Baccharis halimifolia *is useful as a hedge or border as well as a specimen plant. © Archive of Institute Symbiosis.*

The management of Eastern baccharis (*Baccharis halimifolia*)

Measures and associated costs

Scientific name(s)	*Baccharis halimifolia* L.
Common names (in English)	Eastern baccharis
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Common names

BG	Крайморски бакхарис
HR	Istočnoamerički baharis
CZ	Pomíšenka nepitolistá
DA	Ørkenskorsrod
NL	Struikaster
EN	Eastern baccharis
ET	Soolak-puisaster
FI	Pilvisutilatva
FR	Séneçon en arbre
DE	Kreuzstrauch
EL	Βάκχαρη
HU	Tengerparti seprűcserje (borfa)
IE	–
IT	Baccharis a foglie di alimo
LV	–
LT	Pajūrinė varva
MT	–
PL	Komarnik wirginijski
PT	Vassoura
RO	–
SK	–
SL	Vzhodni bakaris
ES	Bácaris
SV	Saltbaccharis

Summary of the measures, emphasizing the most cost-effective options.

Baccharis halimifolia L. (Asteraceae), groundsel bush, is a broad-leaved shrub native to the coastal area of south eastern North America. It was introduced in Europe for ornamental and amenity purposes during the nineteenth century, and has since become naturalised in several coastal habitats, as well as in disturbed areas of western Europe. The shrub is now common on the Atlantic coast of Europe, from northern Spain to Belgium, and is an emerging problem on the Mediterranean coast.

In order to prevent secondary spread of the species, targeted engagement with public who have planted individuals of *B. halimifolia* in gardens can be implemented to raise awareness among the general public (and the local authorities) on how to eliminate it and how to cleanly dispose of plant material. It is also important to prevent unintentional dispersal of plant material during control actions of *B. halimifolia* in invaded sites. Protection, maintenance and/or creation of natural habitat can also prevent new establishment of *B. halimifolia*, usually favoured by disturbance. Visual inspection of existing populations in areas of likely introduction(nurseries, gardens and surrounding areas), in surveillance zones around the invaded areas, along canals or roadsides, and in non-invaded areas with high value for nature conservation (estuaries, coastal wetlands, saltmarshes, humid prairies, cliffs) allows early detection and rapid eradication of the species.

High seed production, long-distance dispersal by wind and the stimulation of germination upon exposure to light make management of this species difficult. If detected very early, young plants (<2 years) can be controlled prior to reproduction, rendering the measure most likely to be successful. Manual control, mechanical excavation and chemical control can be used for eradication of small populations. Manual control has minimal side effects and is particularly relevant for small infestations of young individuals (< 2 years and < 50 cm). Mechanical excavation is best suited for larger-sized isolated adult individuals but will have significant unintended effects through soil disturbance. There are several ways of using chemical control against *B. halimifolia*: foliar spraying is advised for monospecific stands of medium-sized individuals, but it has negative side effects on non-target species, it can contaminate soil and water, and it is negatively perceived by the public. In cases where *B. halimifolia* is mixed with native vegetation, or is located near water bodies, injection of herbicides or application on stumps after cutting or by putting dressings on cuts are efficient alternatives with fewer side effects.

For management of widespread populations, integrated control is the preferred control method (especially a combination of mechanical and manual control). This measure has resulted in good control efficacy in the West and Southwest of France, where large-sized populations scattered over several dozen hectares have been almost eradicated in several distinct sites. Locally, when no other measure is possible, *B. halimifolia* can be managed by removal of stumps and coverage of the tree root by a black plastic (400-gauge) retained with ropes. This measure is, however, considered too expensive and labour-intensive, and cannot be applied on large areas. When there is no funding for a larger control operation, selective cutting of female inflorescences before fruiting and dispersal stages can be used to contain the species. To maintain populations at low densities, grazing or classical biological control can also be applied. Grazing is particularly relevant after mechanical control, to manage the resprouts of *B. halimifolia*. Classical biological control would need a long selection process for a relevant biological control agent, as well as risk assessment and authorisation of release from relevant authorities in each EU country. Its application in Australia has shown that classical biological control can succeed in reducing densities of *B. halimifolia* and its associated impacts.

B. halimifolia demonstrates an important regeneration capacity via resprouting. This makes burning and clearing ineffective (these measures are not further detailed in this technical note) and herbicide application must be made on stumps, not on branches. The high resprouting capacity requires correct treatment of waste after a control intervention. In addition, since *B. hamilifolia* has a transient seed bank with a seed longevity of at least 2 years, any management operation must be followed by monitoring for at least 2–3 years.

Accessibility to areas targeted for management should be checked with great care. As *B. halimifolia* is established in marshes and cliffs, this is a very important factor to consider when planning actions and forecasting costs. Some tasks will also require exceptional means, such as boats, vertical works, etc. Working in marshes and estuaries involves planning the necessary actions depending on the tides. Many areas will be more or less accessible at different seasons and hours of the working day. Accessibility issues can also occur in areas of complex terrain, such as coastal cliffs. Access affects both the workers themselves, but also the specific equipment needed to do the work, or the waste management, if required.

Measures for preventing the species being introduced, intentionally and unintentionally.

This section assumes that the species is not currently present in a Member State, or part of a Member State's territory.

A ban on importing (pre-border measure), selling, breeding, growing, and cultivation, as required under Article 7 of the IAS Regulation, targeting intentional introduction of plants and propagules of *B. Halimifolia*.

MEASURE DESCRIPTION

As the species is listed as an invasive alien species of Union concern, the following measures will automatically apply, in accordance with Article 7 of the EU IAS Regulation 1143/2014:

Invasive alien species of Union concern shall not be intentionally:

(a) brought into the territory of the Union, including transit under customs supervision;
(b) kept, including in contained holding;
(c) bred, including in contained holding;
(d) transported to, from or within the Union, except for the transportation of species to facilities in the context of eradication;
(e) placed on the market;
(f) used or exchanged;
(g) permitted to reproduce, grown or cultivated, including in contained holding; or
(h) released into the environment.

Also note that, in accordance with Article 15(1) – As of 2 January 2016, Member States should have in place fully functioning structures to carry out the official controls necessary to prevent the intentional introduction into the Union of invasive alien species of Union concern. Those official controls shall apply to the categories of goods falling within the Combined Nomenclature codes to which a reference is made in the Union list, pursuant to Article 4(5).

Therefore measures for the prevention of intentional introductions do not need to be discussed further in this technical note.

Unintentional introductions.

MEASURE DESCRIPTION

There are no records of unintentional introductions of *B. halimifolia* on a new territory (introductions in the sense of entry) (EPPO, 2013). Therefore, measures for the prevention of un-intentional introductions do not need to be discussed further in this technical note.

Once the species is introduced, there might be unintentional spread through garden waste or contaminated soils. These aspects are addressed in the following section.

Measures to prevent the species spreading once they have been introduced.

Targeted engagement with public.

MEASURE DESCRIPTION

All wild populations of *B. halimifolia* in Europe are the result of escapes from private gardens, or from public places, where *B. halimofolia* is cultivated for landscaping purposes (for example, soil stabilisation, aesthetic enhancement or windbreaks) (EPPO, 2013; Fried *et al.*, 2016). From these plantings in gardens, on roundabouts or along roads and along pathways close to shorelines, the species has spread to natural habitats, first along roadsides or disturbed grasslands, then into coastal wetlands. Interestingly, Dupont (1966) also observed *B. halimifolia* in green waste disposal sites and proposed that it could have also spread through disposal of garden wastes.

Even with the ban on trading of the species, it is already present as cultivated individuals, and/or as casual, in several countries (see map in Fried *et al.*, 2016). Wherever the species is planted in gardens, roundabouts or along roads, it is likely to spread from existing populations to other habitats. Although most seeds fall within a few metres of the parent bush, records showed that seeds can drift up to 140 m from a 2-m high plant, whereas wind updrafts can carry seeds over many kilometres (Fried *et al.*, 2016).

The present measure aims to raise awareness among the general public (and local authorities) who have planted one or more individuals of *B. halimifolia*, on how to eliminate it (see eradication and management tables below) and cleanly dispose of plant material. It is, however, preferred that professional staff manage the removal from private gardens.

In addition to existing prohibition of selling, planting, holding, moving, and causing the plant to grow in the wild, the following measures should be combined:

- perform public awareness campaigns,
- provide guidance on how to remove *B. halimifolia* from private gardens (with a protocol describing eradication methods and including how to dispose of the plant material following uplifting).

SCALE OF APPLICATION

This measure should be applied at the scale of the whole Union and, more particularly, in areas where the species has been detected (in towns, villages and homes along the coast, and near estuaries and saltmarshes which are the most endangered habitats) and in areas where climatic conditions are suitable for the species (see EPPO, 2013; Fried *et al.*, 2016).

EFFECTIVENESS OF MEASURE

Effective.

As the species is regulated, it is expected that people will easily cooperate to remove the bushes in their gardens. Offering alternative shrubs that fulfil the same functions can facilitate this measure. In France, recommendations in accordance with nursery professionals suggest that *Atriplex halimus*, native from the Mediterranean basin, may be used as an alternative wind-break species, because it is similarly resistant to drought and salt spray. The non-native and non-invasive species *Leucophyllum frutescens* and *Xanthoceras sorbifolia* may also be used for ornamental purposes (EPPO, 2013).

