivi et d'échanges d'expériences, 2011.

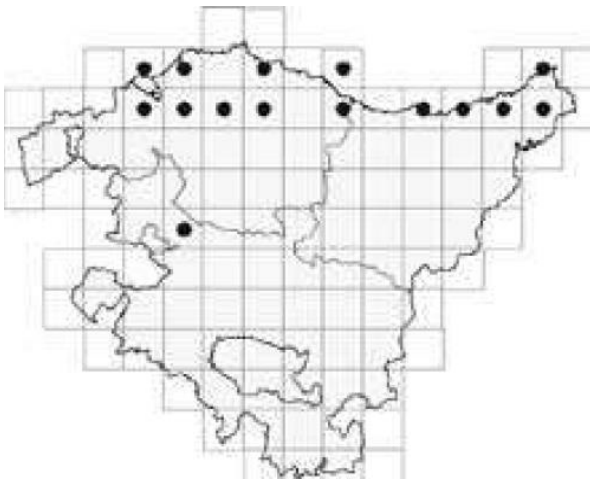
Spain



Distribution of *Baccharis halimifolia* in Spain, the occurrences of the species are indicated by red dots (on the Atlantic coast).

Source : Sanz Elorza M, Dana Sánchez E D & Sobrino Vesperinas E (2004) *Baccharis halimifolia*. In Plantas Alóctonas invasoras en España. Dirección General para la Biodiversidad. Madrid, p 100-101.

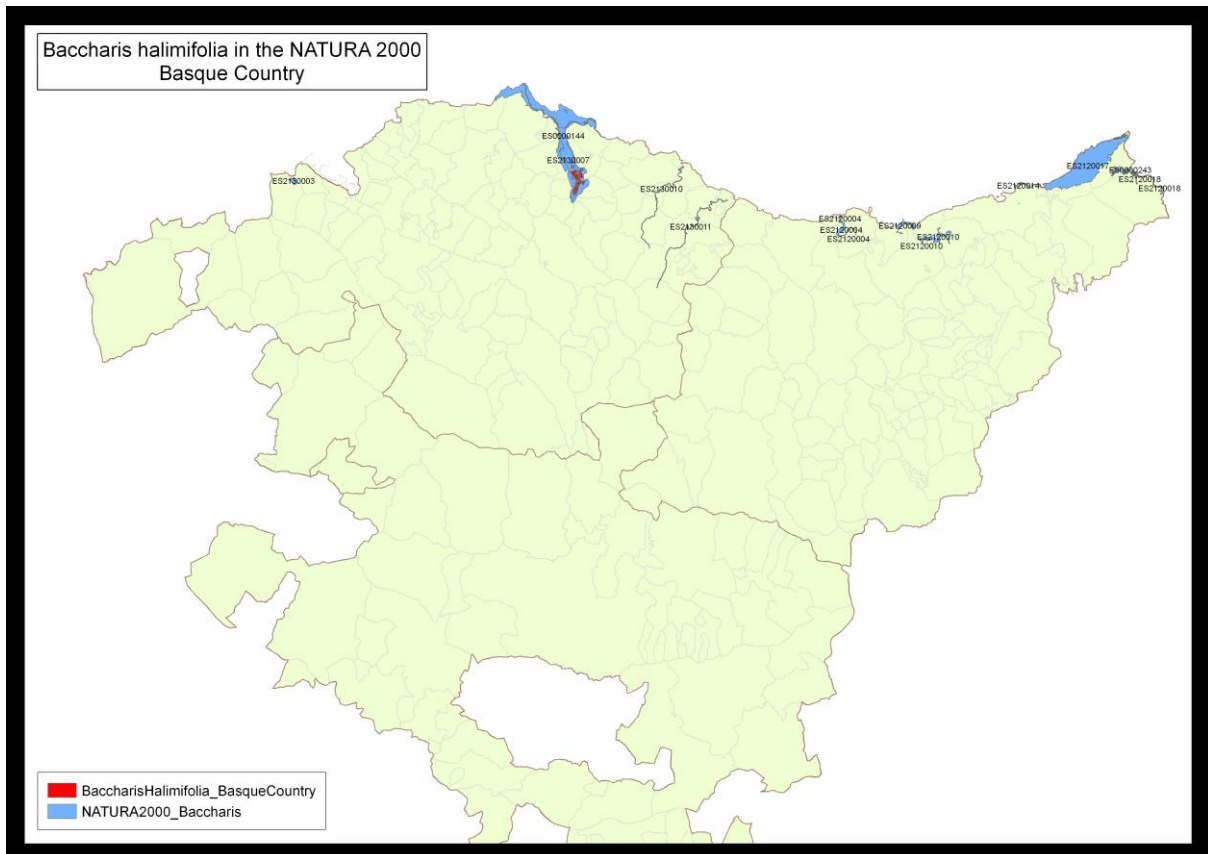
Basque Country



Distribution of *Baccharis halimifolia* in Basque Country.

Source: Diagnóstico de la Flora alóctona invasora de la CAPV. Ihobe. Commission Internationale de suivi et d'échanges d'expériences, 2011.

Appendix 1: Available national distribution maps for *Baccharis halimifolia*




Distribution of *Baccharis halimifolia* in Natura 2000 sites in the Basque Country.
Source: Life project on *Baccharis halimifolia* in Basque Country.

