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BACCHARIS HALIMIFOLIA

Management Manual

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This document has been developed by the Department for the Environment and Territorial Policy of the Basque Government in collaboration with the Group of Specialists on Biological Invasions, In the framework of the LIFE+ Estuaries of the Basque Country project (LIFE08NAT/E/0055), with contributions from the LIFE+ Programme, the European Commission's financial instrument for the environment.

Presentation

This management manual is generated within the framework of the actions of the LIFE+ project "Restoration of Habitats of Community Interest in the Basque Country's Estuaries" and aims to present in a unified way the available information about *Baccharis halimifolia* or sea myrtle, one of the exotic invading plant species that has most impact on wetlands and cliffs along the Atlantic coast, and to serve as a tool when taking decisions in the battle against this plant.

Coastal ecosystems, both estuaries and coastal cliffs, are very important environments for the conservation of our natural heritage for the quantity of relevant biodiversity elements they house, for the importance of the ecological processes that take place in them, for the role they play in the battle against climate change, or for the environmental services and goods they supply. For that reason, in our Autonomous Region, a good proportion of these ecosystems are already protected through diverse instruments: Red Natura 2000 (Nature Network 200), RAMSAR wetlands of national importance or wetlands and coastal sectors of Territorial Plans.

However, recently biological invasions in these environments have been becoming one of the biggest causes of degradation and loss of biodiversity. Their main impact has to do with the loss of natural habitats and the habitats of endangered species of birds, and with significant modifications in the the ecological functioning of the ecosystems in which they settle.

Over the last four years, the LIFE+ project "*Restoration of Habitats of Community Interest in the Basque Country's Estuaries*" has allowed us to face up to many problems caused by the invasive exotic plant *Baccharis halimifolia*, "sea myrtle", whose great colonising and transformational capacity affects some of the estuaries of the Basque Country, above all in the areas most affected: Urdaibai, Txingudi-Bidasoa and the Lea estuary.

In a well-planned initiative, the examples of this species have been eliminated, the habitats have been restored and conditions have been improved for the birds who live in or use these habitats in their migrations. The interventions are accompanied by diverse actions, research work and scientific monitoring, and by an ambitious programme of information spreading and environmental awareness.

The colonisation attempts of sea myrtle are a worldwide problem that affects a large part of the European Atlantic coast, from Brittany to Asturias. One of the main milestones of the Life project has been the creation of an international commission to boost the exchange of information and experiences between the affected territories and to improve coordination, considering the future realisation of joint projects to diminish risks. Taking advantage of the initiative, we have drawn up this manual, whose contents have been worked on collectively in the heart of the international commission, which we trust will be very beneficial, and we encourage you to use it.

Ana Oregi Bastarrika
Minister for the Environment and Territorial Policy

Introduction

Biological invasions are one of the main causes of the loss of biodiversity at global level and plans to minimise their impact involve a great effort in economic and material terms on the part of public administrations. Being a relatively recent problem, knowledge about the behaviour and impact of invasive species is usually thin on the ground and the exchange of valuable information between the different agencies is limited.

To guarantee effective action, in keeping with the needs and characteristics of each situation, it is necessary to have all the available information about the invasive species in question, as well as gathering knowledge of the efficient practices and methodologies that have been tried out. In the implementation of invasive species management projects, the learning generated rarely transcends or is made available to the public, which means that bad practices, errors and logistical or technical problems tend to repeat themselves in each new project.

This is the case of one of the invasive species of exotic flora which is having the biggest impact on the biodiversity of the Basque Autonomous Community: the invasive bush *Baccharis halimifolia*. This plant, originating from the east coast of North America, was introduced on the European coasts as an ornamental plant, and over the last few decades it has propagated itself along the French coast, invading coastal wetlands, estuaries and marshes. In the Basque Autonomous Community (BAC), it has a large presence in estuaries and is ever more present along coastal cliffs. For several years, the Department of the Environment and Territorial Policy of the Basque Government has carried out numerous pilot projects for its elimination on a small scale, but it has been since the implementation of the Life+ Estuaries of the Basque Country project that the problem has been tackled on a larger scale in three of the worst affected estuaries.

The project LIFE08NAT/E/0055 "Restoration of habitats of community interest in the estuaries of the Basque Country" has managed to treat all the affected surface areas in the estuaries of Urdaibai, Txingudi and Lea in a period of four years (2010-2014) with very satisfactory results, given that the vegetation has largely been recovered after it had been replaced by monospecific masses of this invasive species, altering the habitat of threatened species of fauna and flora. This project has also permitted the optimisation of methodologies of elimination of the species and the management of waste from the pruning, analysis of the costs, establishment of criteria for the selection of the methodologies and planning of the work, design of a monitoring plan, etc.

The objective of this manual is to present, in a unified way, all the available information about this species, offering managers a base on which to schedule their projects and actions comprehensively.

The **first chapter** describes *Baccharis halimifolia* biology and ecology, as well as its distribution and impacts. The characteristics that make this a successful invasive species are underlined, as well as the key factors for its management.

The **second chapter** includes some guidelines for prevention and a rapid response and early warning system proposal.

The **third chapter** forms the document core. Based on a planning, implementation and monitoring scheme for the project, it offers useful information for the analysis of the starting position, establishment of objectives of the action and prioritisation, analysis of the different methodologies of elimination and control, and proposals for the monitoring and dissemination of the actions.

This document has been prepared with European financing through the Life+ Programme of the European Commission.

Participating in the writing were the Group of Specialists in Biological Invasions (GEIB) and the Environmental Management Public Company Ihobe.

In its draft phase, the document was presented, checked and put into practice in the II work session of the "International Commission of Monitoring and Exchange of Experiences on *Baccharis halimifolia*", a coordination group between administrators, managers and researchers of the regions affected by the invasive species in Spain and France, created within the framework of the Life+ Estuaries of the Basque Country Project. In the two sessions held in November 2011 and 2013, representatives of the following organisations took part:

- Direction of the Environment and Environmental Planning Department for the Environment and Territorial Policy. Basque Government.
- Environment Management Public Company, Ihobe. Basque Government.
- Directorate-General for the Environment and Forestry Planning. Ministry of Agriculture, Food and Environment.
- Directorate-General for Nature Conservation Xunta de Galicia.
- Directorate-General for Biodiversity. Government of Cantabria.
- Conseil départemental des Pyrénées-Atlantiques.
- Basque Country Coast District.
- Bizkaia and Gipuzkoa Coast Provincial Service.
- Basque Water Agency, URA.
- Provincial Council of Bizkaia.
- Provincial Council of Gipuzkoa.
- Irun Town Council.
- Hendaye Town Council.
- Conservatoire du Littoral – CPIE Littoral Basque.
- Technical Office of the Urdaibai Biosphere Reserve.
- Department of Plant Biology and Ecology. University of the Basque Country.
- Urdaibai Bird Center.
- Botanics Department. Aranzadi Society of Sciences.
- Group of Specialists on Biological Invasions (GEIB).
- Gaimaz Infrastructures and Services (forestry sector company)

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1. DESCRIPTION AND BIOLOGY OF *BACCHARIS HALIMIFOLIA*

A) Description of the species

Photograph 1.1. *Baccharis halimifolia.* (Ihobe)

Deciduous bush of 1.5-4 m high that can sometimes reach 7 m high, generally branched and sometimes shaped as a tree with just one stem

The **trunk** can reach 25 cm in diameter; mature specimens have a brittle look, they are brown and with deeply fissured **bark** in adult specimens. It has abundant, open and sometimes flaky **branching**. Bare stems remain slightly green in winter.

Photograph 1.2. Root detail. (Ihobe)

Its **radical apparatus** is well developed and deep.

Photograph 1.3. Leaf detail. (Ihobe)

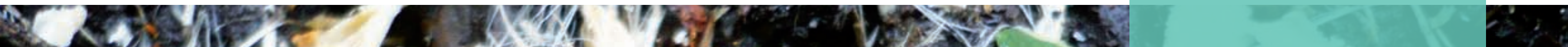
The **leaves** are alternate, thick, with a bright green or green-greyish colour, diamond shaped. They are 1-7 cm long and 1-4 cm wide, with short stalks shaped as a wedge at the base and full upper edges or thickly serrated (1-3 pairs), with glabrous, slightly resinous surfaces.

Photograph 1.4. Female flowers. (Ihobe)

Baccharis halimifolia is dioecious. Flowers are small (6 mm), with chapters, whitish the female and greenish the male. They are grouped in terminal or axillary inflorescences of up to 5 flowers.

Photograph 1.5. Male flowers. (Ihobe)

The fruit (aquenios) in cypselas are formed by a seed (1.3-1.8 mm) with a white-silverish flexible hair tuft (pappus) that can be 10-12 mm long when the aquenio is mature.



Photograph 1.6. Seeds. (Ihobe)

Photograph 1.7. Branching. (Ihobe)

Photograph 1.8. Trunk detail. (Ihobe)

[15, 55, 79, 89, 94]

B) Autoecology

It is a native species of North America with its northern limit in Canada (Nova Scotia), and distributed along the west coast, from Massachusetts to the Gulf of Mexico, with populations in Cuba and the Bahamas.

Detailed distribution

North America: Canada (Nova Scotia), USA (Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Florida, Georgia, Louisiana, Massachusetts, Maryland, Mississippi, North Carolina, New Jersey, New York, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Texas, Virginia, West Virginia).

Central America and the Caribbean: Mexico (Nuevo León, San Luis Potosí, Tamaulipas, Veracruz), Bahamas, Cuba.

Figure 1.1. Native distribution area of *Baccharis halimifolia* represented at regional level for Canada, USA and Mexico, and a national level for the Bahamas and Cuba [34, 46].

Habitat preference in the native and invaded zones

Throughout its natural distribution area (humid subtropical and temperate region), *B. halimifolia* occupies a great variety of coastal habitats, including the upper range of irregular irrigation, sandy areas, dunes, marshes, salty wetlands, open forests and coastal cliffs. Despite its distribution along the coast [83, 91], since the first half of the 20th century, the species has expanded towards the interior, where it has established itself in anthropogenic habitats, such as pastures, wastelands, ditches, forest plantation margins, and along artificial corridors, such as roads, paths and railways [34, 48].

In Europe, where it has been introduced in gardening areas, canal margins and so on (anthropic habitats), *B. halimifolia* has started its colonisation process by dispersing throughout communication channels (roads and canals), invading coastal semi-natural and natural habitats and estuaries, such as wetlands, marshes, dunes, beaches, riversides, riverbeds and dried canals, and, less frequently, although increasingly, cliffs [46, 73]. In France, the species invading the coastal range has started to expand away from the coastline to uncultivated areas and along linear infrastructures (F. Esnault, personal comment).

On the Spanish coast, *Baccharis* colonises more intensely the subhalophile communities of the intermediate marshes: wet prairies of *Elytrigia atherica*, reedbeds of *Phragmite autralis* and rushes of *Juncus maritumus*. Also, it invades the estuarine forests (*Alnus glutinosa*) in the upper areas of the marshes and, more scarcely, the halophile communities dominated by *Sarcocornia fruticosa* in the lower areas. It cannot be found in the communities subject to the influence of the *Salicornia spp.*, *Spartina maritima* and *Zostera noltii* tide [19, 23]. In recent years, it has started to colonise coastal cliff and prairie areas, where its expansion is slower.

Main habitats occupied by the species in Europe (EUNIS classification) [46]	
EUNIS code	**Description**
A2.5	Coastal marshes and saline reedbeds
A2.514	Marshes over accumulated marine waste characterised by *Elymus pycnanthus* with *Suaeda vera* or *Inula crithmoides*
A2.522	Mediterraneal marshes of *Juncus maritimus* and *Juncus acutus*
B1.43	Mediterranean-Atlantic fixed coastal dunes (grey dunes) with herbaceous vegetation
B1.8	Wet depressions of the coastal dune system
B3.3	Coastal plates and cliffs, with angiosperms
C3.2	Edge reedbeds and vegetation of big heliophiles
D5.2	Big cyperaceae beds generally without open waters
E3.1	Damp high Mediterranean meadows
E3.4	Eutrophic and mesotrophic meadows and wet or swamped pastures
E3.41	Atlantic and sub-Atlantic damp meadows
F4.234	Northern landes of *Erica vagans*
F9.3	Southern fluvial thickets and galleries
J4.2	Road networks
J4.3	Rail networks
J4.5	Marine ports
J4.6	Other artificial habitats (leisure areas)
J5	Artificial constructions linked to water

Table 1.1. Main habitats occupied by the species in Europe

Photograph 1.9. Detail of floating *B. halimifolia* seeds. (Ihobe)

Life cycle/reproduction

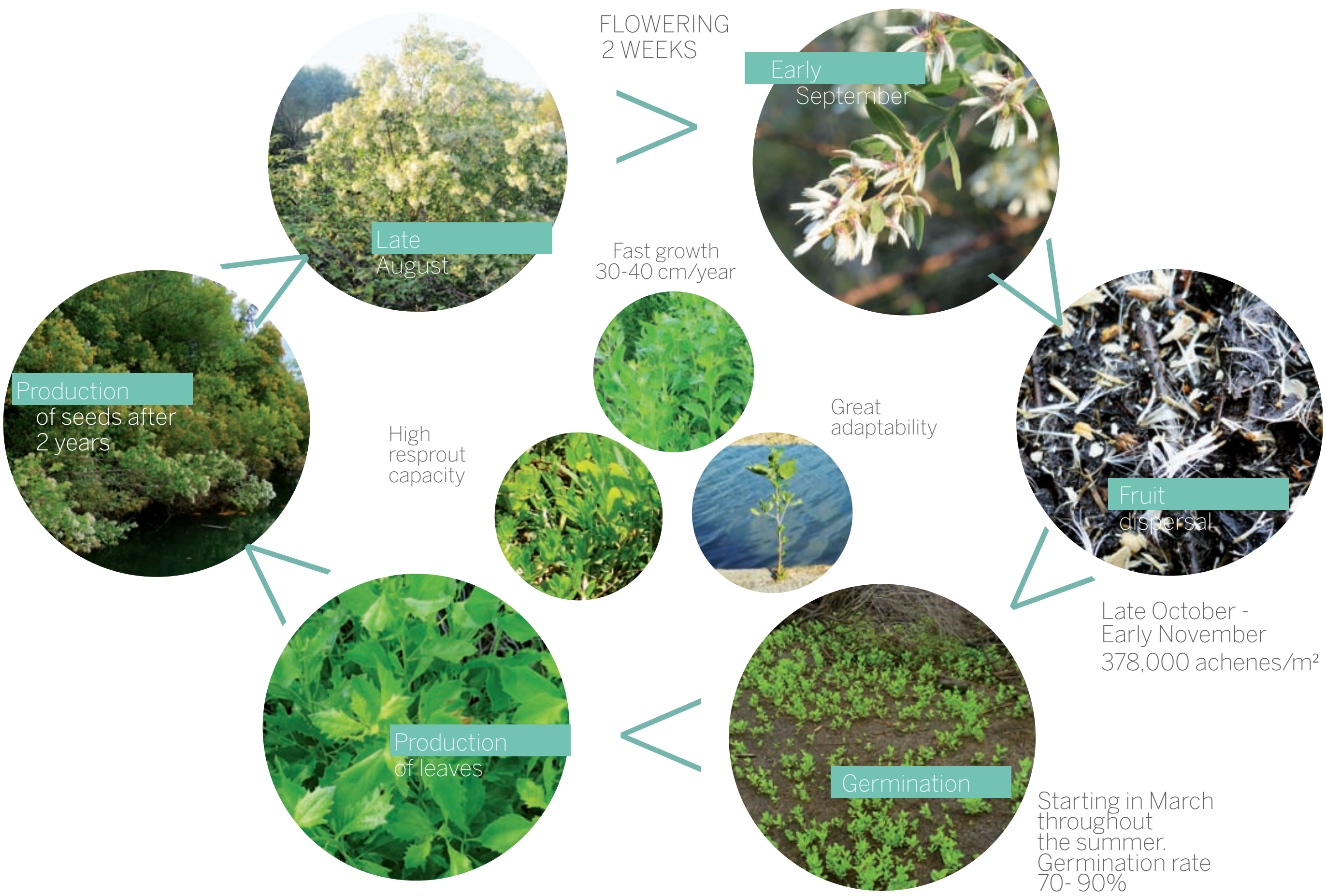
It reproduces sexually and has great regrowth capacity. The species reaches reproductive maturity in the first two years and flowers annually [47]. On the Cantabrian coast, it flowers between the end of August and the beginning of September [23, 86]. Male flowers develop before female flowers [22, 66] and pollination is carried out by the wind [66] and insects [34, 55].