EFFORT REQUIRED

This measure needs to be applied as long as cultivated individuals of *B. halimifolia* are detected.

Detection of cultivated individuals of *B. halimifolia* (such as in gardens and in municipalities, along roads and in roundabouts) may be undertaken in summer and autumn, particularly during the fruiting period (September–October), when the bushes are most visible.

RESOURCES REQUIRED

The resources required include means of communication to reach the general public (inserts in the press, advertising, posters, videos), plus staff time to monitor the catchment and manage the primary focus of introductions in private gardens. The cost of making the general public aware of the presence of the species could be shared with similar measures for other terrestrial invasive plants of Union concern that are still cultivated in gardens (for example, *Asclepias syriaca*, *Gunnera tinctoria*, *Heracleum* spp., *Pennisetum setaceum*, *Pueraria lobata*).

SIDE EFFECTS

Environmental: Positive
Social: Neutral or mixed
Economic: Neutral or mixed
Environmental effects: The engagement of individuals with private gardens provides a form of education to the general public that could help with understanding the issue of invasive species, in general, and result in more positive action with other invasive species. Other invasive species can also be detected in surveyed gardens, parks and other places with ornamental plants.
Social effects: People who appreciate this species in their gardens for its autumnal flowering and fruiting, would be affected by this measure. Nevertheless, as the species is a low volume product, this removal would only concern a very low number of locations, with minimal social consequences.
Economic effects: None to detail.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.
While this measure could be positively perceived by the general public, it might be difficult to convince some people to allow their properties to be accessed in order to check for cultivated individuals of *B. halimifolia*. Others might be reluctant to eliminate *B. halimifolia* individuals from their gardens, especially if this relies solely on them volunteering, without the help from specialised professional staff.

ADDITIONAL COST OF INFORMATION

Implementation cost for Member States: Communication materials detailing the negative impacts of the species, why it should not be cultivated in gardens, and how to eradicate it safely would be essential to educate the public and support actions to prevent secondary spread from private gardens. It is estimated that the cost for an awareness raising campaign could be up to EUR 10,000 per year for each Member State (Tanner, 2017). However, specific sectors of society may bear some of these costs themselves.

Cost of inaction: If the species is not managed, it will invade and establish in new sites, where eradication may cost several hundred to several thousands of euros if detected early. Management costs at a later stage, when populations are already widespread, can reach 2 million euros for 300 ha (Ihobe, 2014).

Cost-effectiveness of the measure: Preventive measures, such as identifying and eradicating source populations in gardens, are usually considered the most cost-effective measures (Simberloff *et al.*, 2013). This is particularly expected for *B. halimifolia*, given its high environmental impact in saltmarshes, its minor economic value in the horticultural trade and the possibility for people to use similar non-invasive vines alternatively (EPPO, 2013).

LEVEL OF CONFIDENCE[1]

Established but incomplete.
There are few documents that support the information given for this measure. Even if no specific information is available for *B. halimifolia*, it is considered that what is provided is established, although incomplete.

1 See Appendix

Containment measures.

MEASURE DESCRIPTION

The main aim of this measure is to prevent unintentional dispersal of plant material during control actions of *B. halimifolia* in invaded sites. When managing *B. halimifolia* (see tables below), different types of waste are generated, depending on the control method used. Waste includes fragments of plants with resprouting or germination capacity (for example, uprooted seedlings that can re-root, fruit branches, etc.). Proper treatment of waste is required to avoid unintentional transport of plant material to new sites.

Similarly, unintentional transport of fragments or seeds from contaminated areas via the transfer of soil material, or through vehicle movement and human activities, should be limited as much as possible. Unintentional transport of seeds can be prevented by restricting movements in invaded areas to periods when *B. halimifolia* is in a vegetative phase.

Waste resulting from control of *B. halimifolia* can be managed in five main ways (Ihobe, 2014):

- Stacking: cleanly stack plant waste generated during disposal work. In order to avoid regrowth, contact with water should be avoided and, for seedlings, contact with the soil should also be avoided;
- Grinding: the remains of the plants are crushed using choppers and are then collected. This is considered a fast and efficient measure that completely prevents regrowth and greatly reduces the volume of waste;
- Controlled burning: after storing the remains of the plants, an authorised burn is performed;
- Incineration: the generated organic waste is burned at high temperature. It is considered a very safe and efficient system that completely eliminates this type of waste;
- Deposit in an authorised landfill: plant waste resulting from the control actions is deposited in an authorised landfill.

SCALE OF APPLICATION

This measure should be applied in all sites where *B. halimifolia* is under management. It should also be applied at the EU scale for all commodities at risk of contamination (especially vehicles, machinery and equipment (VME), as well as soil coming from an area where *B. halimifolia* is already established

EFFECTIVENESS OF MEASURE

Effective.

With the experiences gained through management of the species in Spain (Ihobe, 2014) and France (Fernandez, 2015; Fernandez and Sarat, 2015; Izard, 2015; Blottière and Damien, 2017), management of *B. halimifolia* waste has been greatly improved and unintentional dispersal due to management actions is considered very limited.

EFFORT REQUIRED

This measure should be applied as long as populations of *B. halimifolia* are under management.

RESOURCES REQUIRED

In most cases, this measure requires a lot of resources (time, staff, and budget). According to Ihobe (2014):

- Removal and burning of remains represent between 25% and 30% of the total cost of *B. halimifolia* management (see 'Rapid Eradication' and 'Management' sections);
- Removal and crushing can exceed 50% of the total cost (in terms of volume and the distance between the removal and treatment points);
- Removal, cutting and collection on site represent less than 20% of the total cost.

SIDE EFFECTS

Environmental: Negative
Social: Neutral or mixed
Economic: Neutral or mixed
Environmental effects: Burning plant waste creates particles that contribute to air pollution. If the technique of piling up the plants waste is used, the shade created will inhibit germination or growth of native plants.
Social effects: None to detail.
Economic effects: None to detail.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

Stakeholders responsible for cleaning VMEs will need additional working time, incurring costs, so will potentially be negatively impacted by this measure.

ADDITIONAL COST OF INFORMATION

Implementation cost for Member States: This measure represents additional costs of management, but these have to be considered as an integral part of the total costs of species eradication or ongoing management.

Cost of inaction: At present, if the species is not managed, it will establish and invade new sites, where eradication may cost several hundred to several thousands of euros, if detected early. Management costs at a later stage, when populations are already widespread, can reach 2 million euros for 300 ha (Ihobe, 2014).

LEVEL OF CONFIDENCE[1]

Well established.

A general agreement in the literature has been found (Ihobe, 2014; Fernandez, 2015; Fernandez and Sarat, 2015; Izard, 2015; Blottière and Damien, 2017).

1 See Appendix

Protection of natural habitat.

MEASURE DESCRIPTION

Ecological management consists in modifying the abiotic and biotic conditions of an area to make the invaded or future potentially invaded sites less suitable for *B. halimifolia* (Branquart and Fried, 2016). Most plant invasions occur due to an excess of available resources (arising from disturbance, eutrophication, etc.) and to the absence of regulation by herbivores/natural enemies. The idea of ecological management is therefore to recreate the abiotic (less resources) and biotic (introduce natural enemies) conditions to help keep the species at low densities, which can be applied in combination with other management measures.

Maintaining ecosystems in good ecological status is itself a preventive management measure, because the integrity of the environment is the first barrier to the establishment of any invasive alien species. Land must be managed to maintain healthy native communities in areas that surround known infestations of the species to support containment. Vegetation disturbances in non-invaded areas should be minimised to avoid creating environmental conditions conducive to germination, development and subsequent establishment of *B. halimifolia* (Ihobe, 2014). Promoting competition through good grazing management, reforestation (which requires prior clearing) and planting native species (after management methods that create bare soils) may prevent the establishment or regrowth of *B. halimifolia*.

The aim of this measure is to prevent spread and establishment of new populations (protection of natural habitat) and to reduce the abundance of *B. halimifolia* to a level that causes reduced impacts. Therefore, this measure can also be used for the management of *B. halimifolia* populations.

SCALE OF APPLICATION

Ecological control should be applied at large scale in all habitats suitable and at risk of *B. halimifolia* invasion, especially in areas that surround known infestations.

EFFECTIVENESS OF MEASURE

Effective.

It is acknowledged that establishment of young individuals of *B. halimifolia* is only possible in areas where native plants, especially tall perennial graminoids (including *Phragmites australis*, *Juncus acutus* and *Juncus maritimus* in saltmarshes) have cover <85% (Fried and Panetta, 2016; Fried *et al.*, 2016). The critical factor for *B. halimifolia* establishment is not the available photon flux, but rather drought and/or lack of nutrients resulting from competition with native plants. In summary, *B. halimifolia* will only invade habitats where native vegetation is periodically disturbed, either naturally (by fire, flooding or animal activity) or through human activities (Fried *et al.*, 2016). Therefore, maintaining ecosystems in good ecological status is an effective measure to prevent further spread.

EFFORT REQUIRED

This measure needs to be applied in the long term, as any disturbance will be prone to establishment of *B. halimifolia*.

RESOURCES REQUIRED

Ecological management represents few costs, as its main objective is to avoid creating disturbances. Additional costs may include the cost of sowing or planting native species to enhance restoration of the habitat after management actions. However, these costs can be shared with other actions that aim at restoring ecosystems and preventing invasion by other invasive alien species.