United Kingdom

10km distribution of *Baccharis halimifolia* in Great Britain and Ireland



10km square legend

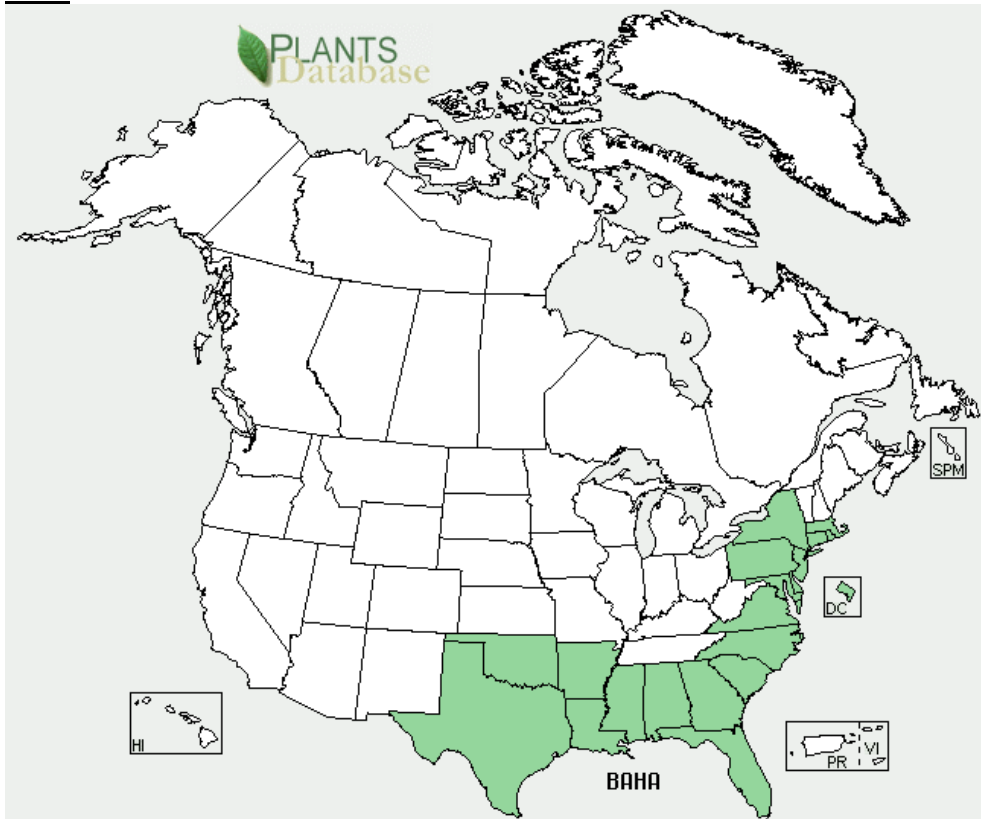
 Present in 10km squares

© Crown copyright and database rights
2011 Ordnance Survey [100017955]

Source: GB Non-native Species
Information Portal

<http://data.nbn.org.uk/gridMap/gridMapLarge.jsp#topOfMap>

USA



Distribution of *Baccharis halimifolia* in the USA, the species is recorded to occur in the States indicated in green.

See U.S. county distributions (when available) by clicking on the map or the linked states below:

USA ([AL](#), [AR](#), [CT](#), [DC](#), [DE](#), [FL](#), [GA](#), [LA](#), [MA](#), MD, [MS](#), [NC](#), [NJ](#), [NY](#), OK, [PA](#), [RI](#), [SC](#), [TX](#), [VA](#))

Source: United States Department of Agriculture – Natural Resources Conservation Service

<http://plants.usda.gov/java/profile?symbol=BAHA>

Appendix 2: Climatic projections for *Baccharis halimifolia*

1. Geographical distribution of *Baccharis halimifolia*

B. halimifolia is a perennial shrub growing up to 5 m originating from Central and North America and the Caribbean. It grows vigorously under wet tropical and sub-tropical conditions.

The distribution of the species was assembled from various sources (including the CABI, 2012), and is as follows:

Native distribution:

North America: Canada (Nova Scotia), Mexico (Mexico, Nuevo Leon, San Luis Potosi, Tamaulipas, Veracruz; Flora of North America Website), the USA (Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Louisiana, Maryland, Massachusetts, Mississippi, New Jersey, New York, North Carolina, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Texas, Virginia, West Virginia; Flora of North America Website).

Caribbean: Bahamas (Correl & Correl, 1982), Cuba (USDA-ARS Website; Weber, 2003).

Note: In Canada, *B. halimifolia* reaches its northern limit range and it is considered as an extremely rare disjunct Atlantic Coastal Plain species, known only from in and near the Tusket River estuary. There are programmes for legal protection and effective conservation (Nova Scotia Website, Species at Risk Conservation Fund 2009 Approved Projects).

Exotic distribution:

Oceania: Australia (Queensland, New South-Wales), New-Zealand (South Island).

Note: in New Zealand, according to Webb *et al.* (1988), the species was recorded as locally established on Banks Peninsula (Canterbury) only: Evans Pass, Lyttelton, Victoria Park and Barrys Bay. There are approximately 40 known sites that are monitored and consist mostly of old, scattered plants on the Porthills area near Sumner. The aim of the management actions where the species is present is eradication (Lynne Huggins, Department of Conservation, New Zealand, pers. comm., 2012). *B. halimifolia* has been declared an unwanted organism under the New Zealand Biosecurity Act 1993, which makes it illegal to knowingly release, spread, display or sell, breed, propagate or otherwise distribute plants or part thereof.

In Australia, the species is considered noxious and is regulated in Queensland and New South Wales (as well as in Northern Territory where it is not recorded as present) (Weeds Australia Database <http://www.weeds.org.au/noxious.htm>).

Asia: Georgia (in Abkhazia, on the eastern coast of the Black Sea) (Westman *et al.*, 1975; Kikodze *et al.*, 2010).

EPPO Region: Belgium (Verloove, 2008), France (Thellung, 1916; Muller, 2004), Italy (Zanetti, 1997; Arrigoni & Viegi, 2011), Spain (Allorge, 1941), and the UK (Clement & Foster, 1994).