At the end of October and beginning of November, after ripening, the fruits are dispersed by the wind thanks to the pappus, partly falling within a 100 m radius of the plant, where they germinate reaching very high seedling densities [30], and partly beyond that distance, reaching even 5 km [29, 86]. The species can also disperse over long distances in the water, as the average flotation time of the seeds is over 40 days [43, 88]. Females produce seasonally between 10,000 [7] and 1,500,000 [88] seeds, with a reproductive performance that can reach up to 376,000 achenes/m2 (Australia data) [74].

Their productive capacity decreases with age and density, but increases with light availability. On the contrary, in extreme shade conditions, they produce fewer seeds, although these have a greater germination capacity than the seeds produced in the sunshine [74, 75, 76]. The germination rate of the species varies between 30 [70] and 99% [25, 41, 75] and varies a lot between maternal lines [25]. Besides, salinity reduces the germination rate [25]. There are discrepancies about the seed longevity, estimated in 14 months by Caño [personal communication] and 5 years according to the EPPO [47]. The *optimum* condition for germination is between 15 and 20 ºC [88], decreasing dramatically under 15 ºC [86].

The species has a high capacity of regeneration by radical shoots or by lower branch rooting. *B. halimifolia* is a fast growing species (30-40 cm per year) [26]. It has deciduous behaviour. However, in the Basque Country, it maintains some folious bracts from the inflorescence and sometimes upper leaves until development of new shoots, which takes place at the end of winter or beginning of spring [18]. The deciduous or semi-deciduous behaviour of the species seems to change depending on environmental conditions, as it varies along the latitudinal gradient of North America [66]. Also, in the same municipality, the leaf loss is greater in more saline habitats [22].

CHARACTERISTICS AND LIFE CYCLE



Tolerance to factors such as stress and phenological variation

B. halimifolia presents the characteristics of a generalist species adapted to the pioneer phases of a succession [88].

It can tolerate a wide range of conditions in relation to variations of pH (from 3.6 to 9) and nutrient availability (Total Kjeldhal Nitrogen of 560-5500 ppm; phosphorus 4-73 ppm) [88]. In low nitrogen level nurseries, the plants can grow for their first 13 weeks and can survive in situations where all nutrients are scarce [88].

Although the species grows mainly in highly organic and humid floors, it can develop in an ample variety of substrates, from sandy to clayish soil [42]. It has even been observed that it can proliferate in areas almost without soil (cracks in concrete walls) [E. Beteta, pers. comment].

It is a halotolerant species which, under saline influence, is very competent when compared with other species. It can be found in areas with salinity ranges between 4 g/L (salty water) and 33 g/L (sea water) [25] and tolerates fresh water floods without adverse effects for up to 9 days, and salty and sea water floods (20 and 30 g/L-1) for about 17 days [83], succumbing to more prolonged expositions [18]. In laboratory experiments, saline concentrations of 2 g/L reduce the germination by 20%, and concentrations of 10 g/L inhibit it [25].

It can resist cold temperatures (up to -15 ºC) [59], droughts, and has high regrowing capacity after fires [88].

Although no studies have been carried out, it seems that direct affliction by sea breeze and salt-loaded winds can have a negative impact in its implantation, based on observations carried out during prospective works in coastal cliff areas (A. Mitxelena, pers. comment).

Caño et al. [23] observed high phenological variation between *B. halimifolia* populations and genders in relation with seasonal changes in salinity and water logging. The authors have recorded a smaller growth rate in high salinity, being the female stems more sensitive than the male, and a greater degree of susceptibility of the latter to natural enemy attacks.

The species gender proportion in the Basque Autonomous Community (BAC) is still unknown, but the phenological response variation seems to show different ratios to 1:1 [23] as well as diversified spatial distributions.

Species characteristics of interest for its management

The high reproductive capacity and long-distance dispersal allow the species to quickly cover large areas of bare vegetation with seedlings, which leave no space or resources for other native species.

To minimise 'seed rain' the elimination of female specimens before the dispersal season (September) should be prioritised, both in the most heavily-invaded areas and in nearby areas where isolated specimens appear.

It is recommended to carry out periodic pull-ups of young specimens to ensure the effectiveness of the control actions.

The radius of areas to be observed should be that of the maximum dispersal distance of the species (about 5 km)

B. hamilifolia presents an **important recuperation by resprout**

It affects the control method: a) it makes burning and clearing ineffective; b) the herbicide application must be made on the stumps, not on the branches.

It implies correct treatment of waste after a control intervention

It involves maintaining active observation in the intervention areas.

Salinity variations and the degree of flooding of the invaded zone can affect the invasiveness capacity of the species. **The biological efficacy of the species decreases when the salinity and waterlogging increases.**

It implies maintenance of active observation in intervention areas

Changes in the phenological response of the species could **influence the design of the control actions**.

In space towards females in less saline areas.

In late August and early September, when the species is weakened by high salinity and presents minimal growth and the attack level by natural enemies reaches its maximum, having invested the resources for flowering without the seeds being developed or matured.

It must be noted that most studies on *Baccharis halimifolia* have been carried out in estuaries and marshes, so the information is biased towards these environments. There is not sufficient information about the behaviour and impacts along coastal cliffs.

2. INTRODUCTION CHANNELS AND CURRECT DISTRIBUTION

The first documented introduction of *B. halimifolia* in continental Europe dates back to 1783, when it was introduced in France as an ornamental plant, having been cultivated continuously in botanical gardens in different parts of the country. Its cultivation as ornamental plant, recommended in many horticulture manuals, drove its use firstly at a personal level (gardens) and, progressively, in public areas, from the second half of the 19th century. Due to its tolerance to salinity, it has been planted in coastal areas along road and roundabout edges, and it has also been used to stabilise canal banks, as windscreen and, less so, as small game hunting shelter and as a medicinal plant.

With different chronologies but similar causes, the species was also introduced in the United Kingdom, Spain, Belgium, the Netherlands, Italy and, outside Europe, Australia, New Zealand and Georgia [46].

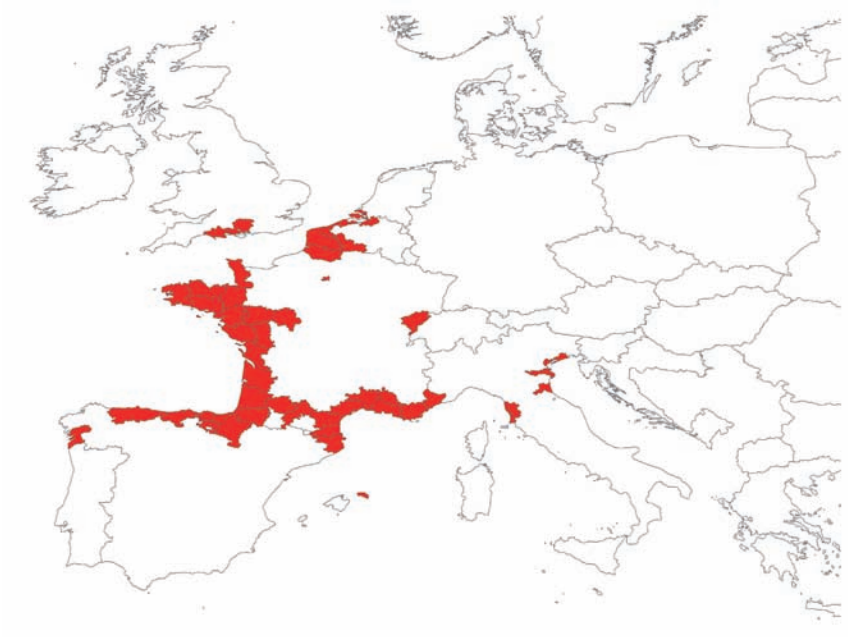


Figure 1.3. Distribution of *Baccharis halimifolia* in Europe, represented at provincial level [24, 46]. In the case of Spain, two more locations unreported in the previously mentioned sources have been taken into account: Pontevedra and Minorca [64, 77].

Caño *et al.* [24] cover the invasion process dynamics in the European continent. Cited as naturalised for the first time in the south of France in 1906, the species would have dispersed towards the north of France and western Spain colonising the coast continuously with locally abundant populations. On the other hand, they mention that the invasive populations dispersed in Belgium, the Netherlands, Italy and the United Kingdom which have experimented strong expansion in the last decade could have been formed separately from local plantations.

In Spain, the species was first found in the Basque Autonomous Community (BAC) [4], where it is currently naturalised along all the Gipuzkoa and Bizkaia coast [19]. It is also mentioned in Araba [21], although in a recent cartographic work this citation has not been confirmed [60]. By territories, its presence is greater in Gipuzkoa than in Bizkaia [60], and the main affected areas are the river Oka (Urdaibai) estuary, with approximately 300 hectares [55], and the Bidasoa and Lea estuaries (1.44 hectares) [30].

The invasion front in the north of Spain is about 300 km, also covering Cantabria and Asturias. According to Caño *et al.* [24], the most western distribution limit of the species is formed by an isolated population near Avilés (Asturias), which seems to have originated independently from plants cultivated in personal and public gardens. According to González-Costales [53], it is known that the species has been planted or cultivated beyond the known naturalisation limits in Asturias (for example, in Navia). However, the currently known naturalisation limit could be established more towards the west if confirmed in an isolated citation of the species in La Ramallosa (Pontevedra) [64].

With the exception of these two foci and that of Avilés, it seems likely that in the north of Spain natural dispersal has played a very important role thanks to the great capacity of the species to disperse a long distance and its outstanding propagation speed (in the 1996-2005 period, the invaded surface in the Biosphere Reserve of Urdaibai has increased 234 hectares) [24]. Nevertheless, the absence of studies about routes of introduction cannot exclude that the species expansion might have been generated as well from local introductions. Other isolated populations have been cited in Navarre [3, 68], Catalonia [8] and the Balearic Islands (Minorca) [77].

Figure 1.4. Distribution of *Baccharis halimifolia* in Spain. 10x10 km fence.

Figure 1.5. Distribution of *Baccharis halimifolia* in the Basque Country. 10x10 km and 1x1 km fences.

Figure 1.6. Distribution of *Baccharis halimifolia* in Cantabria. 10x10 km and 1x1 km fences.

Figure 1.7. Distribution of *Baccharis halimifolia* in Asturias. 10x10 km and 1x1 km fences.

In **France**, *B. halimifolia* was firstly cited as naturalised in 1906, in the southern provinces of the Gironde and Lower Pyrenees. In the mid 70s, it was considered completely naturalised along the Atlantic coast to Brittany. Other populations have been found more recently in Normandy and northern Pas-de-Calais. On the other hand, during the 1980s, the first records of *B. halimifolia* on the Mediterranean coast were reported, a place where it is nowadays widely distributed [24, 46].

Figure 1.8. Distribution of *Baccharis halimifolia* in France.

Despite the apparent absence of the species in the local nurseries of the Basque Country and the fact that it was commercially banned from 1 December 2013 in the whole country as per Royal Decree 630/2013 [11], the species can still be bought, mainly through the Internet.

At least 54 specialised nursery companies in Europe sell this species all year round, locally and through the Internet. Out of these, at least two are in France selling to Spain [46].

Thus the necessity to inform about Royal Decree 630/2013, so it can be followed at all levels with the aim of avoiding the cultivation of the species in personal and municipal nurseries, its retail sale and distribution through the Internet, and the exchange of cuttings and seeds among private parties.

Lastly, it is worth mentioning the role that certain activities can play when it comes to dispersing the species. The cleaning of road edges close to *B. halimifolia* populations and vegetation or soil handling could favour the germination of seeds, since leaving uncovered areas increases exposure to light [46].

The probability that B. halimifolia will colonise a favourable habitat depends on the proximity of the latter to the place of introduction, although in general it is quite high [46].

3. IMPACTS

Spain and France are, in all Europe, the countries suffering the greatest negative impacts from the presence of *B. halimifolia* [17]. The north-east estuary habitats on the Cantabrian coast have suffered several modifications after the introduction of this species [17]. The first warning about its colonising capacity on the Atlantic band between central-eastern Spain and Brittany was made by Dupont in the 1950s [86], being first cited in the Basque Country in 1948 [4], specifically from the village of Lekeitio (on the shores of the Bay of Biscay) to Deba (a village on the Gipuzkoa coast located in the mouth of river Deba). Currently, it is undergoing strong expansion throughout several natural and semi-natural habitats of the Basque Country [55], Cantabria and Asturias coast.

Due to the clear impacts provoked in ecosystems, this species has been referred to as transforming species, that is, an invasive plant that produces changes in the character, condition, shape or nature of ecosystems in a significant area in relation to the extension of such ecosystem [55].

B. halimifolia has invaded the 300 kilometres of estuaries of the northern coast of Spain, expanding at great speed: for example, in the Urdabai Biosphere Reserve (Basque Country, Spain), the number of invaded hectares has gone from 54 hectares in 1996 to 128 in the year 2000, reaching 288 hectares in 2005 [24]. In fact, its presence has been recorded in 10 protected areas belonging to the Natura 2000 network, precisely because the estuaries and coastal areas are very well conserved; among them are the Urdabai Biosphere Reserve (Ramsar, SCI and SPAB), the Lea estuary (SCI), the Txingudi wetlands (Ramsar, SCI and SPAB) or the hygroturbous areas of Jaizkibel (SCI) [45, 121, 122, 125, 45,121,122,125,129].

A) Impacts on biological diversity

The aerial part of *B. halimifolia* is capable of forming a dense covering which prevents germination and growth of native species, excluding them through shade [54], above all sun-loving plants [1]belonging to saltwater wetlands.

They form monospecific communities, structurally simplifying the invaded community and causing substantial changes, in structure, physiognomy and associated diversity [19].

B. halimifolia seriously threatens the **subhalophilic communities** dominated by the native species *Juncus maritimus* [55, 70], *Elymius pycnanthus and/or Phragmites australis*, sometimes even being totally replaced [24, 70]. These species are included within the protected Habitat 1330 "Atlantic Saline Pastures (*Glauco-Puccinellietalia maritimae)*" of the Habitats Directive 92/43/EEC, with a great influence of non-saline waters.

This type of habitat occupies in Europe a surface of around 89,938 hectares, 50% of which are affected by the presence of B. halimifolia [24]. The priority is to avoid the arrival of this species in Galicia, still unaffected by B. halimifolia, given that in this region is to be found 79.32% of the surface area of this habitat in all the state.

Figure 1.9. Habitat distribution mapping 1330 in the BAC. [95]

On the contrary, the halophilic communities[2] of the wetlands seem to resist this invasion, probably due to the values of salinity and waterlogging limiting their survival and propagation. In spite of this, *Baccharis* can be found in lower areas of swamp dominated by the species *Sarcocornia fruticosa* [24].

In France, the species is considered naturalised along the whole south west coast since 1960; in Brittany, it is abundant in some coastal wetlands of Morbihan [69]. In the Basque Autonomous Community (BAC), we can find *Baccharis* in all its estuaries.

1 Heliophilous: species needing great exposure to sunlight.
2 Halophiles: species which live in areas with the presence of great quantities of salts.