SIDE EFFECTS

Environmental: Positive
Social: Neutral or mixed
Economic: Neutral or mixed
Environmental effects: Ecological control by preventing disturbances and/or by seeding/planting native species to restore natural habitats will reduce vulnerability of the habitat to other invasive alien plants.
Social and economic effects: There are no social or economic effects to report.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

Public perception of this measure is expected to be positive. However, there may be problems with economic sectors which exploit and could disturb habitats where *B. halimifolia* occurs (mainly saltmarshes). This includes tourism and agro-pastoralism (grazing). Although grazing can be used to control and reduce large sized populations of *B. halimifolia* (see management section), it also creates gaps in vegetation that can favour new establishment (Fried and Panetta, 2016).

ADDITIONAL COST OF INFORMATION

Implementation cost for Member States: The costs are minimal and this measure could be largely shared with more general actions of ecosystem restoration.

The seeds of Baccharis halimifolia *are toxic to humans. © Archive of Institute Symbiosis*

Cost-effectiveness of the measure: Such preventive actions based on environmental management are considered as largely cost-effective (Simberloff *et al.*, 2013).

LEVEL OF CONFIDENCE[1]

Established but incomplete.

Preventive actions by ecological management are based on general considerations on which there is a strong agreement among invasion biologists (Branquart and Fried, 2016), but examples of its application are scarce.

1 See Appendix

Measures for early detection of the species and to run an effective surveillance system for an early detection of a new occurrence.

Visual inspection in areas of likely introduction.

MEASURE DESCRIPTION

Prohibition measures and targeted engagement with public who cultivate *B. halimifolia* individuals in gardens should be combined with surveillance for early intervention in case the plant is detected in the wild.

The first step of the measure is to conduct a delimitation survey to determine the extent of *B. halimifolia* current distribution in the wild, in Member States where it is already present. Surveillance should be carried out in places of most likely introduction of *B. halimifolia* or of high conservation value (EPPO, 2013; Ihobe,2014; Fried *et al.*, 2016), such as:

– Areas associated to the species introduction pathways (in nurseries, gardens and surrounding areas, as well as areas where substrate is used in construction and other works);
– Surveillance zones around the invaded areas. The radius of the areas of surveillance around a mature plant should be that of the maximum dispersal distance of the species, which is about 5 km, according to Ihobe (2014);
– Dispersal corridors next to invaded areas, for example along canals or roadsides (infested areas and adjacent areas that might receive seeds should be monitored);
– Non-invaded areas with high value for nature conservation (estuaries, coastal wetlands, saltmarshes, humid prairies, cliffs).

Visual inspection of plants in the wild is the most appropriate and effective means available for early detection of new occurrences of *B. halimifolia* in the EU. It is possible to identify the species in the field with very little training, which is mainly needed to avoid confusion with the vegetative stage of some native species (for example, *Arbutus unedo*, *Rhamnus* spp., see Fried (2017)).

All the data collected during surveillance activities to possibly detect new introductions of *B. halimifolia* can be incorporated into a GIS (Geographical Information System) database with other ecological data recorded, in order to better identify the habitats most at risk for introduction of *B. halimifolia*, helping to identify and prioritise areas where inspection should focus (Ihobe, 2014).

SCALE OF APPLICATION

This measure needs to be applied in zones surrounding the areas where *B. halimifolia* is already established, as well as in areas of the EU where *B. halimifolia* is not yet present, but has a high probability of establishment according to bioclimatic modelling (EPPO, 2013; Fried *et al.*, 2016). Priority should be given to the monitoring of areas in a radius of 5 km around established *Baccharis* populations and, within these areas, to habitats of high conservation value in the EU (see above). In non-invaded areas, priority should be given to the places of most likely introduction listed above.

EFFECTIVENESS OF MEASURE

Effective.

B. halimifolia is relatively easy to identify when flowering and/or fruiting and readily available field guides (for example Fried, 2017) can be used for this. With some training, the plant can be identified as soon as it has its foliage in early spring. Visual detection is commonly used by amateur and professional botanists and naturalists for recording *B. halimifolia* in the field. For example, in the northern colonisation front in the Netherlands, the inspection of a natural site of high conservation value has made it possible to detect early an individual of *B. halimifolia* (van Valkenburg *et al.*, 2017).

Obtaining access to discrete areas of land may, however, be problematic with the division of land ownership. Thus, despite intensive surveys, if the species is not detected and controlled everywhere, seeds from remaining undetected populations can be dispersed and the species can colonise new areas.

EFFORT REQUIRED

In the case of a species already widely established in the EU, such as *B. halimifolia*, surveillance should be applied in the long term, as part of the surveillance system of invasive alien species of Union concern required by Article 14 of EU regulation 1143/2014 on invasive alien species.

Each year, the period of surveillance should be from mid-summer to autumn (flowering and fruiting stages), with more intensive surveillance during the end of summer (just before fruiting stage) and in autumn (fruiting stage) when the plant is more easily detectable.

If identified before flowering, there is an opportunity to eradicate the population (see section 'Rapid eradication'). If the plant has already released seeds, the population would need to be monitored and further control measures would be needed in the following seasons.

RESOURCES REQUIRED

Resources needed would involve staff time, travel costs and training workshops. Actual costs of a monitoring programme will depend on the area surveyed. Efforts could be shared with the monitoring of other invasive alien species of Union concern requiring similar surveillance in coastal wetlands habitats, especially some aquatic plants (for example, *Ludwigia* spp. and *Myriophyllum aquaticum*).

Monitoring should be conducted by specifically dedicated staff, but human and financial resources can be optimised by:

- Employing qualified staff in charge of other tasks (looking after natural areas, monitoring inspectors of works and projects, university researchers, etc.);
- Using citizen-science and/or trained volunteers for inspection of the species presence and reporting of its detection to authorities (through NTIC (New Technology for Information and Communication) tools and open science, for example with the EU 'Invasive Alien Species Europe' app specifically developed for observations of IAS of Union concern).

SIDE EFFECTS

Environmental: Positive
Social: Positive
Economic: Neutral or mixed
Environmental effects: The surveillance of new incursions of *B. halimifolia* can lead to the detection of other invasive alien species, potentially having positive environmental effects.
Social effects: If performed by volunteers, this measure can also increase awareness of the public about the problems created by invasive alien species.
Economic effects: None to detail.

ACCEPTABILITY TO STAKEHOLDERS

Acceptable.
The visual detection of *B. halimifolia* is likely to be acceptable to stakeholders and no significant impacts are envisaged. However, it should be noted that local stakeholders may choose not to report new sightings of the species, or may not provide access to their land, in order to avoid associated management costs.

ADDITIONAL COST INFORMATION

Implementation cost for Member States: Depending on the area to survey, the implementation costs will vary considerably. In southern France, 80 km of the Gardon River have been surveyed by a team of two people to monitor the presence of *Humulus scandens* in 2012 and 2014, with a cost of EUR 167 per km, and a total cost around EUR 13,000 (Fried, 2018). Engagement with local environmental NGOs, citizen-scientists and utilisation of volunteer networks can partly reduce these costs. Finally, some regional training workshops would probably be needed to train stakeholders in the identification. It is estimated that each training workshop may cost EUR 3,000 (Tanner, 2017).

Cost of inaction: See section 'Prevention of secondary spread of the species'.

Cost effectiveness of the measure: This measure has the potential to be very cost effective if Member States can cooperate with local natural history or botanical societies and utilise their expertise. Regional funding should be made available to local NGOs to monitor all potential invasive alien plants.

LEVEL OF CONFIDENCE[1]

Established but incomplete.
Few documents exist specifically for *B. halimifolia* (Ihobe, 2014) and no details on the cost of applying this measure to this species are available, but the information provided is expected to be similar to that of other invasive alien plants.

1 See Appendix

Monitoring using satellite imagery.

MEASURE DESCRIPTION

This measure aims to monitor *B. halimifolia* using satellite imagery (for example, Landsat-8 and Sentinel 2A images), which can represent a low-cost way of detecting new occurrences of the species (Calleja *et al.*, 2019). As in the previous surveillance measure, monitoring should be carried out in the areas of most likely introduction of *B. halimifolia* or of high conservation value, as listed above.

This method requires satellite imagery (for example, Landsat-8 and Sentinel 2A images) at a relevant resolutions of 10 or 30 m. Presence data of *B. halimifolia* are necessary to calibrate the algorithm that made possible the classification of pixels identified as *B. halimifolia* versus other vegetation. This method relies on the identification of the canopy of *B. halimifolia* and its specific colour relative to the rest of the vegetation.

SCALE OF APPLICATION

This measure needs to be applied in zones surrounding the areas where *B. halimifolia* is already established, as well as in areas of the Union where *B. halimifolia* is not yet present, but has a high probability of establishment according to bioclimatic modelling (EPPO, 2013; Fried *et al.*, 2016). Priority should be given to the monitoring of areas near established populations (in a radius of 5 km around infested foci) and, within these areas, to habitats of high conservation value in EU. In non-invaded areas, priority should be given to the places of most likely introduction listed in the table above.

EFFECTIVENESS OF MEASURE

Effective.

The measure has the potential to be effective for monitoring *B. halimifolia* presence. According to Calleja *et al.*, (2019), "The pixel-based classifications mapped the invasive species with an accuracy of 70% or higher for both images. The Landsat image had higher accuracy in the overall classification of the vegetation, but the Sentinel image proved better suited for mapping *B. halimifolia* specifically, due to its higher spatial and spectral resolution. In addition, the procedure was implemented using a Landsat image from 2005 and mapped the invasive species with an accuracy of 72% and 88% for producers and users accuracy respectively."