Note: the species had been recorded in the Netherlands but is not present anymore in this country (van Valkenburg *et al.*, 2013). The plant is also recorded as planted in the Ataturk arboretum in Istanbul, but has so far not been recorded in the wild (IOBM, 2012).

See the Appendix 1 of the PRA for available distribution maps.



Figure 1: World distribution of *Baccharis halimifolia* according to the GBIF.

This map is incomplete for data in Canada (Nova Scotia), and Italy, and the distribution point south of Ghana in the Atlantic Ocean must be a mistake.

The species is considered to be resistant to -15°C (Huxley, 1992 in Muller, 2004).

2. World Map of Köppen-Geiger Climate Classification

According to the World Map of Köppen-Geiger Climate Classification (Kottek *et al.*, 2006, see Figure 2), *B. halimifolia* occurs mainly in Cfa climate type (warm temperate climate, fully humid with hot summer) as well as in Aw climate type (equatorial, winter dry) in Florida. In Australia, it also occurs in both Cfa and Cfb climate types (Oceanic climate).

The largest part of the EPPO region is under Cfb, Csa (Hot-summer Mediterranean climate) and Csb (Warm-summer Mediterranean climate) climate types, and are therefore suitable for the establishment of *B. halimifolia*.

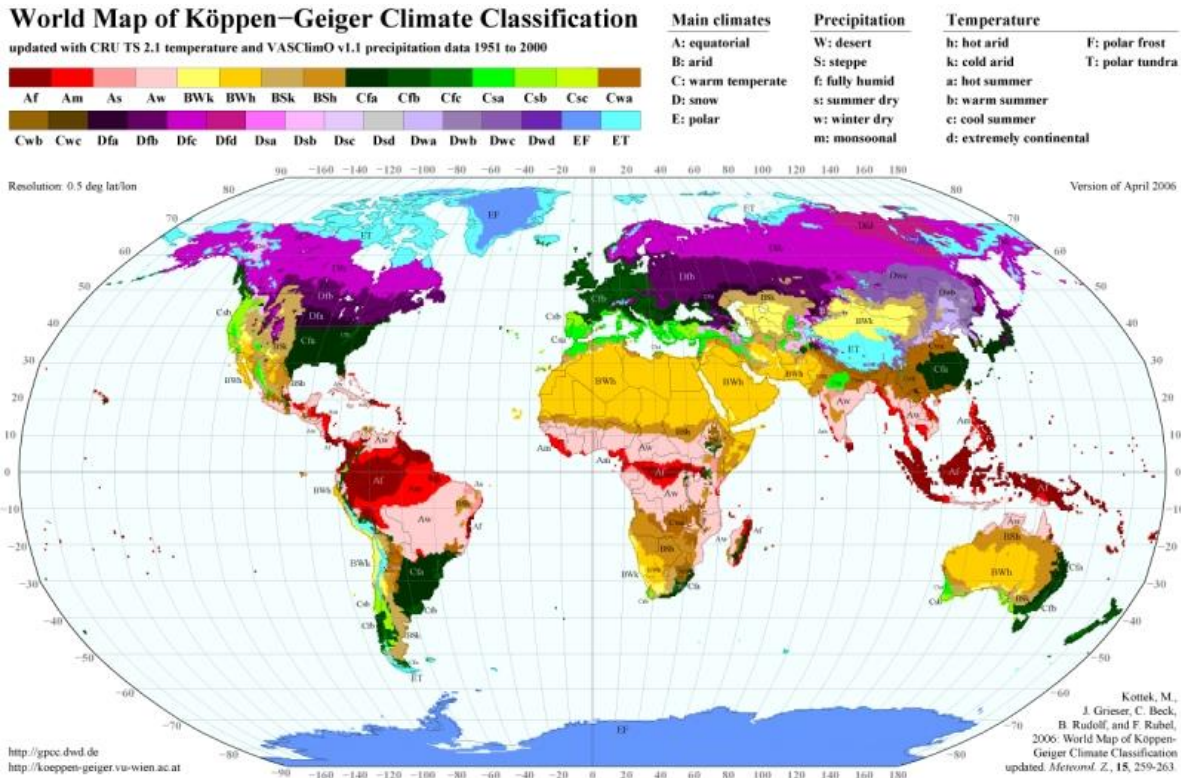


Figure 2: Köppen-Geiger Climate Classification map according to Kottke *et al.* (2006).

3. CLIMEX Projections

The CLIMEX model is a computer programme aiming at predicting the potential geographical distribution of an organism considering its climatic requirements. It is based on the hypothesis that climate is an essential factor for the establishment of a species in a country.

For *B. halimifolia*, a compare location analysis had been undertaken by Sims-Chilton *et al.* (2010). The parameters have been inferred on the basis of the native distribution of the species in North America, and have been checked against the introduced range of the species. A native range model for the species was developed by initially using the sub-tropical template provided by CLIMEX and iteratively modifying temperature, moisture and stress parameters. The model was then validated using an independent dataset of known distributions in Europe (in France and Spain). A survey of the species in Australia throughout South-East Queensland and northern New South Wales was also undertaken, to obtain further distribution data to validate the model.

The parameters were set as shown in Figure 3, according to Sims-Chilton *et al.* (2010).