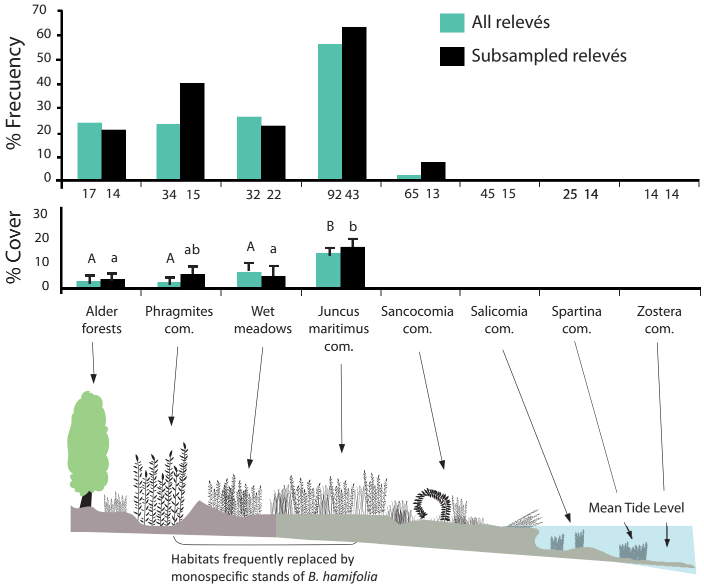


Figure 1.10. Frequency of the presence and coverage of *B. halimifolia* in the communities of estuary in the north of Spain [24].

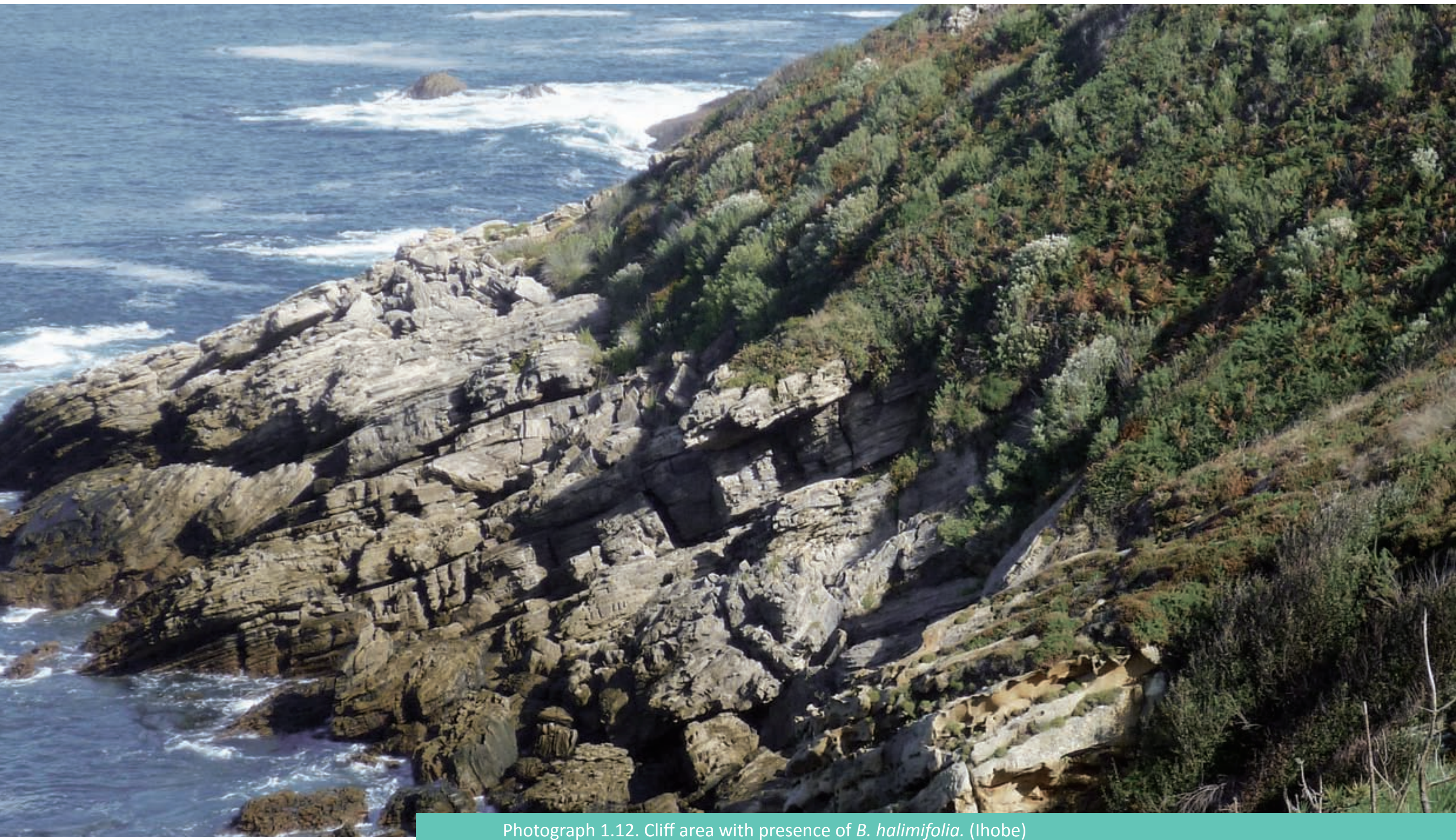
- Over the last few years, the invasion of *Baccharis* could cause a large reduction in the population of certain **native species of great interest**, such as, for example, *Glaux maritima* (a rare species belonging to the Cantabrian estuaries [78, 81]), Dryopteris carthusiana (species classified as "vulnerable" in the Red List of Vascular Flora in the BAC [2, 13]), *Cochlearia aestuaria* (species classified as "vulnerable" in the Red List of Vascular Flora in the CAPV [2]), or *Matricaria maritima* (belonging to halonitrophile habitats and classified as "in danger of extinction" in the Basque Catalogue of Threatened Species of Woodland and Marine Fauna and Flora [19, 55] and in the Red List of Vascular Flora of the BAC [2]). It has been recorded that the invasion by *B. halimifolia* has had an effect on the disappearance of *Sonchus maritimus subsp. maritimus* of the subhalophilic rushes of Urdaibai [2] (it is classified as "rare" in the Basque Catalogue of Threatened Species of Woodland and Marine Fauna and Flora [19, 55] and "in danger of extinction" in the Red List of Vascular Flora of the BAC [2]).

Photograph 1.10. *Matricaria maritima*. (Amador Prieto) Photograph 1.11. *Glaux maritima*. (Amador Prieto)

- Thus, it is possible to find this species in **cliff areas**, in the halocasmophytic communities[3] of the Crithmo-Armerion maritimae Alliance (habitat of priority interest, according to the Habitats Directive 92/43/EEC, code 1230) or in the aerohalinos heaths with the communities of the *Dactylido maritimae-Ulicion maritimi* Alliance (habitat of priority interest, according to the Habitats Directive 92/43/EEC, code 4040) [20].

  Although it is not very frequent on the Cantabrian coast, it is expanding rapidly along the cliffs of the extreme north east of Guipuzcoa (Jaizkibel Special Protection Area) [E. Beteta, per. com.]; meanwhile, on the French coast, it is habitual to find *Baccharis* in this type of ecosystem.

3 Halocasmophitic: vegetation capable of living in cracks (casmophitic) and that is capable of surviving salinity (halophylic).



Photograph 1.12. Cliff area with presence of *B. halimifolia.* (Ihobe)

- It can also been seen invading **estuary forest communities** in the upper areas of the marshes, such as alders (*Alnus glutinosa*). However, it seems that competitiveness between *Baccharis* and native species such as *A. glutinosa* or *Salix atrocinerea* prevents persistence in the long term of the exotic species [24].

- Recientes estudios concluyen que especies como *halimifolia* can force radical changes in the habitat and have a direct effect on the **resting strategies of migratory birds** [5] being the substitution of reedbeds (*Phragmites spp.*) by *B. halimifolia* in marsh ecosystems in the European Atlantic coast a problem of serious consequences for the conservation of migratory birds associated to these reedbeds, which might affect their resting behaviour and performance [6], reducing the attractiveness of the area as a place of nesting, resting and feeding [61]

Some of these birds provoke great interest; for example, the aquatic warbler (*Acrocephalus paludicola*), a threatened species in the whole of Europe, the great reed warbler (*Acrocephalus arundinaceus*), the great bittern (*Botaurus stellaris*), the common spoonbill (*Platalea leucorodia*) or the osprey (*Pandion haliaetus*) [58].

- This species modifies dramatically the **herbaceous communities** of the invaded zones, substituting pastures, damp meadows taken from marshes, and so on, probably due to the umbrella effect caused by the presence of *Baccharis* [55, 61]. It also substitutes helophytic vegetation with *Scirpus maritimus* [19].

Photograph 1.13. *Scirpus maritimus*. (Ihobe) Photograph 1.14. *Elymus athericus*. (Ihobe)

B) Impacts on ecosystem services

- It creates a dramatic **modification in the structure, physiognomy and diversity of the invaded community.** The radicular system of *B. halimifolia* and the great amount of leaves that it produces can cause alterations in the invaded estuary sedimentation, modifying the general geomorphological dynamics of the estuary itself [54, 63].

- *B. halimifolia* has a high capacity to **transform some coastal landscapes**, thus provoking the loss of identity from certain regions [63], and it may also affect the tourist exploitation of the invaded areas.

- The development of great stands of *B. halimifolia* **reduces the amount of available water**, and it seems to favour the frequency of fires [14].

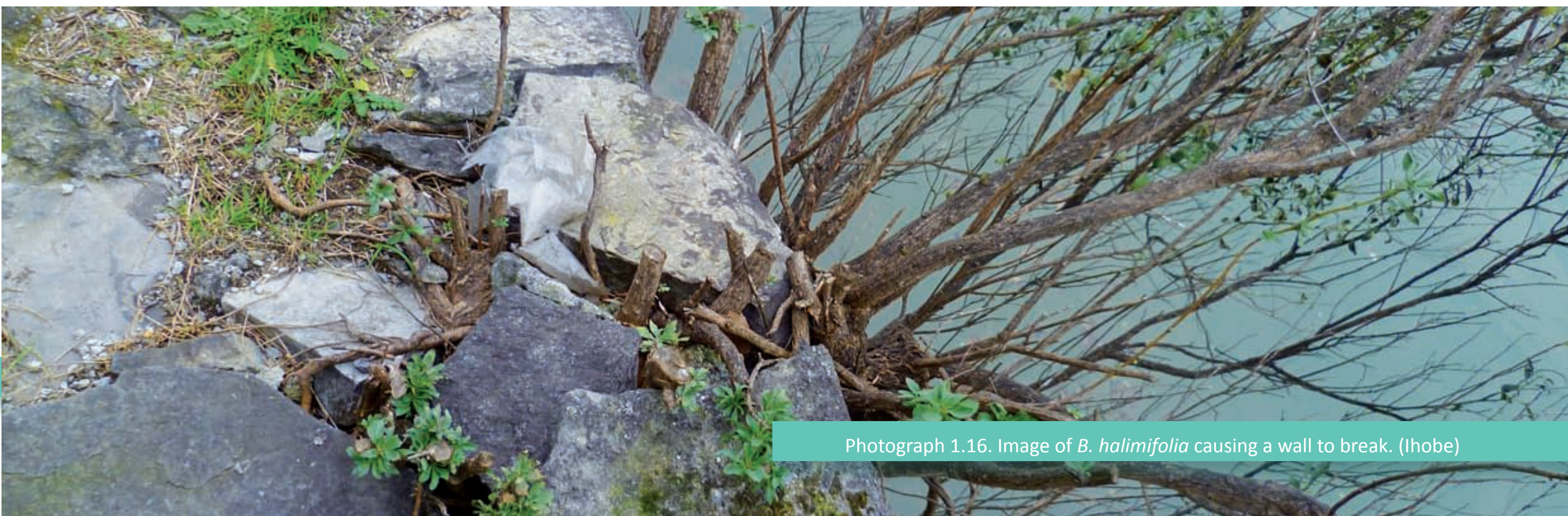
Photograph 1.15. *B. halimifolia* invading marsh areas. (Ihobe)

C) Impacts on economic activities

- Especially invasive in anthropic areas (growing areas and abandoned fields, drained areas, landslides, etc.), the dense formations of *B. halimifolia* can make it difficult or inhibit the **livestock movement** and reduce the **productivity of agricultural land**. In Australia, for example, it has invaded thousands of hectares of pine plantations with subsequent economic losses [63].

- Because its presence reduces air movement and water evaporation, it can slow salt production, as happened in Brittany, where dense formations of the species are an obstacle to access exploitation areas [63].

- Also, its radicular system can damage infrastructures, such as walls, roads, etc.



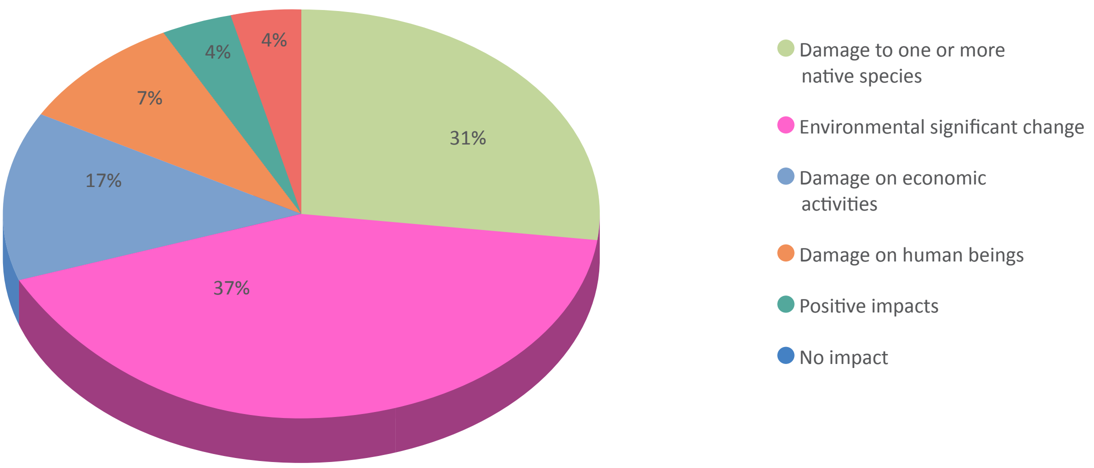
Photograph 1.16. Image of *B. halimifolia* causing a wall to break. (Ihobe)

D) Impacts on health

- The species leaves have some kind of **cardiotoxic glucoside** which produces shivering, convulsion and diarrhoea to livestock [52], and can even be fatal if consumed constantly and in great amounts [63, 86]. However, because it is a little palatable species, the number or registered poisoned cases in the USA is very low [55].

- Regarding human health, *Baccharis* is considered an **allergenic species** due to its high rate of pollen production [55, 63, 86], being, as well, one of the most prolific producers of seeds (from 10,000 to 1,500,000 in one season) [55].

- Dense formations favour the development of **mosquito larvae**, reducing the efficacy of control programmes [1].



Graph 1. Identified impacts in France derived from the presence of *B. halimifolia*.
(http://www.orenva.org/IMG/pdf/Fiches_especes_Mode_de_compatibilite_.pdf)

Summary about impacts created by the presence of *Baccharis halimifolia*
About biological diversity
> Substitution of subhalophile communities dominated by native species *Juncus maritimus*, *Elytrigia atherica* and/or *Phragmites australis*. > Local reduction or even extinction of species of great interest: *Glaux maritima, Dryopteris carthusiana, Cochlearia aestuaria, Matricaria maritima.* > Invasion of halocasmophytic communities (cliffs) of the *Crithmo-Armerion maritimae* alliance. > Invasion of estuarine forest communities in upper areas of marshes. > Changes in the resting strategies of migratory birds. > Modification and/or substitution of herbaceous communities.
About the ecosystem services
> Alteration in estuary sedimentation, favouring saturation in marshes. > Modification of the general geomorphological dynamics of estuaries. > Deep transformation of the landscape. > Increase in the frequency of fires. > Reduction of water availability.
About economic activities
> Impact on livestock. > Reduction of productivity of agricultural land. > Reduction in productivity of saline areas. > Negative impacts on infrastructures (walls, roads, etc.).
About health
> Allergenic effects. > Toxic for livestock.