It should be noted that this measure has never been applied at large scale for real monitoring of this species, so it is difficult to estimate its effectiveness. The information about potential effectiveness provided here comes from a study that aimed to test the possibility of using satellite imagery for mapping this species (Calleja *et al.*, 2019),which concluded that this method represents a good option.

EFFORT REQUIRED

In the case of a species already widely established in the Union, such as *B. halimifolia*, surveillance should be applied over the long term as part of the surveillance system of invasive alien species of Union concern required by Article 14 of EU regulation 1143/2014 on invasive alien species.

Satellite images used for this measure should be taken in spring or summer, when *B. halimifolia* foliage is developed.

RESOURCES REQUIRED

Initial research efforts to investigate the applicability of this measure have already been developed. However, for the measure to be fully effective, there would need to be an initial cost for funding research activities to improve the accuracy of mapping of *B. halimifolia* using satellite imagery, and the cost of training staff to use the method routinely. Accessibility to satellite imagery is necessary, which is costly, as well as equipment to process it and staff to interpret the data.

SIDE EFFECTS

Environmental: Neutral or mixed
Social: Neutral or mixed
Economic: Neutral or mixed
There are no side effects mentioned in literature.

ACCEPTABILITY TO STAKEHOLDERS

Acceptable.

There is no reason for monitoring of *B. halimifolia* using satellite imagery to be contentious or to affect any economic activity.

ADDITIONAL COST INFORMATION

Cost of inaction: See section 'Prevention of secondary spread of the species'.

LEVEL OF CONFIDENCE[1]

Unresolved.

This measure has never been applied for monitoring *B. halimifolia* at large scale. Currently, there are only studies at the experimental stage (Calleja *et al.*, 2019), so the information provided remains to be confirmed by further studies and uses of satellite imagery for this species.

1 See Appendix

Measures to achieve rapid eradication after an early detection of a new occurrence.

Manual control.

MEASURE DESCRIPTION

Manual control involves extracting entire individuals of *B. halimifolia*, ensuring to remove the entire underground system without fragmenting the plant. In some cases, it is necessary to use a small hand tool to remove the root system completely (Ihobe, 2014; Izard, 2015; Fernandez, 2015; Fernandez and Sarat, 2015; Blottière and Damien, 2017).

If the new occurrence contains only young individuals (< 2 years old and < 50 cm high), manual pulling up is one of the best eradication methods. As this method completely removes the plant from the ground, eliminating its roots by hand, it is indeed best adapted to young specimens with poorly developed root systems.

If the individuals are not adults (less than 2 years old), this action can be performed all year round; in case they are older with a greater sexual reproduction capacity, the manual pull-up should be done before flowering to prevent the spread of pollen or seeds. It is also best done when the soil is relatively moist, which facilitates the removal of the plant, provided extreme care is taken to shake the earth remaining in the roots, thus minimising the loss of soil adhered to the root system.

The aim of this measure is the eradication of small infestations of young individuals of *B. halimifolia*.

SCALE OF APPLICATION

When pulling up the plants, the whole root system needs to be removed to prevent resprouting. This method is therefore very labour intensive and cannot be applied to large, well-developed infestations (Fried *et al.*, 2016). It is best adapted for small infestations (Ihobe, 2014), although it has been applied in France over larger areas, for example up to 8.5 ha in SW France in a site where the plant is now almost eradicated (Fernandez, 2015).

EFFECTIVENESS OF MEASURE

Effective.

The probability of successfully eradicating a *B. halimifolia* population using this method is higher for smaller areas. Manual control has proven to be effective in eradicating small infestations, provided it is implemented continuously, especially for small sized mono-stem individuals, taking extreme care to completely remove the root to prevent regrowth (Ihobe, 2014).

EFFORT REQUIRED

Depending on the initial level of infestation, age of *B. halimifolia* individuals and presence of a seedbank, this measure requires between one and several years of repeated control. Seeds have a low longevity (around 2 years), but a follow-up monitoring is still necessary for at least 3–4 years (Fried *et al.*, 2016).

RESOURCES REQUIRED

In Spain, the cost of manual pull-up of young specimens has been estimated between EUR 600 and EUR 10,000 per ha, with an average of EUR 1,800 per ha (Ihobe, 2014). In Western France, in the Grande Brière Mottière nature reserve, EUR 20,000 have been spent to remove about 10,000 *B. halimifolia* individuals (Blottière and Damien, 2017).

Although manual control usually requires a large number of people due to being labour intensive, it is an easy task and can be done by volunteers. In SW France, manual control of *B. halimifolia* involved 128 people in 2012 and between 46 and 66 person/day over three years (Fernandez, 2015).

Equipment needed includes sickles, serpettes (Fernandez, 2015), and spades (Ihobe, 2014). In several regions of France (Brittany, Camargue), stakeholders have developed a specific tool to facilitate extraction of the underground system of *B. halimifolia* (named 'Baccharrache').

SIDE EFFECTS

Environmental: Neutral or mixed
Social: Positive
Economic: Neutral or mixed

Environmental effects: Manual pulling up is very selective and will present low or no impact on non-target species. It may, however, cause alterations in the substrate due to root system extraction, but this is estimated as a very minimal effect since the method should be applied only to young individuals.

Social effects: It has been noted in France that manual control operations on *B. halimifolia* were a factor of social linkage and intergenerational exchange between the different participants (young people in difficulty, people in reintegration and hunters, managers, walkers, etc.) (Fernandez, 2015).

Economic effects: None to detail.

ACCEPTABILITY TO STAKEHOLDERS

Acceptable.

Such proactive management actions that limit costs and environmental side effects are generally well received by the public. If communication actions to increase awareness about the impact and risks of the plant have not been carried out, there is nevertheless a risk of misunderstanding in relation to the management of populations that do not yet have impacts at an early stage of the invasion process.

ADDITIONAL COST INFORMATION

Implementation cost for Member States: Implementation costs can be relatively low and engagement with local environmental NGOs and utilisation of volunteer networks can further reduce costs (Fernandez, 2015). Control costs using this measure range between 600 and 10,000 euros/ha, with an average of 1,800 euros/ha (Ihobe, 2014).

Cost of inaction: If the species is not managed at this stage, small populations will continue to establish, invade the surrounding areas and form more widespread populations. This is particularly expected for a wind-dispersed species such as *B. halimifolia*. Management of widespread established populations of *B. halimifolia* can represent nearly 2 million euros for managing 300 ha, as for example has been observed in the Basque Country (Ihobe, 2014).

Cost-effectiveness of the measure: Although labour-intensive, manual control methods are cost-effective when controlling small populations of *B. halimifolia*.

Socio-economic aspects: *B. halimifolia* can restrict access to waterbodies, thus impacting recreational activities such as fishing. As such, positive effects of eradicating it could include the enhancement of cultural services and recreation activities via removing *B. halimifolia* from wetlands. This advantage applies to any measure used to eradicate or control the species.

LEVEL OF CONFIDENCE[1]

Well established.

The information is well established, based on numerous experiences of management for eradication in France (Fernandez, 2015; Fernandez and Sarat, 2015; Izard, 2015; Blottière and Damien, 2017) and Spain (Ihobe, 2014).

1 See Appendix

Total extraction by mechanical means.

MEASURE DESCRIPTION

This method involves the uprooting of *B. halimifolia* individuals by using heavy machinery (for example, excavators). It can be applied to individuals of all ages and phenological stages. When applied to adult individuals, because of their large root system, this measure may require the removal of much of the substrate, which means significant land movement. In all cases, it is essential to ensure the total removal of the root system. Since this measure will result in barren soils without vegetation, in which *B. halimifolia* seeds are still likely to be found, this action should be always accompanied by a subsequent restoration project (Ihobe, 2014).

The aim of this measure is to eradicate isolated adult individuals or small populations of *B. halimifolia* that can no longer be eradicated by manual means.

SCALE OF APPLICATION

Due to the side effects on the environment and the cost of this measure (see below), it is usually only applied on small areas and in areas of low conservation value or uncultivated land (Ihobe, 2014).

EFFECTIVENESS OF MEASURE

Effective.

This measure is considered as very effective, with no need of subsequent treatments (Ihobe, 2014).

EFFORT REQUIRED

The treatment will only require one operation. However, since this measure generates areas of barren land, it should be followed by restoration measures to prevent open areas from being recolonised by *B. halimifolia* or by other invasive species (Ihobe, 2014).

Monitoring should be conducted for several years and, if resprouting occurs, manual control can be applied.

RESOURCES REQUIRED

Equipment includes a mechanical excavator and staff able to use this kind of machinery.

SIDE EFFECTS

Environmental: Negative
Social: Neutral or mixed
Economic: Neutral or mixed
Environmental effects: Total extraction by mechanical means will have a severe impact on the environment due to the use of heavy machinery and extraction of large volumes of soil attached to the plant root system. It consequently generates areas of barren land prone to re-colonisation by *B. halimifolia* or other invasive plant species (Ihobe, 2014).
Social and economic effects: None to detail.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

The use of heavy machinery in nature reserves may be problematic and not supported by local land managers and the general public.