CLIMEX - Compare Locations (1 species) - [Parameters: Baccharis halimifolia]						
File View Initialization Execution Preferences Window Help						
Edit Comments... Copy to Clipboard						
Moisture Index						
SM0	SM1	SM2	SM3			
0.3	0.6	1.5	2.5			
Temperature Index						
DV0	DV1	DV2	DV3			
5	12	27	35			
Light Index						
Diapause Index						
Cold Stress						
TTCS	THCS	DTCS	DHCS	TTCSA	THCSA	
-4	-0.009	0	0	0	0	
Heat Stress						
TTHS	THHS	DTHS	DHHS			
38	0.015	0	0			
Dry Stress						
SMDS	HDS					
0.2	-0.01					
Wet Stress						
SMWS	HWS					
3	1					
Cold-Dry Stress						
Cold-Wet Stress						
Hot-Dry Stress						
Hot-Wet Stress						
Day-degree accumulation above DV0						
DV0	DV3	MTS				
5	35	7				
Day-degree accumulation above DVCS						
DVCS	*DV4	MTS				
0	100	7				
Day-degree accumulation above DVHS						
DVHS	*DV4	MTS				
0	100	7				
Degree-days per Generation						
FDD						
0						

Figure 3: CLIMEX parameters for *Baccharis halimifolia* according to Sims-Chilton *et al.* (2010).

3.1 Climatic projection in the native range

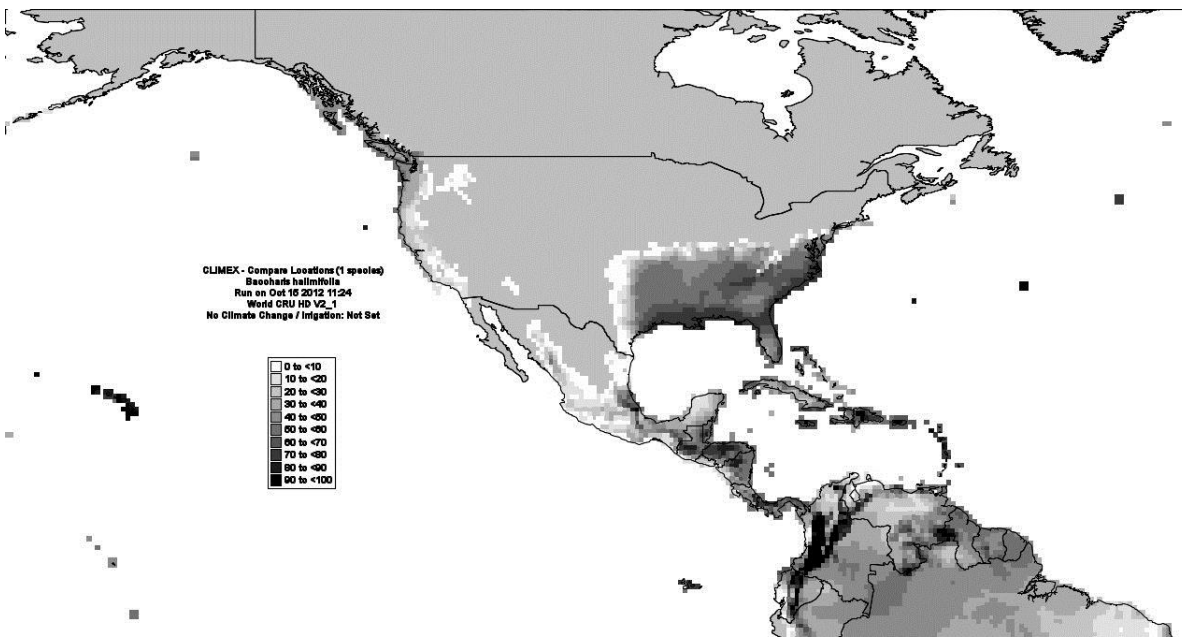


Figure 4: Potential distribution of *Baccharis halimifolia* in its native range in North America with CLIMEX according to Sims-Chilton *et al.* (2010).

The parameters model very well the current distribution of the species in South-Eastern North America, as shown in Figure 4.

The species is present in Nova Scotia in the Tuskent River estuary, and this represents the most northern distribution of the species, where the species is the object of a conservation plan (<http://www.gov.ns.ca/natr/wildlife/conservationfund/2009projects.asp>). This record does not appear on the

projection map, as it is assumed that such a record occurs in a protected location of the estuary, and that such detailed climatic subtlety is not taken account of in the climatic data.

3.2 Climatic projection for the world

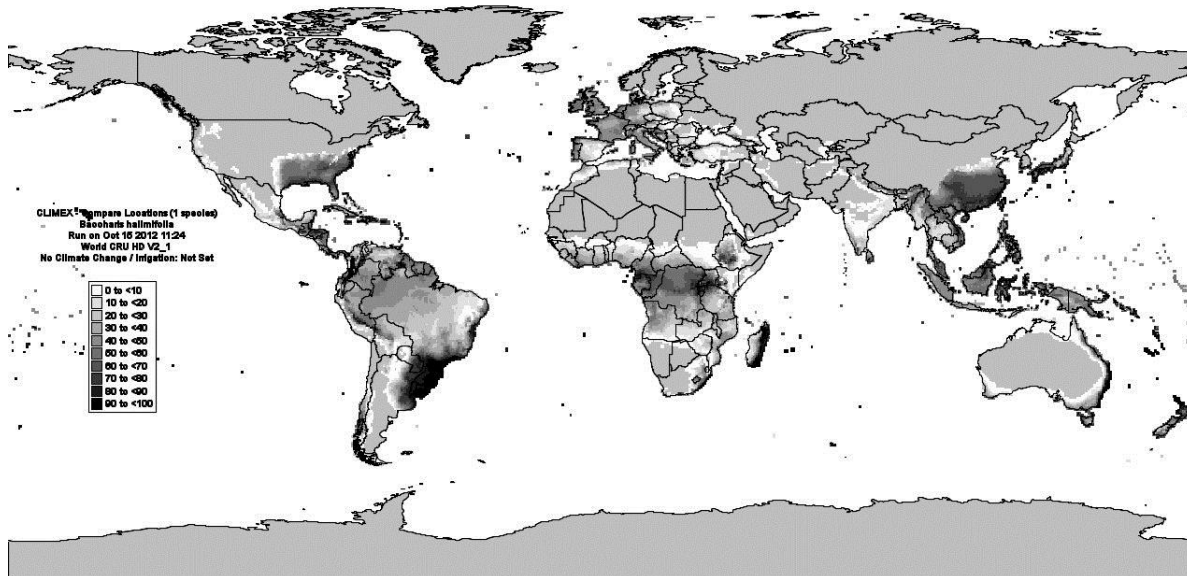


Figure 5: Potential distribution of *Baccharis halimifolia* in the world with CLIMEX according to Sims-Chilton *et al.* (2010).