Table 1.2 Summary about impacts created by the presence of *Baccharis halimifolia*

Habitats affected by the presence of *Baccharis halimifolia*		
Habitat	Habitat Directive 92/43/EEC	Relationship with other habitat classifications
Cliffs with vegetation on the Atlantic and Baltic coasts	1230	EUNIS code: B3.3 CORINE code: 18.21
Pioneering annual vegetation with *Salicornia* and other species from mud and sand areas	1310	EUNIS code: A2.5 CORINE code: 15.1
Spartina pastures (*Spartinion maritimi*)	1320	EUNIS code: A2.5, 15.2 CORINE code: 15.12
Saline Atlantic pastures (*Glauco-Puccinellietalia maritimae*)	1330	EUNIS code: A2.636 CORINE code: 15.13
Saline Mediterranean pastures (*Juncetalia maritimae*)	1410	EUNIS code: A2.5, D6.2 CORINE code: 15.5
Thermo-Atlantic and Mediterranean halophile scrubland (*Sarcocornetea fructicosae*)	1420	EUNIS code: A2.5 CORINE code: 15.6
Damp intradune depressions	2190	
Fixed litoral dunes of *Crucianellion maritimae*	2210	
Stagnant, oligotrophic or mesotrophic waters with vegetation of *Littorelletea uniflorae* and/or *Isoëto-Nanojuncetea*	3130	
Dry coastal Atlantic heathland of *Erica vagans Dactylido maritimae-Ulicion maritimi* alliance	4040	EUNIS code: F4.2 CORINE code: 31.2
Sub-pannonian steppe grassland	6420	
Scarce harvest fields at low altitude (*Alopecurus pratensis, Sanguisorba officinalis*)	6510	EUNIS code: E2.2 CORINE code: 38.2
Transition mires	7140	EUNIS code: D2.3 CORINE code: 54.5
Calcareous fens of *Cladium mariscus* with species of *Caricion davallianae*	7210	EUNIS code: D5.24 CORINE code: 53.3
Alluvial forests of *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)	91E0	EUNIS code: G1.1, G1.2 CORINE code: 44.3
Galleries and thermo-Mediterranean river scrubland (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)	92D0	

TABLE 1.3 Habitats affected by the presence of *Baccharis halimifolia*
[38, 96,98,99,100,101]

Chapter 2

Common basis for the management of invasive exotic species

1. Hierarchical approach

2. Prevention

A) Legal measures.
B) Management and conservation measures.

3. Early detection and rapid response

A) Surveillance and monitoring.
B) Diagnosis.
C) Assessment.
D) Reporting to the competent authorities and information flow.
E) Rapid response.

1. HIERARCHICAL APPROACH

The three-phase **hierarchical approach**, based on the staged application of three management options, was agreed as a political response to the threads imposed by the presence of IES. The three management options are:

1) Prevention;

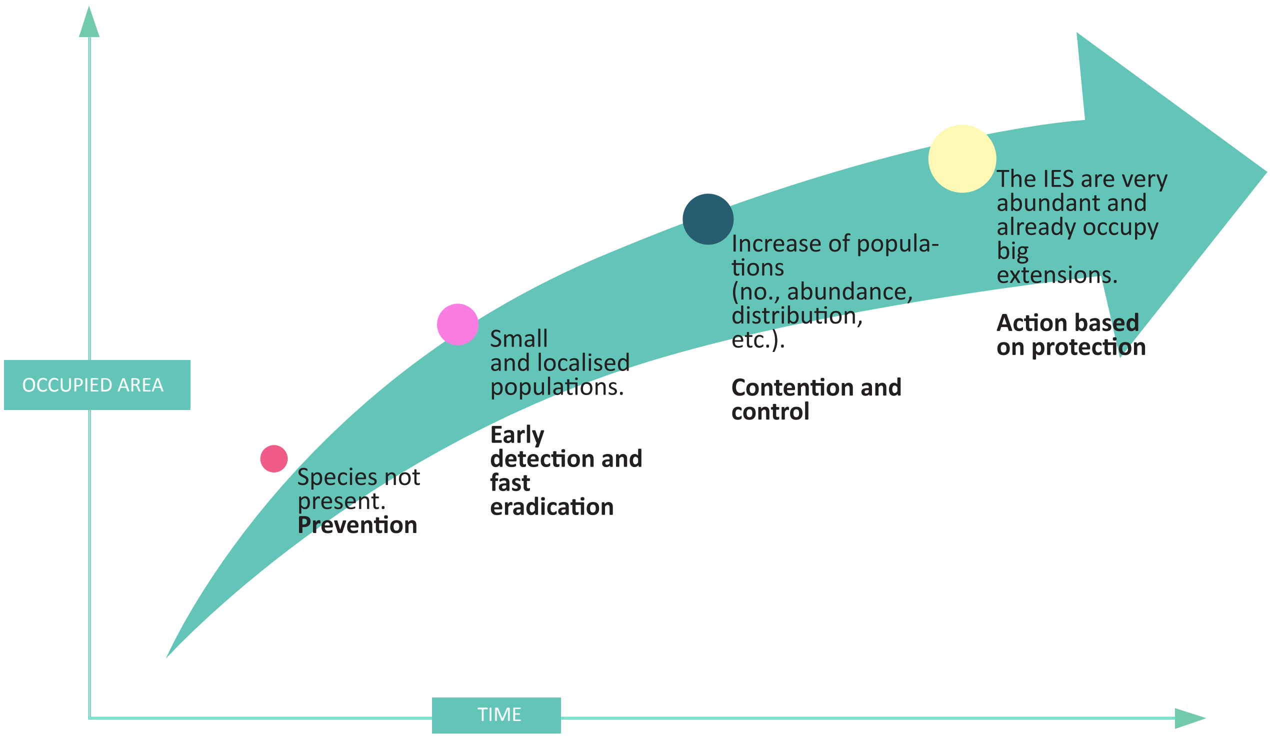
2) Early detection and quick eradication; and

3) Contention and control.

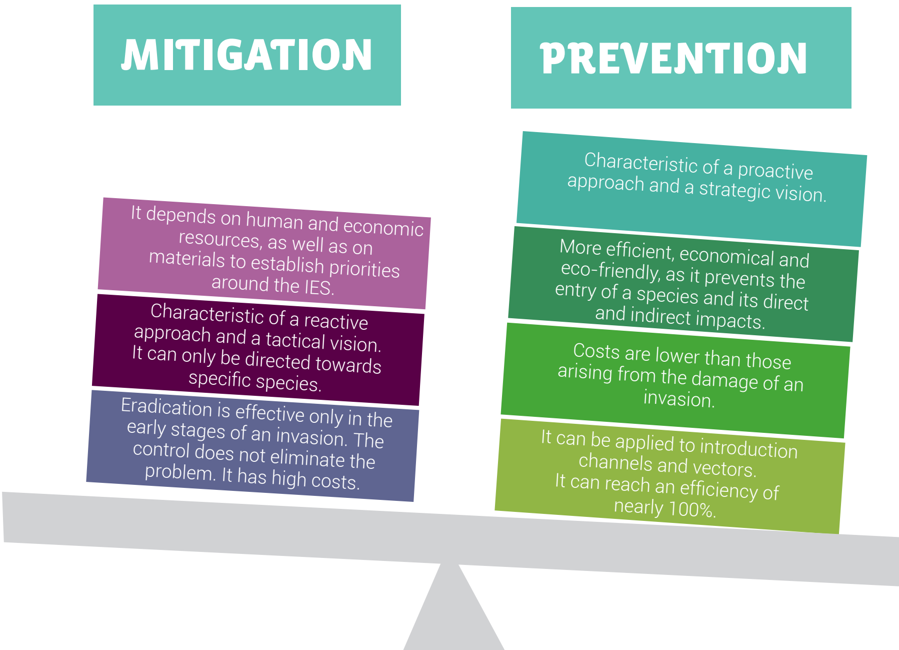
This approach reflects the consensus that, in general, **preventing** the entrance of invasive exotic species is the most recommendable option, both from the ecological and economic points of view.

However, if prevention fails, an **early detection** and an **immediate eradication action** will be key when avoiding the establishment and propagation of an invasive species that has been introduced.

If these two first actions fail or are not applied, **contention and/or control** measures in the long term should be applied, although the control option is the least desirable and, at the end of the day, the most costly [27, 28, 32].



2. PREVENTION



When a species has already established itself, not very often can it be eradicated, so prevention is **the key** for a desirable effective, economical, rational and environmental management, with the aim of preventing the establishment and dispersal of the IES and of minimising their potential impacts.

There are six main channels through which the species is introduced in other areas different from their native distribution: voluntary release; unintentional escape; as contaminants; as stowaways; through artificial corridors (canals, tunnels, etc.); and without any help at all. The effectiveness of the prevention measures to be adopted depends on **knowing the introduction channels and associated vectors**, so the introduction of new species can be limited (see Chapter 1, Section 2). Also, prevention comes with **early detection and quick eradication** (see Section 4 in this chapter), which is associated to **quick alert mechanisms**.

Within the basic tools to prevent the introduction of *B. halimifolia*, we find:

A) Legal measures

Adopting legal measures that deter the use of this species and that allow quick action in case of finding specimens in the natural environment is a key step to prevent their introduction or dispersal to new areas. The national response to this necessity has been the creation of Royal Decree 630/2013.

Royal Decree 630/2013 from 2 August regulates the **Spanish Catalogue of Exotic Invasive Species** [11] and states in **Article 4** the inclusion in the catalogue of those exotic species for which there is scientific and technical information indicating that they are a serious threat to native species, habitats and ecosystems, agronomy or economic resources associated to the use of natural heritage, according to Article 61.1 of Law 42/2007 of 13 December. The flora of said catalogue includes *Baccharis halimifolia* [12].

Its inclusion in the catalogue means that its **introduction in the natural environment is forbidden** within the national application territory stated in the annexe. It also means that it is **forbidden in general to own, transport, traffic and trade** living or dead specimens, their remains or propagules, including foreign trade.

Likewise, it states in **Article 7.3** that the specimens listed in the catalogue that are extracted from nature by any means cannot be returned to the natural environment; in Article 10.3 thereof, that in the case of works in riverbeds, the presence of the species in the catalogue should be reported, reviewing the project to prevent dispersal of the same; in **Article 10.6**, that measures should be taken to avoid the abandonment of remains of exotic plant species, except those accrued under eradication campaigns, provided they do not pose a risk of dispersal. Therefore, the management of waste generated in the control actions must be disposed of properly, depending on they maintaining their vitality and to what extent (burning, chipping, prescribed burning, etc.).

Moreover, in its first **Transitory Provision**, it prohibits trade of plant species included in the catalogue, such as *B. halimifolia*, with entry into force on 1 December 2013, and in its **fifth Transitional Provision**, it provides that specimens of plants included in the catalogue, and that are held by individuals or located in urban parks, public gardens or botanical gardens, acquired before the entry into force of this Royal Decree, may continue to be maintained by their owners, located in landscaped enclosures, with boundaries defined, and provided that specimens are not propagated outside these limits, taking the necessary preventive **measures to prevent the spread of those specimens to the natural or semi-natural environment**. Since the main form of dispersal of this species is by seed, individuals who possess this species should avoid the flowering of the specimen by pruning it.

B) Management and conservation measures

Dispersal prevention protocols:

The main mechanism of expansion of *Baccharis halimifolia* is by seeds, which are mainly dispersed by the wind or by water courses. Therefore, and to prevent its spread from areas where it is present to other non-infested areas, it is recommended:

a) To avoid or minimise travel through the invaded areas, or restrict them to the periods when propagation of seeds is less likely;

b) Not to perform management tasks in invaded areas at the time of flowering and fructification of the species areas;

c) To manage vegetation residues so as to prevent their possible re-establishment in the environment.

Promotion of ecosystem resilience:

Maintaining ecosystems in good condition is, in itself, a form of prevention, since the resilience of ecosystems is the first barrier to stop the introduction of any IES. Therefore, the land must be managed to maintain native communities healthy, able to compete with this and other invasive species, increasing their innate resistance to invasions. Also, disturbance of vegetation in areas not invaded should be minimised to avoid creating environmental conditions that favour germination and subsequent establishment of *Baccharis*.

Exchange of information:

To prevent the introduction of *Baccharis* to areas not invaded by it, a global management is essential in all neighbouring regions where this species is present or where it could be introduced (BAC, Cantabria, Asturias, Galicia), establishing checkpoints in order to quickly detect the introduction of *Baccharis* in areas of potential distribution of the species. It is therefore a priority to collaborate in the development of information systems and databases with information on this species, to use it in any context of any prevention and/or control measure. This information should include potentially threatened areas (with potential distribution models), management protocols (including incidents, successes and failures in the control measures), information on the biology and ecology, etc. This information, as well as procedures and recommendations for the species, should be provided to all stakeholders. A strong point would be the development of a data collection protocolised system relating to observations of the presence of new foci of invasion.

Cooperation, including capacity building:

Depending on the situation, the answer to be given to prevent the introduction of *Baccharis* can be purely internal (for example, of one single autonomous community) or it may require the effort of more autonomous communities, or even several countries (France, Portugal). Such actions could include programmes to share information on the species (introduction channels, vectors, invasive potential, etc.), agreements and joint activities both in relation to management and research and even funding, preparations and training of the workforce (for example, by means of workshops and training, etc.).

Environmental surveillance in public works and projects:

These actions are the usual pathways of introduction of many invasive species, including *B. halimifolia*. Therefore, it is essential to include these issues within the environmental observation plans, with the aim of preventing possible risks of introduction or spread of invasive species resulting from the implementation of a work, minimise the impact caused by the same in the environment and to verify the effectiveness of the prevention and protection measures proposed and executed. Finally, environmental observation will detect unforeseen affections and allow the establishment and coordination of the necessary measures to minimise them.

3. EARLY DETECTION AND RAPID RESPONSE

Although *Baccharis halimifolia* is already established in the territory, detecting new populations or scattered specimens and intervening before the species can stabilise itself and disperse is essential to eliminate, or at least contain, new foci of invasion.

A system of early detection and rapid response has three basic functions: detection, assessment and response. These will be developed through five elements: 1) coordinated observation and monitoring system; 2) diagnosis; 3) assessment; 4) reporting to the competent authorities and flow of information; and 5) rapid response.

EARLY DETECTION AND RAPID RESPONSE SYSTEM

	Detection		Assessment	Answer
SEQUENCE	**Identification of the threat**	**Detection of the threat**	**Risk analysis and management**	**Quick intervention**
	Identification of dispersal modality and introduction channels	Observation and monitoring.	Assessment of the magnitude and severity of the actual and potential impact	Consultation and coordinated actions
	Identification of the influence of the environment	Diagnosis	Assessment of the options for action	Implementation of appropriate measures
	Identification of areas susceptible to invasion	Reporting	Assessment of the legal conditions enabling initiatives	Communication plan
			Assessment of the potential effects of the response	
			Assessment of consequences on the Administration	

A) Surveillance and monitoring

Surveillance is aimed at identifying the presence of new exotic species or new foci of invasion in the event of established species. It can be performed in an active and/or passive way:

- **Active surveillance** requires planning of inspection and systematic sampling in selected areas based on the risk of introduction and biological characteristics of the species.
- **Passive surveillance** includes: a) incidental observations, occasional inspections and incidental sightings; and b) the participation of trained volunteers who report the presence of invasive exotic species depending on their available free time.