ADDITIONAL COST INFORMATION

Implementation cost for Member States: There is no available information about the cost of this measure.
Cost of inaction: If the species is not managed at this stage, small populations will continue to establish, invade the surrounding areas and form more widespread populations. Management of large established populations of *B. halimifolia* can represent nearly 2 million euros for managing 300 ha, as for example has been observed in the Basque Country (Ihobe, 2014).
Cost-effectiveness of the measure: There are no data about cost-effectiveness of this measure.
Socio-economic aspects: *B. halimifolia* can restrict access to waterbodies, thus impacting recreational activities such as fishing. As such, positive effects of eradicating it could include the enhancement of cultural services and recreation activities via removing *B. halimifolia* from wetlands. This advantage applies to any measure used to eradicate or control the species.

LEVEL OF CONFIDENCE[1]

Established but incomplete.

The information is well established, based on management experiences in Spain (Ihobe, 2014). However, there is a lack of data about the cost of this measure.

1 See Appendix

Chemical control.

MEASURE DESCRIPTION

Chemical control consists of applying herbicides on *B. halimifolia* individuals. Effective herbicides for the control of *B. halimifolia* are listed in the table below, mainly based on the methods developed in the Basque Country, Spain (Ihobe, 2014).

The listing of herbicides in this table does not imply that they are approved and available for use in all EU countries. Before using chemical products against *B. halimifolia*, users should carefully check and make sure they follow national regulations. All chemical products should also be used following the label instructions and in line with the relevant plant protection products regulations. In the European Union, some herbicides have been phased out, as they have not been listed in Annex I of Regulation (EC) No 1107/2009 during the active review process. The availability of the remaining active substances varies significantly from country to country, and current product approvals are subject to change under the EU review process for plant protection products (EPPO, 2013). Chemical control may, in particular, not be authorised in nature reserves, especially in wetlands.

There are four different ways of applying herbicides to control and eradicate *B. halimifolia*:

(1) Foliar spraying
Foliar spraying consists of the application of herbicide by spraying the aerial part of the plant, spraying the directed herbicide from a backpack of spray (Ihobe, 2014). The best time for application is at the end of the growing season, during flowering of the plant, between August and October. During this period, assimilated products are increasingly transported from the leaves to the root system, which increases the probability that the product reaches the root and causes the death of the plant (Ihobe, 2014).

Composite and concentration	Proportion	Comments
2,4-D 300 g/litre	100 ml in 10 litres of water	Complete coverage of the plant is necessary
Glyphosate 360 g/litre	700 ml in 100 litres of water	Application on bushes with active growth. Do not apply in winter or very dry summers.
Picloram 45 g/kg	Not diluted	Application by injection in cut stems. Application by injection of a 3–5 mm layer of gel on stems below 20 mm, and of 5 mm of gel on stems over 20 mm.
Triclopyr 600 g/litre	16 ml in 100 litres of water 320 ml in 100 litres of water	Seedlings below 1 or 2 metres high. Bushes over 1 or 2 metres high.
Triclopyr 240 g/litre + Picloram 120 g/litre	1 litre per 60 litres of oil	Bushes over 1 or 2 metres high. Base application on stumps.
2,4 D amine 625 g/litre	320 ml in 100 litres of water	Spray over active growing specimens. Cover the specimen.
Ammonium sulfamate	–	Application by injection in cut stems. No longer authorised in the EU.

(2) Application after cutting or debarking
The first step is to make a cut in the stem with an axe or another similar tool for each main *B. halimifolia* trunk, at a maximum distance of 50 cm from the ground (if cut at a higher level, the active ingredients may not reach the root system). The cut of the stem must reach the cambium. Then, an amount of herbicide is poured in the cut with a non-dripping applicator. Another possibility is to impregnate a dressing with the active ingredient and place it on the cut. The exposure time to the herbicides must be of eight weeks or longer (Ihobe, 2014). Similarly, herbicides can also be applied on debarked branches. The application of salt to cut stems has been tested, but results still need to be confirmed, and the use of salt does not represent a management measure as it is not authorised (EPPO, 2013).

(3) Application on stumps
For plants more than 1.5 m in height, herbicides are most efficient when applied on tree stumps, just after cutting, and this is particularly efficient when the cut is at the soil level (EPPO, 2013). The herbicide is applied with a brush or an applicator. Because the plant is able to quickly seal the cut, application of the herbicide should be made within 30 seconds after the cut to ensure the herbicide enters the plant and the active ingredient reaches the root system, killing the plant (Ihobe, 2014). It is recommended to apply such a measure during the active growth season of *B. halimifolia*, especially in late spring (Ihobe, 2014). If applied earlier in the season, the large amount of sap ascending through the stems will eliminate a great part of the applied active ingredient.

(4) Injection
Injection consists of injecting the herbicide inside the stems to reach the cambium. The first step requires an auger or a drill to make several holes in the stem about 5 cm apart. In the second step, a small amount of herbicide is injected in each hole using a dropper, a dosing syringe, an injection gun or a spray bottle. Finally, the holes must be sealed with resin or other material (Ihobe, 2014). As for the previous method, the application of herbicide should be made no more than 30 seconds after the cut.

Application after cutting, application on stumps, and injection are suitable for specimens near water and when *B. halimifolia* individuals occur together with native vegetation. These techniques greatly reduce the quantities of active substances used, as well as their spread in the environment (see 'Side-effect' section).

After treatment and death of the plants, plant residues that have been in contact with herbicides must be removed and taken to an approved landfill (this is the case for application after cutting and injection).

This measure can also be used for management of the species, especially the control of widespread populations by foliar spraying, which aim is to control widespread populations of *B. halimifolia* in order to reduce their density and related negative impacts, but without targeting complete eradication in the area.

SCALE OF APPLICATION

When chemical control is intended for eradication, it will only be successful at small scales.

In Northern Spain, this method has been applied (among other management measures) to control the invasion of *B. halimifolia* in three estuaries (over 314 ha) as part of a LIFE+ project (LIFE08NAT/E/0055). Chemical control succeeded in locally eradicating small populations, for example in the Lea estuary (3 ha).

EFFECTIVENESS OF MEASURE

Effective.
The use of herbicides is considered effective for eradicating *B. halimifolia*, provided subsequent monitoring and treatments are carried out until no more production of new shoots is observed (Ihobe, 2014). Application after cutting, injection and application on stumps have the highest efficacy.

Based on experiences from Northern Spain and Western France (Fried *et al.*, 2016), herbicides showed high effectiveness (97%) in controlling small or medium-sized invasions, and less effectiveness in controlling large and widespread invasions (70–75%). The latter point is dealt with in the 'Management' section below.

Application of glyphosate or ammonium sulfamate has managed to control 90% of the shrubs/trees in an experiment conducted in Camargue, France (EPPO, 2013).

Treatments with glyphosate, 2,4-D acid or 2,4-D amine achieved over 90% control of *B. halimifolia* in a variety of tests (EPPO, 2013). Weber (2003) reported that chemical control provides satisfactory results with 2,4-D, dicamba plus MCPA, glyphosate, picloram plus 2,4-D, and triclopyr. Gann *et al.*, (2012) reported that triclopyr was far more efficient in hardwood forest than imazamox, aminopyralid and glyphosate. Combinations of herbicides on foliage to control shrubs (for example picloram combined with aminopyralid and triclopyr or 2,4-D combined with dichloprop-p) have provided effective and long-lasting results in France, still visible 6 months after (EPPO, 2013).

Although the reported efficacy of chemical control averages around 90%, there can be complete eradication of the species using this measure. Rapid eradication by chemical control is most often achieved in the case of applications after cutting, of injections or of applications on stumps on individuals of small populations, rather than of foliar spraying on larger populations.

EFFORT REQUIRED

With foliar spraying, reinvasion of the treated area by germination from the seed bank must be expected the first year after treatment, and subsequent manual control may be applied (see the dedicated "Manual control" section above or the "Integrated control" section below). The seed bank is expected to persist for at least 2 years (Panetta, 1979), therefore chemical treatment should be conducted for at least this long, and until no sign of *B. halimifolia* is found. Subsequent surveillance is recommended to ensure the total elimination of the invasion (Ihobe, 2014).

If applied correctly, the other chemical control methods (numbered (2), (3) and (4) above) can be effective with a single treatment/application. However, resprouting may occur, and a need for repeated treatments over several years may be expected in those cases.

RESOURCES REQUIRED

Cost: In the 1970s, the cost of a control program with herbicides (2,4-D and 2,4,5-T) in Queensland, Australia, was estimated to exceed $500,000 per year (Westman *et al.*, 1975). It should be noted that this figure largely concerned pastures, but owing to a legal obligation to control this weed, other land uses would also be involved.

In France, in the Grande Brière Mottière nature reserve, a containment action of a population of 124 trees (spread over 49 locations) was estimated to cost EUR 3,064 (EPPO, 2013).

According to Ihobe (2014), the cost of stump application of herbicides varies from EUR 400 to EUR 8,000 per ha, with an average of EUR 2,300 per ha, while the cost of the placement of dressings impregnated with herbicides is much higher, reaching EUR 20,000 per ha.