The projection for the world fits well with the known distribution of the species in Australia, as shown in Figure 5.

3.3 Climatic projection for the EPPO region

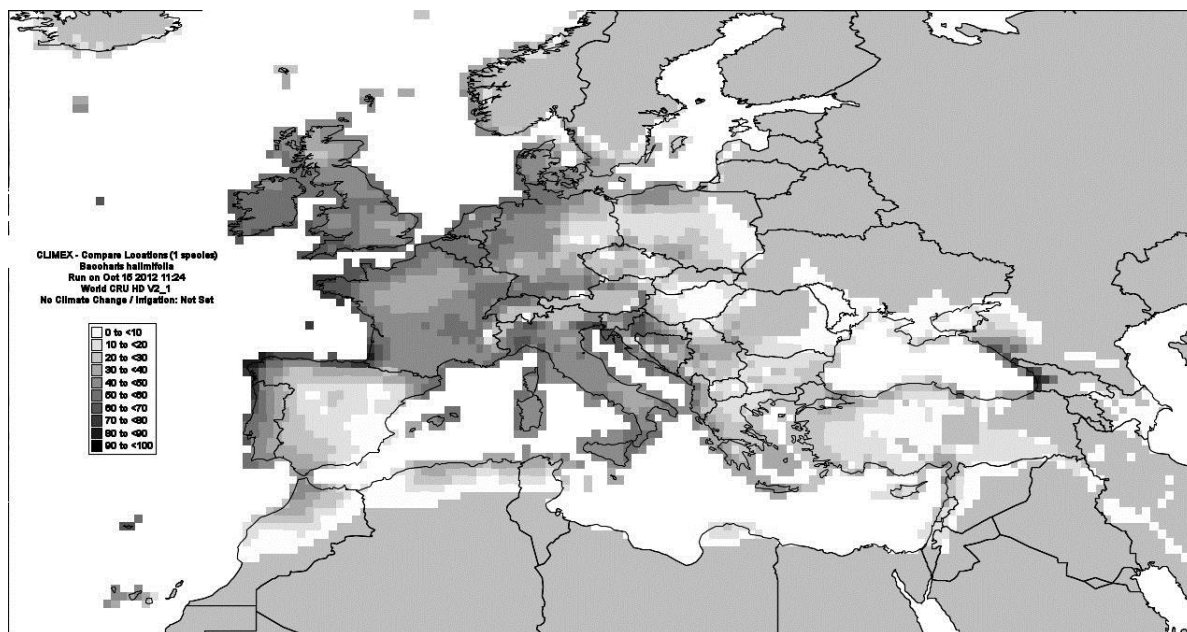


Figure 6: Potential distribution of *Baccharis halimifolia* in the EPPO region with CLIMEX according to Sims-Chilton *et al.* (2010).

The projection in the EPPO region fits with the known distribution of the species (north of Spain, France, Belgium), and it far exceeds its current distribution, as shown in Figure 6.

The countries considered most at risk by *B. halimifolia* according to the Sims et al. (2011) CLIMEX projection map are the following: Algeria, Austria, Belgium, Bosnia & Herzegovina, Croatia, Cyprus, the Czech Republic, Denmark, Former Yugoslav Republic of Macedonia, France, Georgia, Germany, Greece, Ireland, Italy, Montenegro, Morocco, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tunisia, Turkey, the United Kingdom.

Other countries considered to be exposed to a lower risk by *B. halimifolia* are: Azerbaijan, Israel, Jordan, Lithuania, Moldova and Ukraine.

The projected distribution largely encompasses the current distribution of the plant, and some uncertainties remain on the ability of the plant to thrive and be invasive in northern EPPO countries. For instance, *B. halimifolia* had been found in one site in the Netherlands on sand dunes, but the species did not persist. There are two hypotheses: either the plants did not survive the cold winters, or they could not compete with the native community dominated by *Hypophae rhamnoides* (Van Valkenburg *et al.*, 2013 submitted).

4. Maxent projections

4.1 Data sets used

The correlative niche modelling method of Maxent was used to predict the geographic distribution of *B. halimifolia* in the EPPO Region. The Worldclim climatic datasets were used with the following predictor variables: minimum, mean, and maximum monthly temperatures, monthly rainfall, and the 18 Bioclim variables (see <http://www.worldclim.org/bioclim> for full details).

Eight hundred and ninety one (891) worldwide locations of *Baccharis halimifolia* were extracted from the GBIF database, excluding locations in Europe (see Figure 1). The WorldClim data set, including monthly minimum, mean and maximum temperature, precipitation and the 18 Bioclim variables was at a 2.5 arc² min resolution scale.

4.2 Results

The Maxent projection in Europe fits well the area where *B. halimifolia* is the most invasive: Basque Country in Spain and France. The model also predicts well the existing locations on the eastern part of the Black Sea (Georgia). However, some areas where *B. halimifolia* is already established are predicted with a low probability (e.g. South Brittany, Mediterranean part of France), as shown in Figure 7.