In the case of *B. halimifolia*, active surveillance should be carried out during the plant period of growth (before flowering) and particularly when it is more detectable in the flowering season (before fruit ripening), at least in the following areas:

- o Natural and semi-natural areas not invaded and potentially suitable for the species (see Chapter 1)
- o Non-invaded areas with high value for biodiversity conservation (see Chapter 1)

- Disturbed areas
- Areas near high risk of introduction points
- Dispersal corridors next to the invaded areas
- Surveillance zones around the invaded areas (with a minimum radius of 5 km)
- Introduction pathways (nurseries, gardens, substrate employed in works)

On the other hand, **monitoring** is used to gain a better understanding of the ecology, distribution and patterns of propagation of the species, thus contributing to identify and evaluate the best management options [49].

Both active observation and monitoring should be conducted by specifically-dedicated staff from the Administration. However, there are several **alternatives** to optimise human and financial resources:

- Employing qualified staff in charge of other tasks (looking after natural areas, monitoring inspectors of works and projects, university researchers, etc.).
- Using the "passive observation", which has the support of the citizenry (trained volunteers) for the detection of the species and reporting of its find to the authorities (through NTIC tools and open science, for example) [16].

B) Diagnosis

This is the identification phase of the species and its status (exotic invasive or exotic). To make the diagnosis, it is important to consider the most appropriate time for identification, as well as the most favourable locations or habitats for its establishment. In the case of *B. halimifolia,* the flowering season is unmistakable, and coastal areas such as estuaries, dunes, river banks or cliffs (see Chapter 1) are the most suitable.

This phase can also be performed with the participation of the general public, through a crowdsourcing system that can be carried out by using mobile phone applications.

C) Assessment

The assessment of the risks associated with the introduction of a species is necessary to determine which management measures will be taken. This can be carried out at different levels of depth.

A full risk assessment includes: a) an analysis that estimates the likelihood of introduction, establishment and dispersal of an exotic species in a given area, the potential impacts, and b) the management options to prevent its introduction or minimise the impacts after its introduction. Information concerning *B. halimifolia* is available and it would be possible to develop a simplified evaluation system (quick screening) to facilitate this phase [49].

D) Reporting to the competent authorities and information flow

One of the key steps in an early warning system is reporting the discovery of a species or a new focus of invasion to the competent authorities who have the capacity to act on the problem. To do this, it is necessary to **identify the players** that will be informed beforehand and to **create information channels** between different administrations. In order to do this, some mechanisms should be developed to:

1) Strengthen the development of information exchange through the Alert Network established by Royal Decree 630/2013 [11] as well as between administrations (including areas within the same administrative entity), and between them and the scientific community.

2) Favour a) access to information (collected with public funds) through the channels provided on rights to environmental information and b) disclosure of the findings of researchers until the data are published in a scientific journal.

3) Increase citizen awareness of the species and/or administrative bodies that should be informed of a finding.

E) Rapid response

Upon detection of a new invasive species or a new focus of invasion and after assessing the associated risks, it must be decided quickly what action needs to be started and who will implement it [49].

The adoption of one management option or another (eradication, contention, control, no action) depends on several factors related to invasion (the species, the surface affected, etc.), the odds of success, the duration of the action, costs, etc. When it comes to carrying out actions, it is important that the emergency response is free from lengthy approval processes and the chances of success are greater in the early stages of invasion, so the impacts and management costs will be lower [90, 93].

To do this, it would be advantageous to take different measures:

- Develop contingency plans to take into account the impact of the species, designate clear roles, responsibilities and actions to the agencies involved in the response operation, assess the possible political and administrative consequences of the actions and the impact they can generate in public opinion.

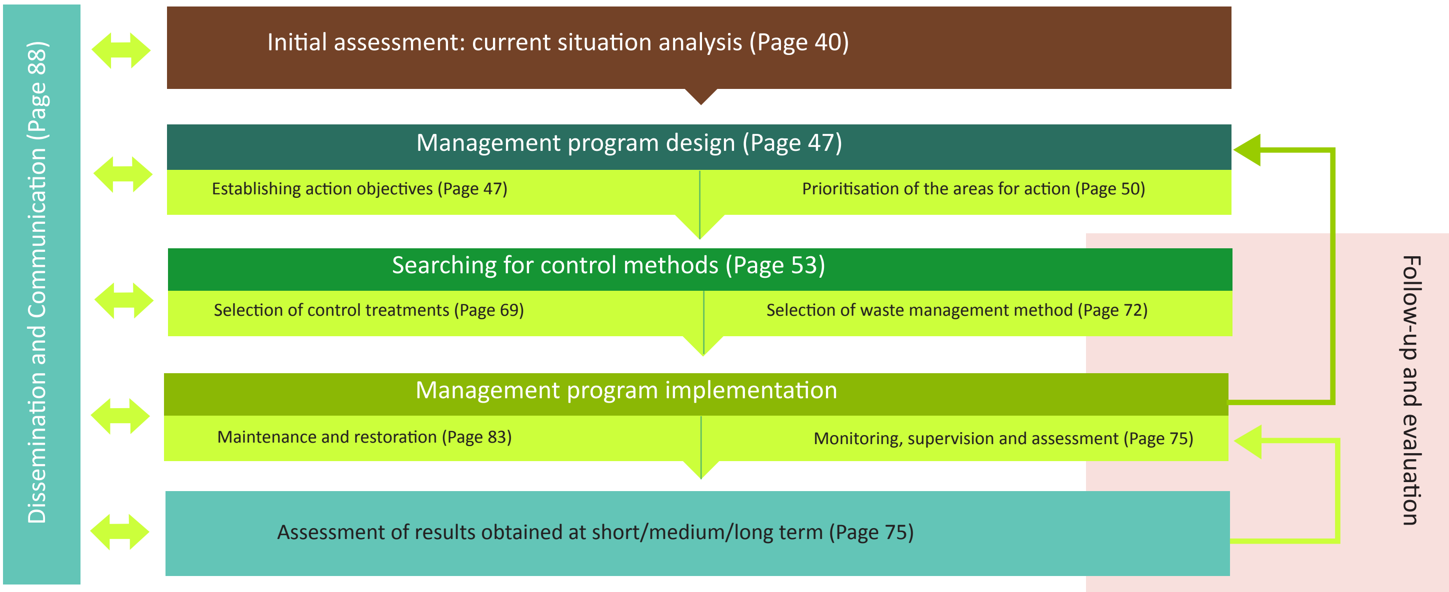
- Enable funding mechanisms at national level such as the Natural and Biodiversity Heritage Fund established by Law 42/2007 of 13 December [12], and at autonomous level to implement these systems.

Chapter 3
Design of *Baccharis halimifolia* management actions

1. BACCHARIS HALIMIFOLIA MANAGEMENT *PLAN*

Before commencing an action on *Baccharis halimifolia*, a management plan should be developed. Any action must begin with an analysis of the baseline situation, the characteristics of the invasion and the area of operation.

Depending on the financial and human resources available, and with the participation of players, we can establish our performance targets. If acting on the front of the invasion is decided, the areas should be prioritised and the methodologies for each situation should be selected.



Finally, it is essential to design a monitoring plan based on the magnitude of the performance, and provide restoration and maintenance activities to ensure the success of the intervention. Also, some suggestions are included relating to the outreach of actions.

2. ANALYSIS OF THE SITUATION

There are a number of variables that must be taken into account when designing a control action in areas invaded by *B. halimifolia*.

A) Assessment of the invasion

The strategy design will greatly depend on the following factors:

1. Type of invasion:

- **Monospecific** population: pure masses of *B. halimifolia*. In this case, clearing measures may facilitate future work of operators.

- **Mixed or dispersed** population: mass or specimens of *B. halimifolia* mixed with native vegetation. It is necessary to establish what proportion the native vegetation occupies in order to define the action strategy. In these cases, it is preferable to opt for selective control methods (such as manual pulling up, selective clearing or herbicide application after cut) over other non-selective (for example, flooding, foliar spray or grazing), preserving native vegetation and causing the least possible alteration on the environment [39].

2. Predominant age of specimens and characteristics:

- **Incipient invasion** (young specimens or specimens coming from seeds): manual pulling up will be one of the best methods to act.

- **Consolidated invasion** (adult specimens): other methods should be used, such as coverage of stumps, clearing, herbicide application on stumps, etc., in combination with the manual pulling up of seedlings from seeds.

- The **diameter** of stems and branches and the density of the specimens also influence the organisation of working crews and the number of operators required [78].

Photograph 3.1. *B. halimifolia* invasion in the Camargue (Ihobe).

3. Abundance of the species:

The strategy will depend on whether they are **isolated specimens**, if there are few populations and are well located, if they are numerous and scattered throughout the study area, or if the species is abundant with populations in contact with each other, thus occupying **large areas**. This section will influence the effort to be made, the duration of the intervention, as well as its final amount.

Costly methodologies, such as covering the stumps, will not be very feasible when handling large *Baccharis* infestations, so in most cases more economical methods shall be chosen.

4. Proximity to water bodies:

The proximity of **water bodies** will determine the use of chemical methods; e.g., foliar spraying is not advisable in areas close to water because of the risk derived from the product.

B) Characteristics and area of action

1. Fragility of the affected ecosystems:

The various control methodologies applicable to *B. halimifolia* also vary depending on the type of impact or potential side effects that can generate on a particular ecological environment and on the native species that inhabit it.

1. Protected or endemic species: the presence of protected or endemic species, both of flora and fauna, may be affected by the action. Anticipating and avoiding possible damage to this type of species is crucial, since they are usually restricted to a specific geographical area.

2. Areas and breeding seasons of fauna: it is important to take into account the time of year in which the actions will be carried out to not influence, for example, the reproduction of the species of birds nesting in the area. The actions should be planned taking into account the life cycle of the species that inhabit the area intervened.

3. Wetlands: wetland areas (estuaries, marshes, etc.) are recognised as highly fragile ecosystems, because they are reserves of water and harbour wildlife of interest, among others aspects. Certain methods may affect the balance and health of these areas, so the possibilities of unbalancing or damaging this type of environments should be anticipated and minimised.

2. Natural areas and specific regulations:

Certain methods may not be suitable from a regulatory point of view, or, if they are, the potential impact may be incompatible with the conservation objectives of a particular area, such as in **Protected Natural Areas** or in the field of the **Natura 2000 network** [39]. Therefore, any specific regulations should be considered, for example, for the use of chemicals, for the circulation of machinery, etc. in order to request the necessary approvals prior to commencement of work.

Apart from the above, and depending on the area where the actions are going to be carried out, different specific regulations should be taken into account, such as the Forest Act 43/2003 of 21 November, renovated in 2006 by Law 10/2006 of 28 April (BOE no. 102.), the Sectoral Territorial Plan of Wetlands in the BAC (Decree 160/2004 of 27 July; BOPV no. 222 of 19-11-2004), Plans for Natural Resources and Protected Areas Management, Provincial Law 3/1994 on Forestry and Management of Protected Natural Spaces of Bizkaia, Provincial Law 7/2006 on Forestry in the province of Gipuzkoa, etc. [63], or other regional regulations, as appropriate.

3. Natural and political boundaries:

B. halimifolia is a species that disperses by wind and water, without effective natural barriers for its dispersal, so it is very difficult to try to eradicate this species in one area if it is present in adjacent areas, as recolonisation from seeds will be a fact. Conducting partial actions due to the existence of political boundaries has a high probability of failure.

Given its association with water courses, it is important to have the support of the Water Boards in the case of intercommunity basins, and of the Basque Water Agency in the case of intracommunity.

In the case of intracommunity basins, and in the particular case of the BAC, Law 1/2006 of 23 June on Waters (BOPV no. 137 of July 19) must be followed. In the case of public water in the BAC, in intercommunity basins, competencies correspond to the Spanish Cantabrian and Ebro Hydrographic Confederation, while in intracommunity basins competencies correspond to the Basque Water Agency [63, 78].

4. Accesses:

The accessibility to the areas for action should be analysed. Since *B. halimifolia* is implanted in marshes and cliffs, it is an important consideration when planning the actions and foreseeing costs. Some tasks will also require exceptional means, such as boats, vertical work, etc.

Working in marshes and estuaries involves planning the necessary actions depending on the tides. Many areas will be more or less accessible in different seasons and hours of the working day.

The major accessibility problems can also occur in areas of complex terrain, such as coastal cliffs. It will be necessary to anticipate the need for means of access that require the extraordinary safety measures associated to vertical work or even special equipment. Access affects both the workers themselves as the equipment required to perform the work, or the management of garden waste if applicable.

Photograph 3.2. Operators working in areas without access to vehicles (Ihobe).

C) Sectors and players involved

It is important to note that often the competencies to run an intervention are spread over several administrations and, within them, between different services or areas. On the other hand, beyond the question of competencies, it is advisable to **involve from the start of the project** different players that can play an important role in the success of the performance. The extent of the network, the sectors involved and the number of players involved will depend on the management type and extent expected in the area.

Table 3.1 below identifies some of the major players whose contributions could help generate positive synergies in the different aspects related to the management of *B. halimifolia*:

SECTOR	ACTORS	A	B	C
Administration	*National*			
	- Central Government Environmental Body	x	x	x
	- Hydrographic confederations	x	x	x
	- Coastal demarcation	x	x	x
	Autonomous Community			
	- Central and territorial services with competencies in the field of environment, biodiversity, agriculture, education, etc.	x	x	x
	- Hydraulic administrations	x	x	x
	Provincial			
	- Department of Environment, Agriculture and Education	x	x	x
	Local			
	- Areas with environmental, planning and observation of the territory, and education competencies	x	x	x
	Other administrative levels			
	- Regions	x	x	x
	- Association of municipalities	x	x	x
Research	Universities and affiliated centres	x	x	
Education	University professors and primary and secondary school teachers			x
	Botanical gardens			x
Private	*Environment*			
	- Private companies and/or with publicly held acting as instrumental means of administrations in the field of IES management	x	x	x
	Trade			
	- Import and export companies of ornamental exotic vegetable species		x	x
	- Nurseries, garden centres and exotic plant shops		x	x
	Agriculture and forestry			
	- Companies and cooperatives dedicated to import substrates and other elements used in restoration of the natural environment		x	x
	- Nurseries specialised in the production of vegetable species for restoration and reforestation		x	x
	Other			
	- Professional groups (garden architects, landscape architects, gardeners)		x	x
Communication	Companies specialised in communication and the environment			x
	Environmental trainers and teachers			x
	Press, radio and TV journalists, trained in environmental aspects			x
Third sector	Scientific associations	x	x	x
	NGOs	x	x	x

A = Knowledge Building; B = Management; C = Awareness

Table 3.1. Main players to be taken into account in the management of *B. halimifolia*.

In order to promote an integrated and dynamic management of *B. halimifolia*, **networking** among the different players involved can provide great benefits. This means promoting processes and mechanisms to exchange experiences, identify existing points of convergence by setting "basic agreements", and having various forms of operational coordination through concrete actions and lines of work [65].

Key elements for networking

- The willingness of the people in charge from all involved entities, so this collaboration can exist.
- The delimitation of competencies and responsibilities of each entity in connection with the action to be performed.
- The alignment of targets.
- The establishment of "visible" references/contacts within each entity.
- Regular contact with other players.
- The adoption of an open data practice.
- The injection of dynamism and continuity of networking.

D) Economic and human resources

1. Economic:

Management programmes of invasive exotic species are associated with very high costs, and the availability of economic resources plays a key role. Often, budgetary constraints do not allow intervention in all areas affected simultaneously, and pose the problem of how to manage the funds available with maximum efficiency. For this, we recommend:

- To prioritise interventions depending on the financial resources available, as these determine the extent of the areas that can be treated [67].
- To take into consideration that other factors (initial distribution and density of the species, their biological features, topography, natural and anthropogenic disturbances, re-invasion) influence the success of control actions, and therefore, the total budget, as well as the distribution of funds for annuities [67].
- To ensure that control tasks can be carried out in full and are subject to a monitoring plan to assess their effectiveness and/or detect any eventual corrective measures (see Table 3.2.).
- To consider other operational aspects and types of actions when planning the budget allocation.