In the Basque Country, Spain, a LIFE+ project has been implemented to suppress *B. halimifolia* in three estuaries (Urdaibai, Txingudi and Lea). In 2011, 298.08 ha were treated, with a total cost of EUR 630,000. The cost per hectare was:
First treatment (139.69 ha in total): high density areas, EUR 2,896/ha; low density areas, EUR 2,282/ha.
Further treatments (158.39 ha in total): review using herbicide, EUR 1,410/ha.
In the following year (2012), more elimination works were carried out, with a total cost of EUR 207,000. Here, the cost per hectare was:
First treatment (21.50 ha in total): high density areas, EUR 2,795/ha; low density areas, EUR 3,011/ha.
Further treatments (82.93 ha in total): review using herbicide, EUR 811/ha.

Staff: Trained staff are required to apply herbicides, as the treatments can only be performed by authorised personnel, in accordance with the current legislation.

Equipment: Sprayer backpack (EUR 150), applicator, non-dripping applicator, brusher, driller, dropper, a dosing syringe, an injection gun or a spray bottle and safety equipment are required.

SIDE EFFECTS

Environmental: Neutral or mixed
Social: Neutral or mixed
Economic: Neutral or mixed
Environmental effects: The use of herbicides, particularly foliar spraying with large spectrum herbicides (for example glyphosate) can have non-intended side effects on the surrounding flora and fauna. In particular, foliar spraying on foliage is expected to spread the active substances to non-target plants and could then transfer to soil and water. Therefore, this method is not advisable in areas too close to water, because of the risks derived from the product. The presence of protected or endemic species of flora or fauna in the intervention area should be considered, as well as the breeding seasons of different fauna species, and the fragility of the ecosystem, in particular wetlands.
Nevertheless, application of herbicides after cutting, on stumps or by injection will have no or minimal side effects (Ihobe, 2014). For this, applying the herbicides with a brush on the stump should be done without sudden movements to avoid dripping or splashing. As such, environmental side effects of herbicides are therefore mixed, with negative effects of foliar spraying and almost neutral effects of injection, or application on stumps or after cutting.
Socio-economic effects: There are no socio-economic effects to detail.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.
Herbicides, in general, are not well accepted by stakeholders and the public, due to the potential side effects on the environment and health concerns. For instance, using herbicides by foliar spraying in a nature reserve or in wetlands where large stands of *B. halimifolia* occur is no longer accepted by the public (Tassin, 2014).
Although it involves higher concentrations of active ingredients, application on stumps could be more acceptable than foliar spraying, due to the limited scale of application. Moreover *B. halimifolia* often occurs in protected areas or in Natura 2000 sites, and using herbicides in such areas is not well perceived by the public, naturalists and land managers. The acceptability is mixed, because the measure would be considered as unacceptable in sensitive areas, but considered acceptable in less sensitive areas, where benefits could be higher than environmental costs.

ADDITIONAL COST INFORMATION

Implementation cost for Member States: Depending on the method used and the local conditions (accessibility), implementation costs range between EUR 400 and 20,000 per ha (Ihobe, 2014).

Baccharis halimifolia *is a native species to Nova Scotia, the eastern and southern United States, eastern Mexico, the Bahamas, and Cuba. © James H. Miller and Ted Bodner, Southern Weed Science Society, Bugwood.org. CC BY 3.0*

Cost of inaction: Management of widespread established populations of *B. halimifolia* can represent nearly 2 million euros for managing 300 ha, as for example has been observed in the Basque Country (Ihobe, 2014). Cost of inaction is therefore very high at this stage and it is worth trying to eradicate small populations.

Cost-effectiveness of the measure: Herbicides, although initially expensive to apply, may give long-term control and are considered as cost-effective for eradication actions (Ihobe, 2014).

Socio-economic aspects: *B. halimifolia* can restrict access to waterbodies, thus impacting recreational activities such as fishing. As such, positive effects of eradicating it could include the enhancement of cultural services and recreation activities via removing *B. halimifolia* from wetlands. This advantage applies to any measure used to eradicate or control the species.

LEVEL OF CONFIDENCE[1]

Well established.

There are a number of local management reports using chemical control from Spain (Ihobe, 2014) and France (Charpentier *et al.*, 2006) that are in agreement, and that are summarised in the EPPO Pest Risk Analysis (EPPO, 2013), the EPPO National regulatory control systems (EPPO, 2016), and updated in Fried *et al.*, (2016).

1 See Appendix

Measures for the species' management.

Integrated control management.

MEASURE DESCRIPTION

This method consists of the combination of all available control methods mentioned before:

– manual control for small individuals, usually young plants < 50 cm, although manual removal can be used on plants up to 1.5 m (Blottière and Damien, 2017);
– mechanical control for dense stands of plants of larger size (> 50 cm) (Fernandez, 2015; Fernandez and Sarat, 2015);
– combination of mechanical and chemical control by cutting the stem and devitalising the stump for old, isolated individuals of large stature, such as > 1.5 m high (Blottière and Damien, 2017). Note that the elimination of regrowth and the devitalisation of the stump can also be done using a hatchet (Fernandez and Sarat, 2015), in cases where stakeholders want to avoid the use of chemical control (in nature reserves, near water, etc.).

The aim of this measure is to contain *B. halimifolia* and reduce its density in sites where the plant is already widespread. In some cases, this measure can almost lead to eradication (Fernandez and Sarat, 2015).

SCALE OF APPLICATION

This measure can be applied on large areas: it has, for example, been applied over 13 ha in the Prés d'Arès (Fernandez, 2015), or over 39 ha in Lège-Cap Ferret (Fernandez and Sarat, 2015), both in SW France, and on scattered populations of *B. halimifolia* distributed over the 7,000 ha of the core of the Grande Brière Mottière nature reserve in Western France (Blottière and Damien, 2017).

EFFECTIVENESS OF MEASURE

Effective.

While each method taken individually is difficult to implement on large areas to reach the objective of control, the combination of two or three of the methods makes this measure very effective.

Several experiences using these combined measures have almost led to the eradication of the species, such as in the Prés d'Arès in SW France (Fernandez and Sarat, 2015) and in the Grande Brière Mottière nature reserve in Western France (Blottière and Damien, 2017). In the Grande Brière Mottière nature reserve, manual pulling up of *B. halimifolia* has been applied from 2007 to 2016, with the number of *B. halimifolia* individuals pulled up decreasing from 5,731 in 2008 to 28 in 2016 (99.7% of the individuals initially detected have been removed). Even if the plant is not completely removed, the objective of containment and of reducing the invader's density is largely reached.

EFFORT REQUIRED

This measure needs to be applied during several years and, most often, during more than ten years (Blottière and Damien, 2017).

For an area managed by manual control, the example of the Grande Brière Mottière nature reserve, France, shows that eradication is almost reached in ten years (Blottière and Damien, 2017). For further information on effort required, see this section of the "Rapid eradication" table for manual control.

For an area managed by devitalisation of the stump, see this section of the "Rapid eradication" table for chemical control. For an area managed by cuttings, this method needs to be repeated several times to exhaust the plant. Plants regrow vigorously after having been the object of a rotary flail (such as, gyrobroying), and more than 10 branch stems may regrow instead of three or four (Commission syndicale de Grande Brière Mottière, 2007). Mechanical control by slashing does not cause the death of the specimen because of the regrowth capacity of *B. halimifolia*. Gann *et al.*, (2012) found that two annual cuttings, one during the dormant and one during the growing season, resulted in 43% and 26% mortality, respectively. Mechanical control undertaken during the dormant season could therefore be more effective. Such measures should be repeated every 2 to 3 years, as the plant forms new cuttings. In the Domaine de la Palissade (Camargue, France), the Conservatoire du Littoral has applied two slashings per year over 17 years, yet *B. halimifolia* has not yet been eliminated.

RESOURCES REQUIRED

In the Grande Brière Mottière nature reserve in Western France, about EUR 27,000 over 10 years have been spent for the combination of manual control, cutting and devitalisation (Blottière and Damien, 2017).

In 2008, in Lège-Ca-Ferret (SW France), the combination of manual control, slashing and cutting combined with devitalisation represented 89 hours of work and 9 hours spent on machine maintenance for a total cost of EUR 991, including EUR 775 for maintenance costs, and EUR 216 for fuel (Fernandez and Sarat, 2015).

Staff involved is variable, from two permanent people in Lège-Ca-Ferret (Fernandez and Sarat, 2015) to 128 volunteers for manual control in the Prés salés d'Arès, also in France (Fernandez, 2015).

Equipment needed includes sickles, serpettes (Fernandez, 2015) and spades (Ihobe, 2014) for all the volunteers or staff involved in manual removal, axes and chainsaws, brush and/or an applicator, a backpack brush cutter or a machine equipped with wide tracks and a blade at the front.

SIDE EFFECTS

Environmental: Negative
Social: Neutral or mixed
Economic: Neutral or mixed
Environmental effects: For manual control, see this section of the "Rapid eradication" table for manual control. Application of herbicides after cutting, on stumps or by injection will have no or minimal side effects. If employable, selective cutting will have no impact on non-target species and will not disturb the soil, compared to manual pulling up or excavation. However, it is usually very difficult to avoid cutting neighbouring species, especially when using a rotary flail (such as, gyrobroying) or when using machinery equipped with wide tracks and a blade at the front for controlling dense stands.
On the other hand, it has been observed that the habitats restored after management are recolonised by native flora and fauna (Fernandez and Sarat, 2015).
Social and economic effects: There are no socio-economic effects to report.