2 A minute of arc, arcminute, or minute arc (MOA), is a unit of angular measurement equal to one sixtieth (1/60) of one degree (circle/21,600), or ($\pi/10,800$) radians. 2.5 arc min correspond roughly to 5 km spatial resolution.

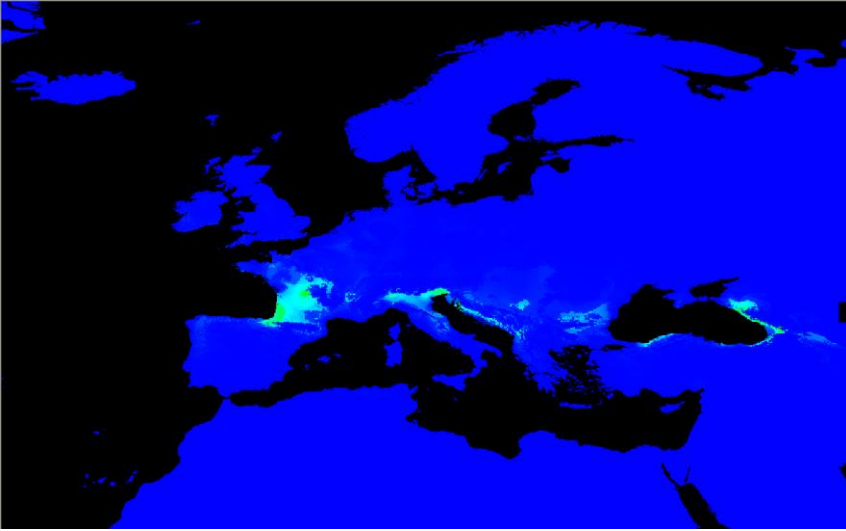


Figure 7: Potential distribution of *Baccharis halimifolia* in the EPPO region according to Maxent.

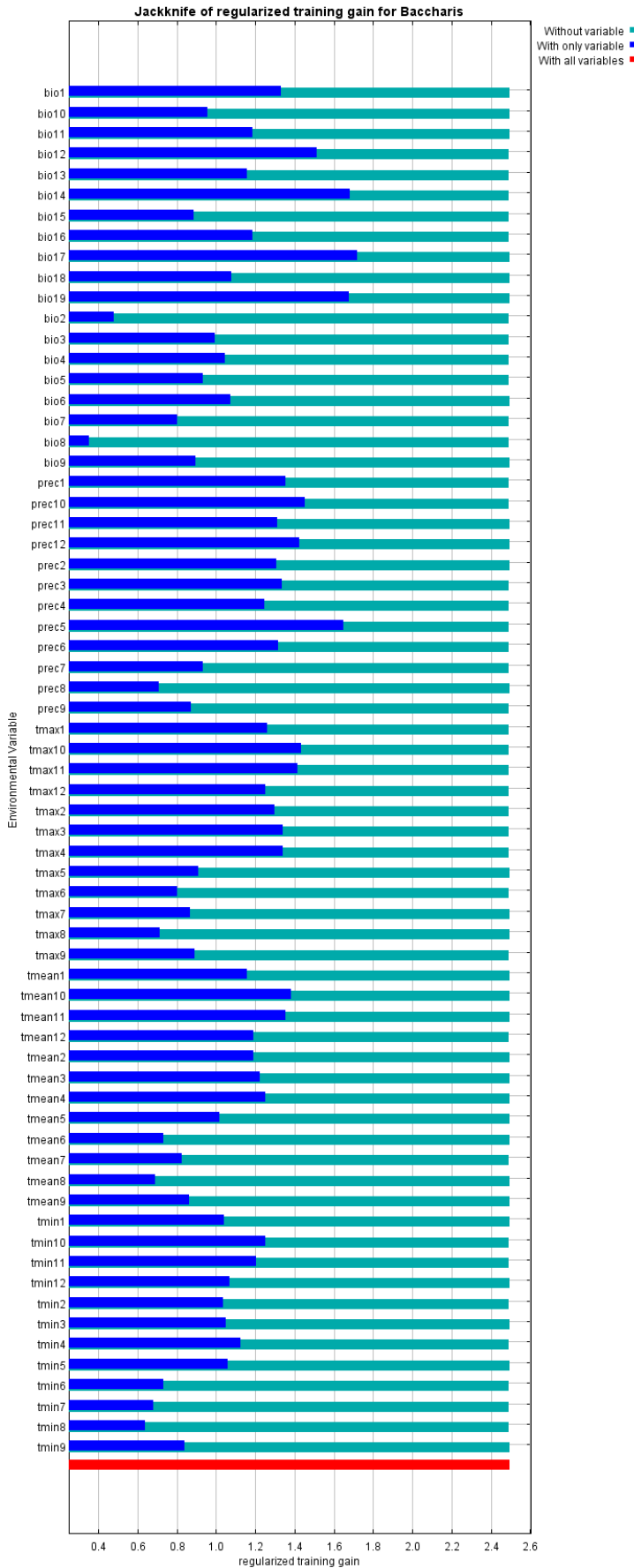
This model should be taken with caution as the projection is very conservative and may underestimate some areas of potential establishment of the species. The countries considered to be at risk with the Maxent model are: Bosnia & Herzegovina, Croatia, France, Georgia, Italy, Montenegro, Romania, Serbia, Slovenia, Spain, Russia and Turkey. The results can nevertheless be used to identify areas where the climate is the most similar to the area of origin, which are considered to be the most at risk.

The outputs of the model Maxent also include a function to visualize the contribution of each climatic variable through a jackknife test³ (Figure 8). The procedure is as follows: in a first step, a number of models are created through this jackknife test. Each variable is excluded in turn, and models are created with all the N-1 remaining variables. In a second step, models are created using each variable in isolation. A model is finally created using all variables.