EXAMPLE OF ACTIONS PLANNED UNDER A PROJECT TO CONTROL *B. HALIMIFOLIA*	
Preparatory actions	o Localisation of the species and characterisation of the invasion o Prioritisation of the areas for action o Development of protocols for the systematisation of data collection and management tasks o Preparation of the management plan o Staff training o Etc.
Management actions	o Implementation of eradication/control measures of the species o Monitoring and monitoring o Observation o Habitat restoration o Etc.
Awareness and dissemination actions	o Communication and media campaigns o Maintenance of a website o Conferences and seminars addressed to different audiences o Production of information material

Table 3.2. Samples of actions to control *B. halimifolia*.

Better use of available resources

Underinvestment and/or budget cuts lengthen the time needed to eradicate the species or consistently reduce their populations, while increasing the total budget required [67]. Regarding the start of further action, it is preferable to invest the available economic resources in lower cost activities; for example, consolidation of already treated areas, containment, new methodologies experimentation, etc.

2. Human:

The technical feasibility of a management programme is also conditioned by the availability of human resources. The **human team** will vary depending on the size of the programmes to run. When involving a variety of agents (administration staff, sub-contractors, volunteers, etc..), it is appropriate that **roles and responsibilities** are clearly defined from the outset (see Table 3.3.).

FUNCTIONAL AREAS	ASSOCIATED RESPONSIBILITIES
General coordination	Coordinate all programme activities and manage the resources required for its execution. An important part of the process is to know the legal framework, authorities and obligations before drawing the control programme.
Coordination of the control works	Responsible for the activities carried out in the field and for maintaining direct and constant contact with staff.
Coordination of research, monitoring and monitoring	Any control action should consider monitoring and research to better understand the state and evolution of the invasion. It needs accurate scientific and technical capacity to coordinate tasks with staff and partners working on the project (technical, researchers, etc.).
Coordination of dissemination and education	Responsible for developing, monitoring and disseminating messages and material aimed at informing and raising awareness about the need to carry out the control programme.

Table 3.3 bis Responsibilities associated according to functional areas.

The **organisational model** proposed below (see Figure 3.1.) takes into account the involvement of the wider range of human resources. Smaller programmes involve the participation of fewer agents and less complex organisational levels to be adapted to the specific conditions of each initiative.

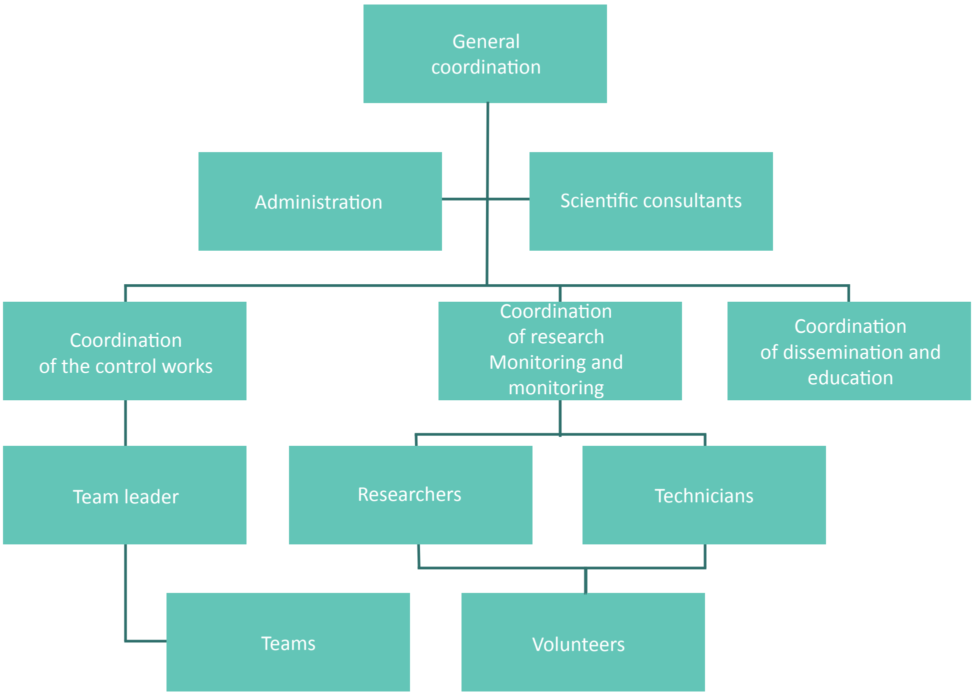


Figure 3.1. Example of basic organisation chart for a control programme.

The human resources of a control programme may be integrated by the different agents [10, 72]:

Agent	Functions	Advantages
Staff from administrative bodies	Programme coordination and supervision	Global programme monitoring
Counterparts (inter-administrative and cross-border)	Exchange of knowledge and experiences Programme support within its competence field	Training of mixed teams Action synchronisation Long-term results
External consultants	Technical work	Specialised knowledge Training
Technical and subcontracted assistance	Research, monitoring and monitoring Eradication tasks Production of information material	Staff and material provision Rapid time results Investment savings Additional experience
NGOs and volunteering	Observation Dissemination and awareness	Reinforcement in particular programme aspects
Other synergies (care, researches, naturalists, fishermen, nurseries, gardeners, etc.)	Observation Dissemination and awareness	Public support Collaboration of involved sectors

Table 3.4. Summary of functions of different agents in the management programme and benefits provided in its scope.

Identifying the resources (financial, material and human) is essential in order to plan effective interventions. Availability, a well known problem by local authorities, is one of the main limiting factors. Administrations often do not have enough spending power, means and personnel. In this context, the establishment of agreements and cooperation networks and inter-institutional work is proposed as the best solution, not only to find ways of financing, but also to provide collaborative intangible assets (human resources) and materials to facilitate or assist the execution of actions.

3. ESTABLISHING ACTION OBJECTIVES AND PRIORITISING THE INTERVENTION AREA

Determining when management measures are necessary, setting achievable and measurable goals based on available resources, and selecting effective management strategies are essential factors to achieve viable and permanent results over time.

A) Aim of the action

Within the management options, we can distinguish **four major management objectives** (see Figure 3.2): prevention, eradication, containment and protection-based control.

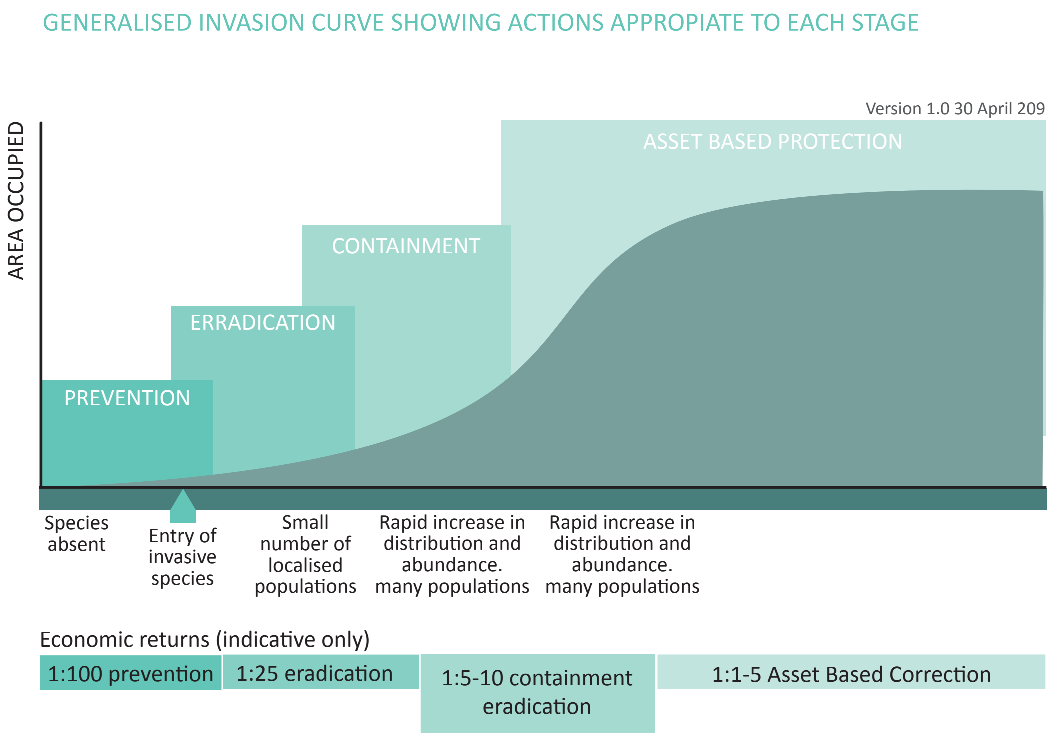


Figure 3.2. Appropriate actions to implement, depending on the invasion state of the species (Taken from: Department of Primary Industries, Australia)

To set specific targets for action, answering the following questions will be very helpful:

Are there any methods and resources available for an ecologically rational, economically viable and socially acceptable management?

Is it possible to determine the efficacy of the control methods?

Will the selected measures offer convincing results?

Is there a high probability that the results are sustained over the long term?

Can the target population be reached by implementing management measures safely?

What resources are available for the restoration of native communities of plants and animals?

Is there enough (social, economic, administrative) support to decision making to sustain actions in time?

Once the above points have been specified, the response strategy will be established. The full range of possible answers against an invasion of *B. halimifolia* are [87, 97]:

1. No action:

It is the last resource, applying it only to low priority populations, to low value and high disturbance areas, or when there is no budget for the management of the species. Despite its name, this objective involves supervision to assess routinely the extent and threat of the invasion, the changes in the population of the species, the risk involved, and the future change of management priorities and targets.

Priority areas: disturbed areas of low conservation value, away from natural areas.

2. Prevention:

Prevention is applicable only when the species is not present at the site, either because it has not arrived (the different ecological communities differ in their susceptibility to invasion by *B. halimifolia*) or because it is an area where there have been successful eradication actions.

It is the aim of the main action in areas with a high risk of being invaded by the species, either because of their characteristics (marsh areas or cliffs, humidity, etc.), for their **plant formations in origin**, for their **proximity to *Baccharis* foci** and/or for their **fragility** and conservation **value** [63]. Its characterisation will provide valuable information for prioritising areas of prevention and early detection, as well as for giving preference to control actions; for example, in areas of high ecological value or those of greater sensitivity.

The data related to this species can be incorporated into a GIS (Geographical Information System) database with other ecological data, in order to determine the susceptibility or resistance of different communities to invasion by *Baccharis*, helping to identify, characterise and prioritise, in terms of vulnerability to the invasion, areas where the species is more likely to be established or may have greater impact [97].

Priority areas: areas with high risk of invasion; areas already treated.

Photograph 3.3. Preventive flood in Arteaga (Urdaibai, Bizkaia). (Ihobe)

3. Control:

Control actions involve removing *Baccharis* specimens and limit their growth in invaded areas. Control can be by **containment** (preventing large invasions of *Baccharis* extending to other areas where the species is not present; it is generally more effective to attack the satellite populations than the front of the invasion; it involves methods that prevent reproduction and dispersal of propagules; perimeter treatment of the invaded area or removal of small satellite populations) or **suppression** (reducing the size and abundance of the species populations, i.e., density and coverage, and promoting native vegetation; on a larger scale, suppression is not usually effective unless massive resources are provided).

Priority areas: large invaded areas where eradication is not feasible in the short term (either because of lack of funding or because of the characteristics of the invasion themselves).

4. Eradication:

This involves implementing control measures until the **complete elimination of the species and its propagules**, as long as it is possible (the best choice in small-scale infestations, usually in the introductory phase), preventing their new re-establishment. Whenever feasible and with the necessary resources available, it is the most recommended option; however, it is not always possible, due not only to the characteristics of the species and the invasion itself, but also due to the lack of funds.

The goal of an action should aim at eradicating *B. halimifolia* when there is environmental benefit, when the probability of success is high, and when there are economic resources available.

In small and localised populations, delaying actions increase the cost of control and decrease the chances of success, so action thresholds in these cases are very low, having to act quickly, with priority to eradicate this type of populations instead of those already established.

Priority areas: small and localised populations, recent establishment locations, areas of high conservation value, areas with high probability of eradication success.

5. Mitigation:

In this case, the effects of the invasion are offset; for example, by the creation, restoration or enhancement of an alternative habitat for wildlife. Mitigating the effects caused by the presence of *Baccharis* is not a simple task. However, certain impacts can be mitigated; for example, in the case of migratory birds, as attractive areas could be conditioned so resting and performance strategies are not greatly affected.

Priority areas: areas compatible with the unintended effect to be mitigated.

6. Research:

Research as an objective is proposed if resources are scarce or if it is considered to be necessary before carrying out a large-scale project. Basic research on the species is included, testing and improving methods of elimination, such as the impact or behaviour study of the species in certain environments, among others.

Priority areas: controlled, small and localised populations, areas with low conservation value.

A possible guiding diagram (see Figs. 3.1 and 3.2) to aid in making a decision on **which management objective to set**, is shown in the following figure, initially based on whether the species is present or absent in the area:

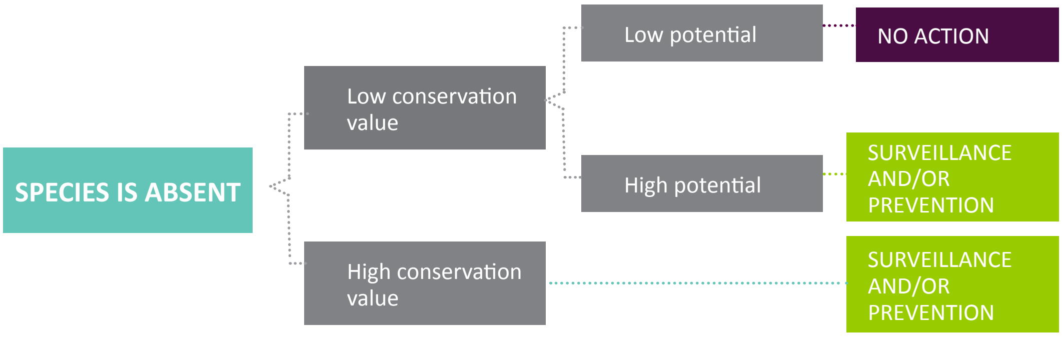


Diagram 3.1. Selection of the action objective in an area where the species is not present.

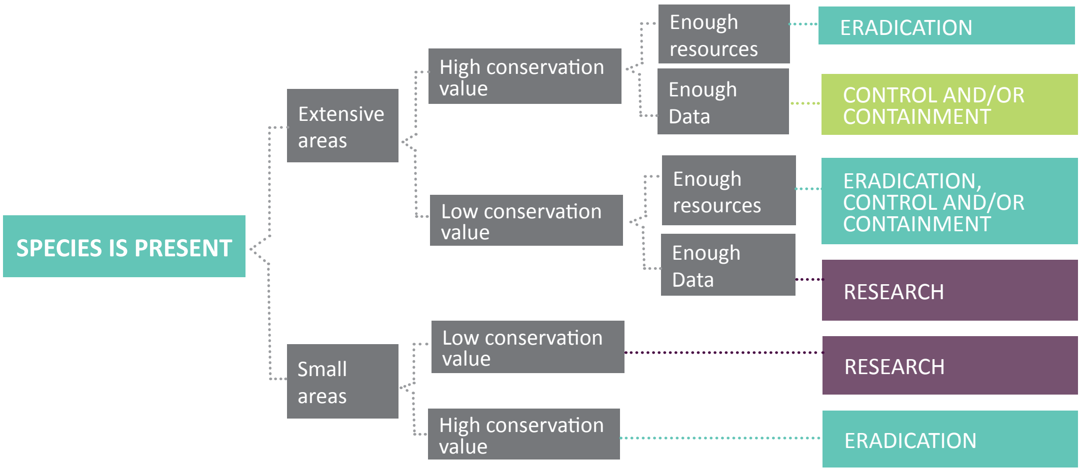


Diagram 3.2. Selection of the action objective in an area where the species is already present.

B) Prioritisation of areas

Once the objective of the action is set, it is possible that, with the available resources, we cannot cover all affected areas or we have to select the order of intervention.