ACCEPTABILITY TO STAKEHOLDERS

Neutral.
It is difficult to evaluate the whole acceptability to stakeholders, since integrated control can use many different combinations of practices. As raised above, the use of heavy machinery in nature reserves may be problematic and not supported by local land managers and the general public. Similarly, herbicides are not well accepted by stakeholders and the public, due to the potential side effects on the environment and health concerns. However, in cases where stakeholders want to avoid chemical control, devitalisation of the stump can also be done using a hatchet (Fernandez and Sarat, 2015).

ADDITIONAL COST INFORMATION

Implementation cost for Member States: Management experience in France has indicated that the cost of integrated control applied on an area of dozens of hectares amounted to EUR 1,000 to 3,000 per year, with usually ten years of management required (Blottière and Damien, 2017; Fernandez and Sarat, 2015). Using volunteers for manual control can reduce the cost.
Cost-effectiveness of the measure: This measure is considered cost-effective by land managers (Blottière and Damien, 2017; Fernandez and Sarat, 2015).
Socio-economic aspects: See section 'Rapid eradication for new introductions'

LEVEL OF CONFIDENCE[1]

Well established.
There are a number of local management reports from Spain (Ihobe, 2014) and France (Fernadez, 2015; Blottière and Damien, 2017; Fernandez and Sarat, 2015) that are in agreement, and that are summarised in the EPPO Pest Risk Analysis (EPPO, 2013), the EPPO national regulatory control system (EPPO, 2016) and updated in Fried *et al.*, (2016).

1 See Appendix

Removal of stumps and coverage of the tree root.

MEASURE DESCRIPTION

Through this measure, after cutting and removing the aerial part of the plant at a height of approximately 50 cm (by any relevant means, usually mechanical), the trunk is covered with a geotextile made of polyethylene, or black polyethylene plastic, of at least 400-gauge thickness, connected to the trunk by ropes or bridles, which kills the individuals (Ihobe, 2014). Stumps should not have sharp edges, as these could pierce the cover.

The objective of this measure is to remove some individuals that cannot be managed by other measures, as part of a larger population control or containment operation.

SCALE OF APPLICATION

This measure is labour intensive and cannot be applied at a large scale. It is well suited for application on isolated individuals, where other measures cannot be applied (for example, when access is difficult for machinery or when stakeholders want to avoid application of herbicides).

EFFECTIVENESS OF MEASURE

Neutral.

Based on the experience developed in the Basque Country, Spain, this method was rated with a medium efficiency due to the high resprouting capacity of *B. halimifolia* (Ihobe, 2014).

EFFORT REQUIRED

It is necessary to maintain the coverage of the stump for a long period of time (several growing seasons) to ensure that the entire root system is dead. Regular inspection work is needed to detect any cracking of covers, as well as to eliminate potential re-sprouts around the stump.

RESOURCES REQUIRED

Based on experience from the Basque Country, Spain, this measure has been estimated to cost EUR 20,000 per hectare (Ihobe, 2014).

SIDE EFFECTS

Environmental: Neutral or mixed
Social: Neutral or mixed
Economic: Neutral or mixed

Environmental effects: One of the advantages of this measure is that there is no impact on non-target species. However, using plastic is not considered environmentally friendly, so there are some indirect environmental effects.

Social and economic effects: There are no socio-economic effects to report.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

This measure does not imply the use of chemicals, so it should be acceptable to the general public. However, the use of plastic in nature reserves is not aesthetically pleasing and could be negatively perceived by the public. Moreover, this measure has a high cost and a medium efficiency, so land managers may not accept using it.

ADDITIONAL COST INFORMATION

Cost-effectiveness of the measure: The measure is not considered as cost-effective. It is among the measures with only a medium efficacy and, to be effective, it has to be properly applied.

Socio-economic aspects: See section 'Rapid eradication for new introductions'.

LEVEL OF CONFIDENCE[1]

Unresolved.

There is only one report from Spain for the application of this method on *B. halimifolia* (Ihobe, 2014).

1 See Appendix

Selective cutting of inflorescences.

MEASURE DESCRIPTION

This measure involves cutting the inflorescences of female individuals before seed dispersal (Ihobe, 2014). This can only be done when plants are flowering, in order to be able to distinguish between males and females, but it must be done before the flowers reach maturity. In Europe, this occurs approximately in October, although variations may occur, depending on the yearly weather conditions or other characteristics of the sites. Therefore, it is advisable to observe flowering from mid-August and to start acting when the female plants can be clearly differentiated from males.

This method does not imply the death or removal of the plant and it is therefore considered as a containment and prevention method. The objective is to avoid infestation of new areas by dispersal of seeds and to limit the increase of the seed bank in invaded lands. This measure can be applied temporarily, for example while waiting for resources to eradicate or otherwise control populations.

SCALE OF APPLICATION

Although it is labour intensive to cut all inflorescences of female individuals, it is not very expensive (see estimated cost per hectare below) and it can be applied at large spatial scale.

EFFECTIVENESS OF MEASURE

Effective.

The method is considered effective in relation to its objective (containment), since no new seeds are produced, as long as all female inflorescences are cut (Ihobe, 2014). In dense stands composed of old individuals of *B. halimifolia* reaching 3–4 m height, it can be difficult to get access to all the female inflorescences (G. Fried, pers. obs., 2019).

EFFORT REQUIRED

This method needs to be applied as long as there are populations of *B. halimifolia* in the target area. As the measure does not kill the plant, its application must be repeated.

RESOURCES REQUIRED

The cost of applying this measure ranges between EUR 450 and EUR 1,100 per ha, with an average of EUR 775 per ha (Ihobe, 2014).

As is the case for manual control, this measure also requires actions to be undertaken by numerous people. Participation of volunteers can reduce the costs.

Equipment needed includes tools to cut fertile branches and bags to evacuate cut inflorescences.

SIDE EFFECTS

Environmental: Neutral or mixed
Social: Neutral or mixed
Economic: Neutral or mixed
Environmental effects: This is a very specific control method, with no expected impact on neighbouring plants (Ihobe, 2014).
Socio-economic effects: None to detail.

ACCEPTABILITY TO STAKEHOLDERS

Acceptable.

There is no reason to believe that this action, which is easy to implement and has no collateral impacts, would not be accepted.

ADDITIONAL COST INFORMATION

Cost of inaction: The cost of inaction would correspond to an increase in spread of the species, therefore incurring higher eradication or management costs.
Cost-effectiveness of the measure: The measure is considered as cost-effective by land managers (Ihobe, 2014).

LEVEL OF CONFIDENCE[1]

Unresolved.

Information is only based on one experience in Spain (Ihobe, 2014).

1 See Appendix

Flooding.

MEASURE DESCRIPTION

Flood management involves, where possible, altering the water level and flooding the invaded area for long periods of time, creating anoxic conditions, fatal to *B. halimifolia* (Ihobe, 2014). If the area is connected with the sea at high tide, the increase in salinity can also affect *B. halimifolia*.

The aim of the measure is a strong reduction of widespread populations of *B. halimifolia* in a delimited area, based on the fact that invasiveness of *B. halimifolia* is reduced under extreme water logging and salinity.

SCALE OF APPLICATION

In the Basque Country, Spain, flooding has been applied in Barrutibaso (Urdaibai) over a surface of 17.5 ha (Ihobe, 2014).

EFFECTIVENESS OF MEASURE

Effective.

B. halimifolia cannot withstand prolonged flooding, so this method can be effective in areas with appropriate flooding features (Ihobe, 2014). Flooding has been shown effective in Spain and France to control the species. In the Basque Country, although it was reported that in the flooded areas *B. halimifolia* still sprouts, a dense colonisation of the area by a dominant native species *Phragmites australis* has been seen (Ihobe, 2014). In the marshes of Atxaga, a flooding action was performed as a preventive measure, as *B. halimifolia* was not yet present in this site (Ihobe, 2014).

Experiences carried out in Bassin d'Arcachon, SW France, have shown that even a temporary flooding of several months during winter can eliminate adult *B. halimifolia* plants (Agence Méditerranéenne de l'Environnement, Conservatoire Botanique National Méditerranéen de Porquerolles, 2003).

EFFORT REQUIRED

This measure is based on the modification of the abiotic conditions and results in a new habitat. Therefore, to be effective, it is applied only once, but the new state of the habitat must be maintained permanently. In case of temporary flooding of several months, the measure should be repeated every year.

RESOURCES REQUIRED

In the Spanish Basque Country, an area of 17.5 hectares has been flooded in a fluvial area receiving water from a stream and a source, and where the sea also enters at high tide, creating a permanent standing water that prevents rooting and regrowth of new individuals of *B. halimifolia* (Ihobe, 2014). The costs of this operation were mainly related to the preparation of the area. In order to delimit the flooded area, this measure required the construction of floor lifts with a door. Excavation and remodelling of pits was estimated at EUR 7,650 to EUR 12,600 per ha, with an average of EUR 10,000 per ha (Ihobe, 2014).
Heavy machinery (for example, diggers) is also required for this measure.

SIDE EFFECTS

Environmental: Neutral or mixed
Social: Neutral or mixed
Economic: Neutral or mixed
Environmental effects: On the one hand, flooding completely modifies the existing habitat (for example salt marshes dominated by *Juncus maritimus*),with a high impact on the native fauna and flora. On the other hand, the new habitat created (reed wetlands) is generally beneficial for several flora and fauna species of interest, normally scarce or reduced. Therefore, the environmental effects are mixed.
Socio-economic effects: The landscape will also be strongly modified, together with the recreational activities associated with that habitat. Consequently, some activities may be negatively impacted, while others will be positively impacted by the creation of a new aquatic environment (for example bird watching, hunting).