Figure 8: Jackknife test of important variables with Maxent. The darker blue bars show the environmental variable with highest gain when used in isolation (which is here the precipitation in the driest quarter: bio17 and which therefore appears to provide the most useful information by itself). The lighter blue bars show the amount of useful information which is not already contained in the other variables. Here, all lighter blue bars have about the same values, meaning that omitting each variable in turn did not decrease the training gain considerably.

³ Jackknifing is a resampling statistical method, used to estimate the bias and standard error (variance) of a statistic. The Jackknife test uses a random sample of observations for the calculation.

Appendix 2: Climatic projections for *Baccharis halimifolia*



This jackknife test clearly shows that the regime and amount of precipitation are important parameters, as well as temperature, especially in autumn during flowering and seed maturation. The most suitable areas

have, among other characteristics: at least 200-350 mm rainfall during the driest quarter, 100-180 mm during May, an annual rainfall ranging between about 1000 and 2000 mm, and maximum temperature in October averaging between 10 and 20°C (according to the important variables identified in Figure 9).

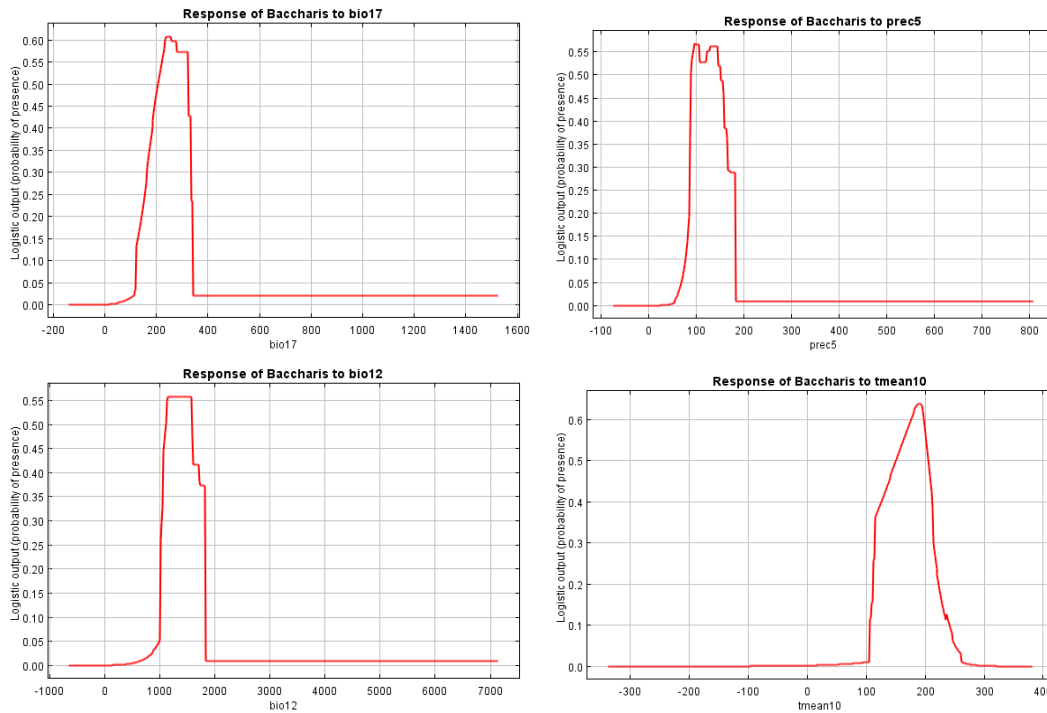


Figure 9: *Baccharis halimifolia* response to a) precipitation of the Driest Quarter (bio 17), b) precipitation in May (prec 5), c) mean annual amount of precipitation (bio 12), d) maximum temperature in October (tmean 10). Each of the curves represents a different Maxent model created using only the corresponding variable. Units: mm for precipitation, °C x 10 for temperature. (These plots reflect the dependence of predicted suitability both on the selected variable and on dependencies induced by correlations between the selected variable and other variables.)

5. GBIF Niche model

The GBIF Niche model provides an integration between openModeller and the occurrence point data available within the GBIF portal. Its main purpose is to demonstrate the integration of GBIF-mediated occurrence data with other applications like modelling tools.

All the parameters were retained to run the model as they are all considered to be influential in the distribution of the species, as demonstrated with the Maxent model (Annual mean temperature, Mean diurnal range, Isothermality, Temperature seasonality, Maximum temperature of warmest month, Minimum temperature of coldest month, Temperature annual range, Mean temperature of wettest quarter, Mean temperature of driest quarter, Mean temperature of warmest quarter, Mean temperature of coldest quarter, Annual precipitation, Precipitation of wettest month, Precipitation of driest month, Precipitation seasonality, Precipitation of wettest quarter, Precipitation of driest quarter, Precipitation of warmest quarter, Precipitation of coldest quarter).

The following map was obtained with the GBIF Niche model (Figure 10), on the basis of the distribution records provided by GBIF (available at [http://data.gbif.org/occurrences/searchWithTable.htm?c\[0\].s=20&c\[0\].p=0&c\[0\].o=3129663](http://data.gbif.org/occurrences/searchWithTable.htm?c[0].s=20&c[0].p=0&c[0].o=3129663), and displayed in Figure 1).