In the case of species like *Baccharis*, whose seeds are dispersed quickly over long distances, it may happen that the priority should be given to the **largest infestation**, depending on where it is located and on the adjacent areas (high conservation value, urban areas, degraded areas, etc.).

One way of prioritising the different management options is based on the **relative degree of risk of presence of the species in an area** (level of disturbance or proximity of the area to the donor population) and on its **value in terms of conservation and/or production of the invaded habitat** (see Figure 3.3) [97].

Eradication and subsequent restoration will be the most recommended option in high value areas where the species is present; in areas with presence of *Baccharis* but with little natural value, the preferred option will be monitoring and control, mainly to prevent its expansion to areas of high natural value.

Meanwhile, in areas with little risk of presence of the species, but with high natural value, active prevention must prevail (along with fast response).

Finally, areas with low probability of presence of the species and low conservation value will have lower priority, opting in these cases for the "no action" approach.

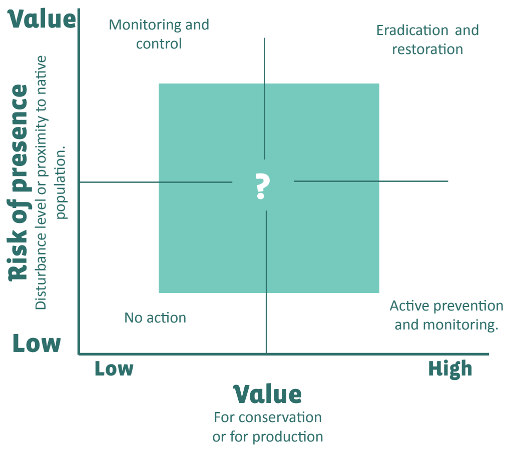


Figure 3.3. Prioritisation diagram for relative degree of risk of presence and area value.

1. Prioritisation between different invaded areas:

One way to assess the intervention priorities between different areas invaded by this species is based on the ***Baccharis* viability of control and on the feasibility of restoring the area** against **future potential impac**t that the invasion has based on its **value in terms of conservation and/or production** (considering, for example, the abundance of high value native species).

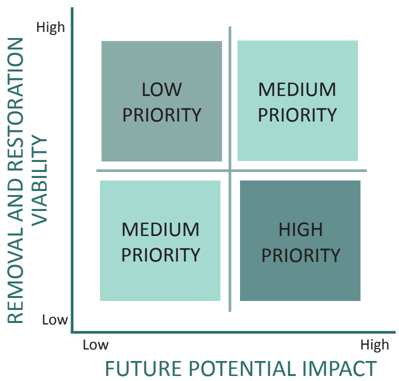


Figure 3.4.A. Diagram for setting priorities in the first stage of invasion, the impact still being potential [33].

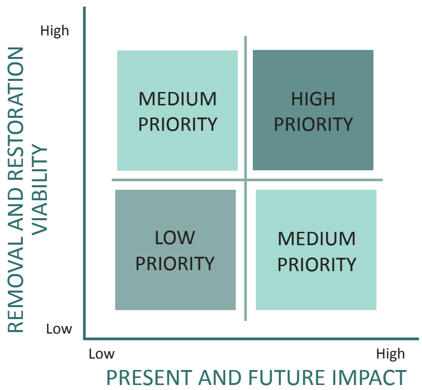


Figure 3.4.B. Diagram for setting priorities in advanced stages of the invasion, and the impact being visible and recognised in the medium [33].

According to the diagram in **Figure 3.4.A**, in the case of having different areas with recent presence of *B. halimifolia*, the areas to be prioritised are those which, due to their characteristics and value, present the risk of having a high potential impact resulting from the presence of the species, and that have a low feasibility of removal and subsequent restoration in the event that the species becomes established. Medium priority will be allocated to those areas of high potential impact, but where, in the event of the species becoming established, the possibility of eradicating it and restoring the area is high. Finally, those areas with a low potential future impact and where *Baccharis* could become established but could be easily eliminated, will have a low priority.

Figure 3.4.B shows a priority diagram when *B. halimifolia* has already been established in several areas and impacts on the environment. In this case, the highest priority should be given to areas where the impact is high and where it is more feasible to eradicate the species and restore the environment. Medium priority will be given to those areas where the impact is high and the feasibility of eradication is low, along with areas where the impact is not high but its eradication is feasible. The lowest priority is given to areas where the impact is lower and it is less likely to eradicate the species.

2. Prioritisation between different areas:

For **riverside populations**, the strategy should be firstly to treat the population of the species upstream and secondly, downstream. There is a clear reason for this: *B. halimifolia* can be dispersed over long distances by water (hydrochory), since the average floating time of its seeds is over one month.

Furthermore, *Baccharis* seeds also disperse by wind (anemochory), so another way to prioritise work within an area invaded is based on the **prevailing winds** in the area, the action to be carried out in the same direction of the prevailing wind. Thus, it is more difficult that the treated area can be invaded again by seeds from plants which have not been eliminated yet, or by seeds that can be "freed" during the actions conducted.

In the case of facing the invasion of a **great extension area**, a good option is to start the eradication from the periphery of the invaded zone, moving gradually towards the centre of the population foci (see Figure 3.5, *Bradley Method*). Thus, the area decreases progressively, giving the option to the surrounding native species to occupy areas where the species has been removed, making easier a later recuperation and/or restoration. Hence, indirectly, the competence of native plants is also being favoured against those of the invasive species, increasing the resilience of the ecosystem itself.

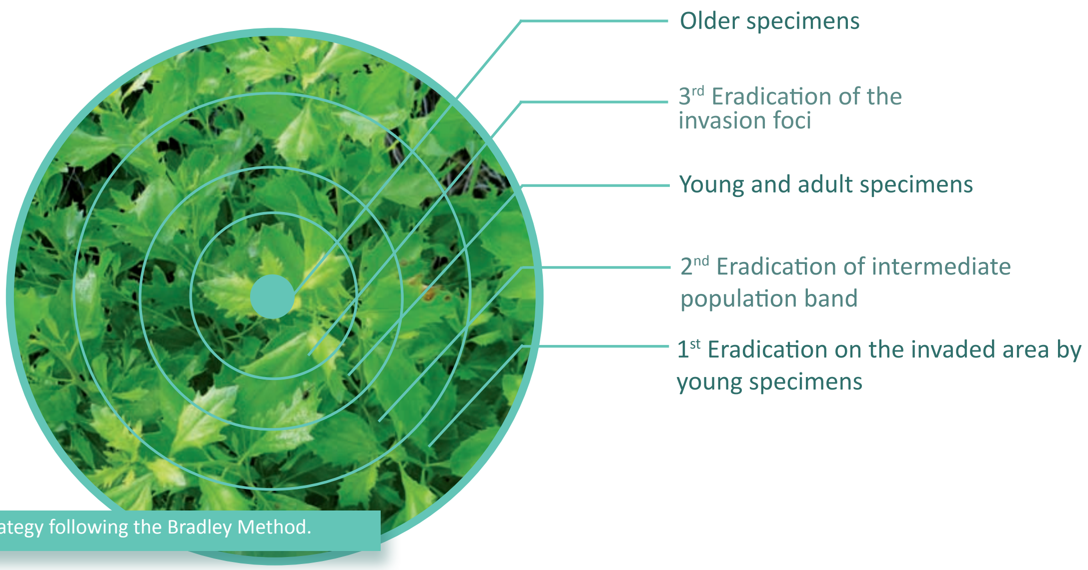


Figure 3.5. Strategy following the Bradley Method.

Bradley Method: this consists of organising works by first removing the plants on the periphery of the invaded area, which have lower density. Thus, the surrounding native species may occupy more easily areas where the species has been removed, slowing the spread of the source. Gradually, there is a move towards the invasive species population core [20].

Within the same area, we can also prioritise based on **management objectives**, especially if there are limited resources: eradication in the periphery followed by containment of the rest of the population; eradication of the first two bands and containment of the foci to cover a bigger extension; eradication of masses with greater ability to affect a potentially bigger surface that could be invaded, etc.

The cases discussed are not unique, but will depend on each specific area and time, so prioritisation should be studied case by case.

4. SELECTION OF THE CONTROL METHOD

A) Description of each control method

Note: Most methods have only been tested in habitats of estuaries and marshes. There are not enough data to evaluate the effectiveness of the methods proposed in coastal cliffs habitats, so it is considered a field to explore and investigate in the future. Therefore, guidelines, advantages and disadvantages analysis, and the results and costs are primarily aimed at marsh and estuarine habitats.

1. Physical/mechanical methods:

1.1. Manual removal:

This method removes completely the plant from the ground, eliminating its roots by hand, which is useful for young specimens with poorly developed root system, usually specimens under two years old that do not exceed 50 cm in height [78]. It is also useful for small areas or other areas where other type of method is not practicable, and also as a method of going through already treated areas again, removing seedlings from the seeds [9].

Photograph 3.4. Manual pull-up of *B. halimifolia* seedlings from seeds in Urdaibai (BAC). (Ihobe)

It has proved to be valid in small infestations, provided there is a continuity in its implementation, especially for small mono-stem specimens [9], taking extreme care to completely remove the root to prevent regrowth [78]. In some cases, it is necessary to use a small hand tool to remove the root system completely.

If the specimens are not adults (less than 2 years old), this action can be performed all year round; in case they have great reproduction capacity, the manual pull-up should be done in before the 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.

Under the Life+ Basque Estuaries project, it has been observed that manual pull-up is the most effective method, since in plots with a density of 100% occupancy by *B. halimifolia* seedlings, this has decreased to less than 10%, and there has been a recovery of over 75% by species of native flora. The species that have experienced a highest level of recovery are in general *Atriplex prostrata*, Phragmites autralis y Juncus maritimus [78].

MANUAL REMOVAL	
Advantages	**Disadvantages**
Manual pull-up has the advantage of being a very selective method that causes little or no impact on other species or the ecosystem where it is carried out, provided this is insensitive to the removal of soil [44]. Therefore, it will only be carried out with young specimens, so manual pull-up does not destabilise the substrate.	Although it is a very selective method, the possible impact on some types of substrate should be taken into account. Since the material removed by this method is alive, it should be handled as potentially invasive. Likewise, contact of roots with the ground should be avoided, so collection should be made with the roots facing up.

Table 3.4. Advantages and disadvantages of manual pull-up.

Photograph 3.5. *B. halimifolia* regrowing after slashing. (Ihobe)

1.2. Slashing:

Slashing is a selective method consisting of cutting the aerial part of the plant, leaving the root intact, thus suppressing the flowering of the species and reducing its spread by seed.

Because of the regrowth capacity of this species, this method does not cause the death of the specimen, although regular slashing can *eventually* kill the bush, especially in young plants that do not have a well-developed root system. Therefore, it is an option to consider in long term eradication programmes that involve the use of other methods, such as herbicides, pasture improvement, etc. [78].

The action should be made when the plant is not in bloom and has no fruit, to prevent the spread of pollen or seeds.

Among the actions of the Life project, a test was carried out to remove an area of seedlings of about 50 centimetres, making a weekly cutting for a month (4 cuttings in total). The result was negative, as the seedlings were reappearing, so manual pull-up was carried out before the development of the root system prevented it [Ihobe, personal communication].

Slashing	
Advantages	**Disadvantages**
It does not alter the structure of the substrate and does not involve the use of chemicals.	Subsequent treatments are needed (for up to several years) until the death of the specimen. For example, in Domaine de la Palisade (Camargue), the Conservatoire du Littoral has been performing two annual slashings in an area of high conservation interest for 17 years, and they have not yet managed to completely eliminate *Baccharis* present in that area [Ihobe, personal communication]

Table 3.5. Advantages and disadvantages of slashing.

1.3. Stump covering:

After removal of the aerial part of the plant to 50 cm tall, the trunk is covered with a polyethylene geotextile or black polyethylene plastic of at least 400 thickness gauges, joined to the trunk with ropes or bridles [9], thus killing the specimen. Stumps should not have sharp edges, because these could pierce the cover.

Stump covering	
Advantages	**Disadvantages**
It does not need the use of chemicals. Medium efficiency, as *B. halimifolia* has the ability to re-sprout even at several tens of centimetres from the stump [Ihobe, personal communication]	The problem is that this method is too expensive, so it is not used routinely; likewise, it is necessary to maintain the coverage of the stump for long periods of time, to ensure that the entire root system is dead. Control work is needed to detect any crack of covers, as well as to eliminate potential re-sprouts around the stump.

Table 3.6. Advantages and disadvantages of covering stumps.

Photograph 3.6. *B. halimifolia* stumps covered with plastic. (European of Forestry Work)

1.4. Total extraction by mechanical means:

This method involves the uprooting of specimens by using heavy machinery, and can be applied to all age and feature specimens. Adult specimens, because their root system, may require the removal of much of the substrate, which means significant land movement. In both cases, it is essential to ensure the total removal of the root.

This action can be a stage prior to flooding (see below) or be the final object of the action, always accompanied by a subsequent restoration project, since the result will be a soil devoid of vegetation in which *B. halimifolia* seeds are likely to be found.

TOTAL EXTRACTION BY MECHANICAL MEANS	
Advantages	Disadvantages
Highly effective, as specimens are completely removed. It allows a total restoration of the affected area, and does not require subsequent treatment.	The use of heavy machinery means severe impact on the environment. This methodology can be applied in areas of low conservation value or uncultivated land. The extracted specimens should be treated as material with invasive potential, thus complicating subsequent management. They can be buried in the same process, provided that culminates in flooding. In other cases, proper management to prevent the outbreak or infestation of new areas will be required.

Table 3.7. Advantages and disadvantages of total extraction by mechanical means.

1.5. Flooding (temporal or permanent):

In this case, before the flowering season of the species, the invaded area is flooded for long periods of time, creating a permanent film that alters the oxygen levels available for the plant, causing its death by anoxia. *B. halimifolia* cannot withstand prolonged flooding, so this method can be effective in areas with appropriate flooding features [9]. This method requires previous clearing and removal of vegetable remains. Since the material removed is alive, it should be handled as potentially invasive.

The flooding method has been used in the BAC in Barrutibaso (Urdaibai). After constructing soil levees with a gate, a surface of 17.5 hectares was flooded in the river area that receives waters from a brook and spring, and where the sea also penetrates at high tide, creating a permanent water film that prevents rooting and re-sprout of new specimens of *B. halimifolia*. This work has been effective because, although in the surfaced areas *Baccharis* still sprouts, a dense colonisation of the area by native species *Phragmites australis* can be seen [9]. In the marshes of Atxaga, a flooding action was performed as preventive measure, as *Baccharis* was still not present. Some experiences carried out in Bassin d'Arccachon have shown that a temporary flooding of several months during winter can eliminate adult *Baccharis* specimens [1].

Photograph 3.7. Flooding performed in Barrutibaso, after an initial treatment with herbicide. (Ihobe)

Flooding	
Advantages	Disadvantages
It does not need the use of chemicals, and subsequent treatment is not necessary. A habitat is created which is generally beneficial for several flora and fauna species of interest, normally scarce or reduced.	It modifies completely the existing habitat, so it is necessary to carry out a deep assessment of the benefits derived from this type of action. This action can only be performed in areas with the appropriate level, where the incoming of tides or damming of fresh water is possible, and using heavy machinery. In general, *B. halimifolia* continues to sprout in surfaced areas (levees, diked marshes, dikes, islands) where it is necessary to use other methods.

Table 3.8. Advantages and disadvantages of flooding.