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

The public perception and acceptability of this measure will depend on the use of the initial terrestrial habitat and the potential use of the new aquatic environment after flooding. A mixed acceptability is therefore expected.

ADDITIONAL COST OF INFORMATION

Cost effectiveness of the measure: The measure is considered as cost-effective by land managers (Agence Méditerranéenne de l'Environnement, Conservatoire Botanique National Méditerranéen de Porquerolles, 2003; Ihobe, 2014).

LEVEL OF CONFIDENCE[1]

Established but incomplete.

The information provided is from two sources, in France and in Spain, with general agreement (Agence Méditerranéenne de l'Environnement, Conservatoire Botanique National Méditerranéen de Porquerolles, 2003; Ihobe, 2014).

1 See Appendix

Grazing.

MEASURE DESCRIPTION

Grazing by cattle, especially sheep and goats, can be considered as a measure to contain the species. The success of control depends on the grazing intensity, including the number of animals per ha and the period of time over which grazing is applied (see effectiveness of the measure). This measure aims to keep *B. halimifolia* at low densities.

SCALE OF APPLICATION

Management of *B. halimifolia* by grazing can be applied on large areas, as for example has been done in 21 ha grazed by sheep in the Marais du Rostu, France, in 2015 and 2016 (Pervez and Blottière, 2018).

EFFECTIVENESS OF MEASURE

Neutral.

The effectiveness of the measure is mixed, with contrasting results according to grazing intensity and time of the year when grazing is applied.

In France, sheep have been used to control *B. halimifolia* resprouting after application of physical methods on large areas. For example, on the Natura 2000 site of Ria d'Etel (Morbihan), two to four sheep were used on 6,000 m² over 3 years (2009–2011), with two grazing periods of ca. 30–50 days each, first in spring and then at the end of summer. The first results were mixed due to an insufficient grazing pressure (Izard, 2015). Since 2012, sheep have grazed continuously on these saltmarshes, with almost no *B. halimifolia* remaining (Izard, 2015). Results are also better when *B. halimifolia* is cut before grazing, because resprouts are more palatable than older branches.

In another trial, Pervez and Blottière (2018) used 113 sheep on 21.2 ha, such as 5.33 sheep per ha, and had good control results, with no more plants higher than 50 cm being observed after implementation of the measure. *B. halimifolia* individuals have not disappeared, but they are puny and defoliated, which weakens their flowering and thus limits the risk of spread. In the "marais de Kervarin", where the size of the initial population was small with only young individuals, no more *B. halimifolia* were observed after one year of grazing. On the Duchess Saline, after two years of grazing, the young plants of the year and individuals larger than 50 cm have disappeared, which corresponds to 72% of the total number of *B. halimifolia* individuals observed at the beginning of the intervention (Pervez and Blottière, 2018).

EFFORT REQUIRED

Grazing should be applied on the long term to provide results and to prevent establishment of new populations.

RESOURCES REQUIRED

This measure requires at least a flock of sheep or goats (or other appropriate cattle species), a shepherd, and fences.

The cost was about EUR 5,000 in the site of 6,000 m² of 'Ria d'Etel'(Morbihan, France), with most of the resources required to install the fences (EUR 4,500) (Izard, 2015). However, the farmer has borne most of the costs of installing the fences. In return for the operation, he received from the Community of Municipalities, the municipality of Mesquer and the Association of Friends of the Mesquer sites, the sum of EUR 5,000 in total. In 2017, fencing for the extension of the grazing area was funded by the Pays-de-la-Loire Region (EUR 8,000), the Town Hall of Mesquer (EUR 500) and Friends of the Mesquer sites (EUR 1,500).

SIDE EFFECTS

Environmental: Neutral or mixed
Social: Positive
Economic: Positive

Environmental effects: Depending on grazing intensity and timing, this measure can have a negative impact on native vegetation (Ihobe, 2014). At the same time, species adapted to grazing will be favoured at the expense of other species. In some nature reserves with plant species of high conservation value that are sensitive to grazing, this may be a reason not to use the method. On the other hand, preventing the formation of dense stands of *B. halimifolia* by grazing can favour the re-establishment of typical grassland species.

Social effects: The presence of livestock in salt marshes could be positively perceived by the public because of the "use" and "valorisation" of the land.

Economic effects: Grazing of invaded areas can be economically exploited by farmers (Ihobe, 2014).

ACCEPTABILITY TO STAKEHOLDERS

Acceptable.

Farmers will be prone to use new areas of saltmarshes and grasslands for their cattle, provided some of the initial costs are funded.

ADDITIONAL COST INFORMATION

Cost-effectiveness of the measure: The measure is considered as cost-effective by land managers (Izard, 2015;Pervez and Blottière, 2018).

Socio-economic aspects: The measure is beneficial for agricultural activities in salt marshes areas.

LEVEL OF CONFIDENCE[1]

Well established.

There are a few local management reports of this measure being used in France, which are in agreement (Izard, 2015; Pervez and Blottière, 2018).

Baccharis halimifolia. *The flowers of which produce abundant nectar that attracts various butterflies. © John D. Byrd, Mississippi State University, Bugwood.org. CC BY 3.0*

1 See Appendix

Biological control.

MEASURE DESCRIPTION

Biological control involves the introduction of a plant's natural enemies into a new territory where they do not occur naturally. The aim of the measure is to reduce the abundance of *B. halimifolia* to a level that causes reduced impacts.

Australia launched a biological control programme of *B. halimifolia*, with the release of the first agent at the end of the 1960s, and release of the final agent, the groundsel bush rust (*Puccinia evadens*), in 1997. Over 35 different insects were tested, but only six became permanently established in the field: *Aristotelia ivae* (Lepidoptera: Gelechiidae), *Bucculatrix ivella* (Lepidoptera: Bucculatrigidae), *Hellinsia balanotes* (Lepidoptera: Pterophoridae), *Megacyllene mellyi* (Coleoptera: Cerambycidae), *Rhopalomyia californica* (Diptera: Cecidomyiidae) and *Trirhabda baccharidis* (Coleoptera: Chrysomelidae). In addition, *Puccinia evadens* (Basidiomycota: Pucciniaceae) was released in 1997 and is now well established (Palmer *et al.*, 2010; Queensland Government, 2013).

SCALE OF APPLICATION

Biological control should be applied at large scales in all habitats suitable to *B. halimifolia*. In fact, the advantage of this measure is that it can be applied on very large spatial scales, as soon as the biological control agent is established.

EFFECTIVENESS OF MEASURE

Effective.

In Australia, where biological control has been used against *B. halimifolia* (using all the agents listed above), although the measure has not been completely successful, *B. halimifolia* is no longer considered a problematic weed, in marked contrast to the situation in the 1970s (Sims-Chilton *et al.*, 2009). As such, in relation to its objective of reducing the abundance and impact of the targeted species, the method can be considered effective.

EFFORT REQUIRED

In Australia, biological control only started to be successful more than 40 years after the initial release of the first biocontrol agent (Fried *et al.*, 2016). Some agents, such as *Puccinia evadens*, have become effective more rapidly, soon after their introduction (Sims-Chilton and Panetta, 2011).

RESOURCES REQUIRED

The release of biological control agents is subject to specific procedures in individual EU countries . Developing a biological control programme requires research on useful agents, and host specificity testing to ensure the absence of impacts on non-target species. This long process needs significant funding and research staff for about ten years (Bale *et al.*, 2008). In the case of *B. halimifolia*, the work could be based on what has already been done in Australia, with the aim of adapting it to Europe.

Once biological control agents are released and established, the costs are very low, consisting only in staff time to monitor the biological control impact on *B. halimifolia*.

SIDE EFFECTS

Environmental: Neutral or mixed
Social: Neutral or mixed
Economic: Neutral or mixed
Environmental effects: No negative environmental side effects were recorded for biological control in Australia (Sims-Chilton *et al.*, 2009).
Social and economic effects: There are no social or economic effects to report.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

The perception and acceptability of biological control is often mixed. On the one hand, biological control could be perceived positively, because it does not involve using chemical products or heavy machinery in natural areas. On the other hand, some people, especially in Europe, fear non-intended effects associated with the introduction of a non-native species.

ADDITIONAL COST OF INFORMATION

Implementation cost for Member States: This measure mainly entails costs to pursue research on biological agents for *B. halimifolia*.

Cost-effectiveness of the measure: The measure is considered cost-effective; the benefit: cost ratios of weed biological control ranged from 50:1 for invasive sub-tropical shrubs, to >3000:1 in case of the biological control of invasive Australian trees (de Langeand and van Wilgen, 2010).

LEVEL OF CONFIDENCE[1]

Well established.

There is a long experience of biological control of *B. halimifolia* in Australia (Sims-Chilton *et al.*, 2009).

1 See Appendix

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Appendix

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

- **Well established:** comprehensive meta-analysis[1] or other synthesis or multiple independent studies that agree.
- **Established but incomplete:** general agreement although only a limited number of studies exist but no comprehensive synthesis and/or the studies that exist imprecisely address the question.
- **Unresolved:** multiple independent studies exist but conclusions do not agree.
- **Inconclusive:** limited evidence, recognising major knowledge gaps.

1 A statistical method for combining results from different studies which aims to identify patterns among study results, sources of disagreement among those results, or other relationships that may come to light in the context of multiple studies.

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