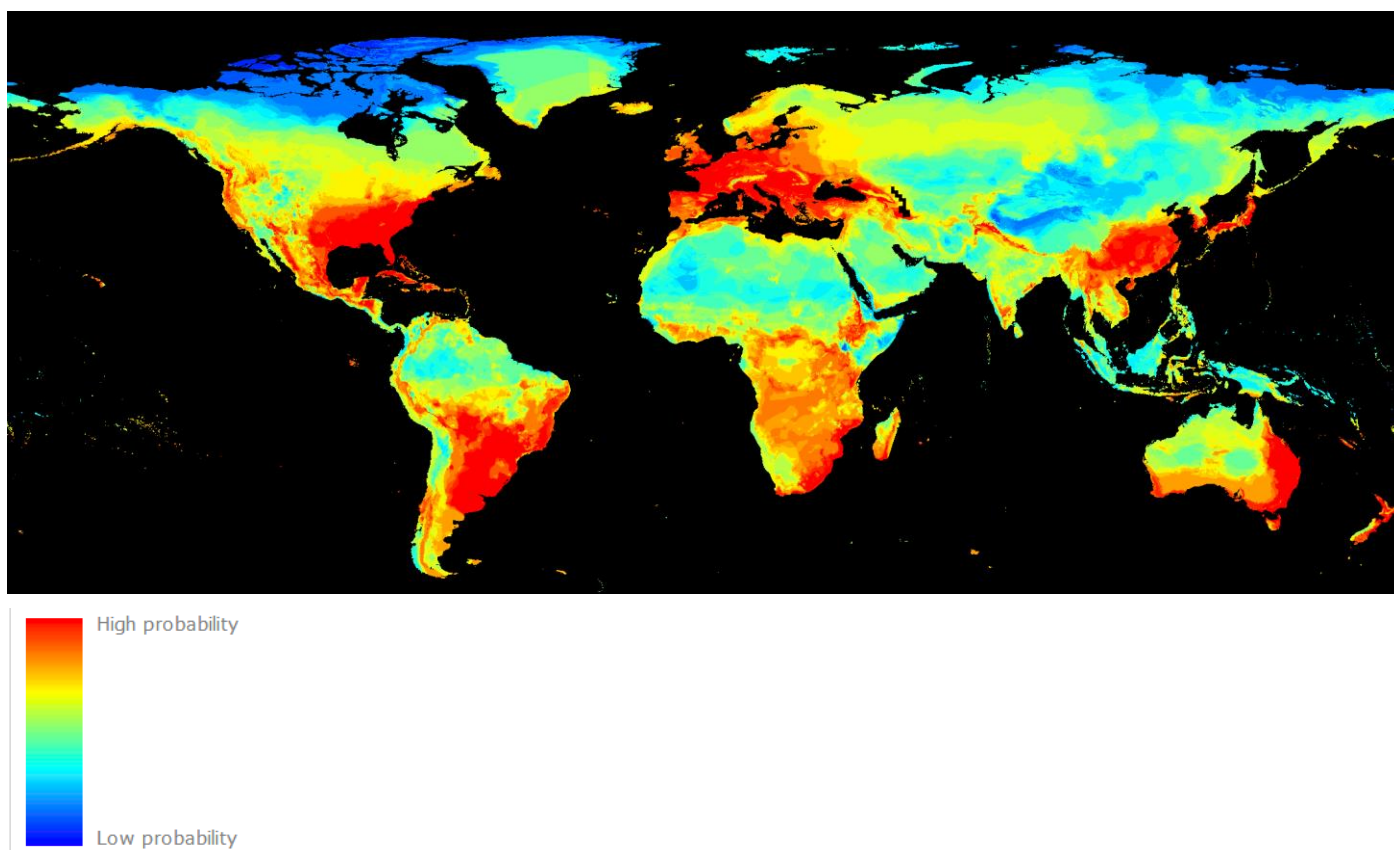


Figure 10 : GBIF Niche model using Openmodeller and the GBIF distribution points.

This Niche model projects a quite large distribution of the species, but which is very similar to the CLIMEX projection. Such model therefore confirms that the species is considered to be able to establish in the EPPO region, in particular in the Mediterranean European countries, in Atlantic Western Europe, as well as in Central Europe.

6. Conclusion on the countries at risk from *B. halimifolia*

The potential distribution of *B. halimifolia* was projected with the software CLIMEX using the parameters of a previous study undertaken by Sims-Chilton *et al.* (2010), as well as with MAXENT and the GBIF Niche model.

The Maxent projection map is identifying a very limited endangered area which may be an underestimate. The CLIMEX and GBIF Niche Model projection maps are concordant, although the EWG considered that the CLIMEX projection maps provided by Sims-Chilton *et al.* (2010) may overestimate the potential range of the species in the EPPO region, particularly in northern countries. Uncertainties remain on the cold and drought resistance of the species.

According to both climatic requirements and habitat preferences, the following coastal areas would be most at risk from the plant:

- the **Atlantic coast**, from north of Morocco to Scotland (including France, Ireland, Portugal, Spain, the United Kingdom);
- the **Mediterranean Basin**: Albania, Bosnia & Herzegovina, Bulgaria, Croatia, Cyprus, Former Yugoslav Republic of Macedonia, France (Mediterranean part), Greece, Italy, Montenegro, Romania, Serbia, Slovenia, Slovakia, Spain (Mediterranean part), Turkey (Mediterranean part). The Southern Mediterranean coast may be too dry for the species to thrive, but may still be at risk: Algeria, Israel, Jordan, Morocco, Tunisia.

- the eastern part of the **Black Sea**: Georgia, Turkey, Russia.

Uncertainty remains on the ability of the species to thrive under colder and arid climates, and the following areas are considered to be less suitable but may still be at risk:

- the **North Sea coast** (including Belgium, the Netherlands, Germany) ;

- from Denmark to Poland, and in the south of Sweden on the **Baltic sea coast**.

- **temperate areas**: Austria, Azerbaijan, the Czech Republic, Denmark, Germany, Hungary, Lithuania, Moldova, the Netherlands, Poland, Serbia, Slovakia, Switzerland, Ukraine as well the Scandinavian and Baltic coasts of Finland, Norway and Sweden.

- **arid areas**: Azerbaijan, Israel, Jordan.

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