1.6. Selective clearing of inflorescences:

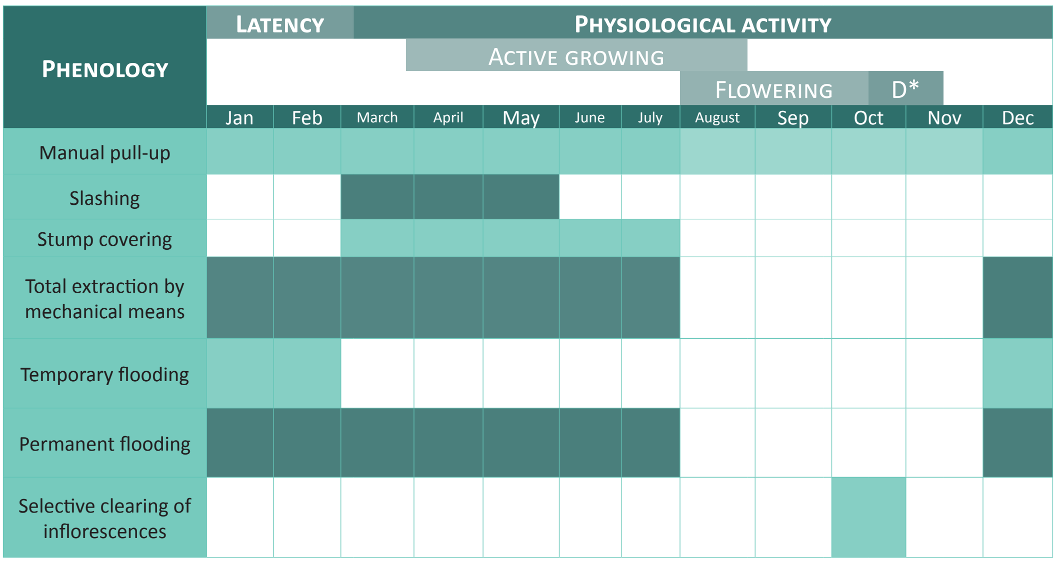
This method does not imply the death or removal of the plant; it is therefore a containment and prevention method. The objective is to avoid infestation of new areas by dispersal of seeds and to limit the increase of the seed bank in invaded lands.

The action is to clear the aerial part of the female plants that present inflorescences in a stage previous to seed dispersal. It is important that the action is carried out at the time where the plant presents a developed flower, so a distinction can be made between male and female stems, although it should be performed before the flowers mature. In our territory, this happens in October approximately, although variations may occur depending on climate conditions or other characteristics. It is convenient to observe flowering since mid August and to start acting when female stems can be clearly differentiated from male stems.

Selective clearing of inflorescences	
Advantages	Disadvantages
Easy and inexpensive action. It is an alternative in case of low budget or as a containment measure in big surfaces.	It does not remove the plant, so it will have to be repeated annually or other control measures will need to be applied. The pruning remains should be treated properly, as they can be a source of seed dispersal.

Table 3.9. Advantages and disadvantages of selective clearing.

Photograph 3.8. Remains of selective pruning of female inflorescences in Urdaibai. (Ihobe)



D*= Seed dispersal

Table 3.1. Ideal time for the application of mechanical/physical treatments depending on the species phenology.

Methods proved to be ineffective for the control of ***B. halimifolia:***

- **Prescribed fire:** This method has proved to be ineffective because *B. halimifolia* has great capacity of regeneration after fire [9, 90], with buds re-sprouting over substrate at 60 days after treatment [86]. For example, in the Astillero marshes (Cantabria), after treatment with prescribed fire, the species re-sprouted in practically 100% of the cases.
- **Demolition:** In the case of large specimens, their demolition can be an effective first step in a more comprehensive control programme, but it can generate a large impact on *non-target* species and the environment due to the use of heavy machinery [9]. A special case is restoration projects of a complete marsh, in which case this method has high efficiency [Ihobe, personal communication].

2. Chemical methods:

Herbicides have been widely used in the control of many invasive plant species, due to their low cost, the ease of use and rapid action. They are the most widely used option for the control of *Baccharis*, because physical and mechanical methods are not sufficient to exhaust the large seed bank existing on the floor.

In the case of using chemical methods, a number of **considerations** should be taken into account:

1) Misuse of herbicides can generate resistance in the treated species; it needs to be ensured that the selected herbicide is suitable for *Baccharis halimifolia* (glyphosate, 2,4-D, triclopyr, picloram, clopyralid);

2) Misuse can have adverse effects on *non-target* species or the ecosystem, and may result and cause water or soil pollution; it is essential to understand the mechanisms of dissipation of the active ingredient (persistence, degradation, possibility of moving in air or water, etc.) and its behaviour in the environment (soil, water, vegetation);

3) They may have adverse health effects (note the correct application, toxicity and safety).

The use of herbicides is effective, provided monitoring tasks and subsequent treatments are carried out until no more production of new shoots is observed [78]. In Spain, mainly systemic herbicides such as glyphosate have been used, especially for those adult specimens that cannot be pulled up manually [78].

The treatment should be performed by authorised personnel in accordance with the current legislation. Plant residues that have been in contact with the herbicide (it does not occur in all methods of application) must be removed and taken to an approved landfill, after having consumed at least 50% of the total life of the herbicide [45].

Glyphosate is a non-selective wide-spectrum herbicide. It is absorbed by the leaves, not the roots. It inhibits the enzyme responsible for the formation of aromatic amino acids. It is marketed in different solutions with different names, which can contain other ingredients causing various effects. Upon contact with the calcium or magnesium present in the soil and in the water, they are inactivated but damage the soil surface and contaminate the water. In fact, it is classified by the EU as dangerous for the environment and toxic to aquatic organisms.

If using chemicals, some **precautions** should be taken into account (**for more details, see Annex 1**) and the obligations contained in **Royal Decree 1311/2012** of 14 September, which establishes a framework for action to achieve a sustainable use of plant protection products:

- The preparation of the herbicide must always take place in areas where spills cannot cause pollution, following the manufacturer's instructions, complying with current regulations and observing the directions on Good Agricultural Practice in the application of pesticides [71].

- Depending on the selected method, when applying the product, those periods in which no species can harm beneficial insects, avoiding the middle hours of the day, should be taken into account, whenever possible and, if necessary. Also, it must be considered whether the method of application can be used on rainy days (entrainment of products could occur), or in areas close to watercourses. In general, they should be performed when weather conditions are favourable (no wind, proper temperature), ensuring low drift.

There are different **methodologies** that differ in the form of herbicide application:

2.1. Foliar spraying:

It is the application of a herbicide spraying the aerial part of the plant, spraying the directed herbicide from a backpack or spray. If this method is used (only in monospecific populations away from water), avoid clearing, as the production of new stems would be stimulates, decreasing the effectiveness of the treatment. For example, in Asturias glyphosate was applied at 3% or 2% (depending on the sensitivity of the treated zone) by spraying directed with manual backpacks [9]. This method has also been tested in coastal heathland habitats in the Jaizkibel Special Protection Area (Gipuzkoa) with preliminary positive results observed and without damage to the surrounding flora (heather, gorse) (J. Zulaika, Provincial Council of Gipuzkoa, pers. comm.)

Spraying may also be performed after a previous clearing (a few months before), weakening the plant and reducing the number of shoots on which to spray. This is useful for large specimens, on which it is difficult to spray without affecting the rest of the surrounding vegetation. For small specimens, it can be done without prior clearing. A complete action may comprise clearing before flowering and spraying the following year, once the sprouts are produced.

The best time for application is between August and October, coinciding with the flowering of *Baccharis*. During this time, increased transport of assimilated products from the leaves to the root system occurs, which increases the probability that the product reaches the root and causes the death of the specimen.

Foliar spraying	
Advantages	Disadvantages
It does not alter the soil structure and its cost is relatively low.	Herbicide drift or volatilisation may occur, with the possible affection of *non-target* species, the aquatic environment and the ecosystem as a whole.

Table 3.10. Advantages and disadvantages of foliar spraying.

Photograph 3.9. Foliar spraying on *B. halimifolia*. (Ihobe)

2.2. Application after cutting:

Firstly, a cut on the stem with an axe or similar tool should be made, penetrating to the cambium of the plant [45]. Immediately after that (within 30 seconds), an amount of the herbicide is poured by means of a non-dripping applicator. Another application possibility is to secure a dressing impregnated with the active ingredient on the cut. The application must be made immediately after the cut, to ensure that the full dose enters the stream of the plant sap. A variant is the basal application, in which a banding is performed on the base of the stem, applying herbicide with a brush or paintbrush. The exposure time of the herbicide is at least 8 weeks [45].

The application must be made in each main trunk *Baccharis*, no more than 50 cm from the ground. If the specimen is highly branched (multi-stem) and is of great size, in addition to treating all stems, it is advisable to strengthen treatment with dressings at 1.5 meters in the thickest branches [45].

Photograph 3.10 (a, b & c). Application of herbicide with dressing.

The best time for application is during the active growing season of *Baccharis*. After the treatment, and once the death of the plants has been certified, the clearing is performed.

Application after cutting	
Advantages	Disadvantages
It does not alter the soil structure and it has high efficiency. It presents a very low risk of drift.	It is expensive and requires trained staff. For example, this methodology has been used in Cantabria and in the ACBC by girdling branches and applying a dressing soaked in glyphosate at 45%, but widespread use has not been implemented due to the high cost involved. Large amount of herbicide is used, and slashing waste have herbicide residues, so they should be treated as hazardous waste.

Table 3.11. Advantages and disadvantages of applying herbicide after cutting.

Photograph 3.11. Multi-stem specimen of *B. halimifolia.* (Ihobe)

2.3. Injection:

It involves injecting the herbicide inside the stems, reaching the cambium. This requires an auger or drill to be used to make small holes in the stem about 5 cm apart. Using a dropper, a dosing syringe, an injection gun or spray bottle, the herbicide is injected, placing one or two millilitres of the product in each hole, and subsequently sealing them with resin or other suitable material. As with the previous method, the time between the cut and the application of the herbicide should not exceed 30 seconds. The compound should be soluble in water so that it is transmitted through the plant [39]. It is helpful to mark the treated specimens to facilitate the work of operators.

It is suitable for specimens of *Baccharis* near water, where invasion species coexists with other native vegetation.

The best time for application is during the active growing season of *Baccharis*. After the treatment, and once the death of the plants has been certified, the clearing is performed.

INJECTION	
Advantages	Disadvantages
It does not alter the soil structure and it has high efficiency. The risk of contamination is negligible, since the application is directed, being very difficult for the product to drift or volatilise.	It is very expensive and requires trained staff. Slashing waste has herbicide residues, so it should be treated as hazardous waste.

Table 3.12. Advantages and disadvantages of applying herbicide by injection.

2.4. Application on stumps:

It consists of cutting the aerial part of the specimen, followed by an immediate application of the herbicide on the stump with a brush or applicator, without sudden movements to avoid dripping or splashing. There should be no more than 30 seconds between slashing the specimen and applying the herbicide, as the plant can quickly seal the cut and the application of the product becomes ineffective (there will be less likelihood that the product reaches the root system killing the specimen); if a delay occurs, you must re-cut and apply the product on the fresh surface.

It is suitable for specimens of *Baccharis* near water, where invasion species coexists with other native vegetation.

In Asturias, removal of stumps and subsequent application of glyphosate and oil with a brush (to increase penetration of the phytocide through the stump) at 50% has been used [9]. It has also been used in the BAC, cutting the specimens at a height of 20-40 cm off the ground and applying in a localised way a mixture of glyphosate and oil at 50%. Subsequently, it has been used glyphosate at 45% and at 36% of commercial dilution, mixed with water [Ihobe, personal communication].

The best time of application is during the active growth season of *Baccharis*, especially in late spring, as in early spring the large amount of sap ascending through the stems may eliminate a great amount of the product [39].

Photograph 3.12. Application of herbicide dilution after cutting. (Ihobe)

Application on stumps	
Advantages	**Disadvantages**
It does not alter the soil structure and it has high efficiency. It presents a very low risk of drift.	The cost is very high, due to the difficulty of getting around the estuarine and marsh areas, the pruning of large specimens and the removal of the plant residues. There is a risk of product spillage or splashing which causes pollution of the environment, so it is essential that the work is performed by trained personnel.

Table 3.13. Advantages and disadvantages of applying herbicide on stumps.

Under the Life+ Basque Estuaries project, over 70 % of the stems treated with herbicide have been eliminated, although results vary based on the characteristics of the environment. It seems that the higher the level of tidal influence, the better the results, with the regrowth percentage between zero and 10%, while in the most isolated and elevated areas, such as areas diked marshes and filled areas, in some plots and transects there has been a higher regrowth, reaching a range between 40% and 75%, reaching in some isolated cases 100% [78].

Phenology	Jan	Feb	March	April	May	June	July	August	Sep	Oct	Nov	Dec
	Latency	Latency	Physiological activity									
			Active growing (March–August)									
								Flowering (August–Sep)		D* (Oct)		
Foliar spraying									■	■		
Application after cutting			■	■	■	■	■	■	■	■		
Injection			■	■	■	■	■	■	■	■		
Application on stump			■	■	■	■	■	■	■	■		

D*= Seed dispersal

Table 3.2. Ideal time for the application of chemical treatments depending on the species phenology.

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	In 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 on stems over 20 mm.
Triclopyr 600g/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 240g/litre + Picloram 120 g/litre	1 litre per 60 litres of oil	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.

Table 3.14. Effective herbicides for the control of *B. halimifolia* [22].

3. Biological methods:

Biological control is based on reuniting IES with their natural enemies, generally absent in the area where they have been introduced, trying to establish some balance that tends to reduce the population of a specific exotic plant within the invaded plant community. Biocontrol can control **slowly and steadily** an invasive species, but, as the biological control agent does not completely remove the host plant, it is just a **control** option to keep the population below a certain safety threshold, not to eradicate it totally.

The **success** of the biocontrol agents depends on different **factors** and on the method used. Within these factors, there are:

- biotic factors (density of the host plant, interactions with other organisms, etc.)
- abiotic factors (climate, rain, latitude, perturbations, average temperature, etc.)
- procedure factors (before release [selection of site, gender ratio, etc.], at the time of release [host, time, life cycle state, etc.], after release [area management, detection of organism, etc.], personal [experience, knowledge, follow-up, etc.]).

Knowing these factors will help to select the correct site, time of release and time of year, the ideal agent, the expected impact on the *target* species, etc.

This method is slightly controversial, as its long term efficacy and potential impacts are not all known, so it is necessary to consider the possible consequences of its use, analysing *pros* and *cons*. After releasing a biocontrol agent, a follow-up must be carried out to detect how it establishes itself in the natural environment, the intensity of the attack, the effects on the invasive plant and on the *non-target* species, and the effects on the environment.

There are different approaches to biological control:

Classic.	Inoculation	Flooding	Preservation	Wide spectrum
Intentional introduction of an exotic species as a biological control agent; this will be established permanently in the environment and will control plant invasions in the long term.	*Deliberate release of a biological control agent so it multiplies and controls the invasive species for a long time, but not permanently.*	*Controlling invasive species is achieved with the release of biocontrol agents, and not with their progeny. A massive release of the agent is done in order to achieve immediate effects.*	*Modification of the media or management practices of an area in order to encourage the presence of natural enemies.*	*Using polyphagous in small quantities and in limited areas.*

Regarding *Baccharis halimifolia,* the first biological control agents used to the species were released in Australia in 1969. Since then, the establishment in the environment of six of these biocontrol agents has been documented:

Lepidoptera	Coleoptera	Dipteral
· *Aristotelia ivae:* larvae eat the leaves · *Bucculatix ivelia:* larvae mine the leaves · *Hellensia balonates:* larvae eat the leaves, inflorescences, young and adult stems	· *Megacyllene ellyi:* species whose plant density in Queensland was reduced to 50% in 10 years [10] · *Trirhabda bacharidis:* larvae that eat off the plant	· *Rhopalomyia californica:* species forming galls

All of them are native of North America, except the South American species *M. mellyi* [84]. More recently, in 1997, *Puccinia evadens* was released. It is a pathogen fungus from North America which seems to have established to and whose life cycle evolves around *B. halimifolia*, causing the regressive death of the leaves and of plants below 30 cm high [78, 82, 84].

One of the most successful control agents has been *Rhopalomyia californica*; it is a high specificity mosquito with adults not surviving over 24 hours. The eggs are placed on the stem tips and after hatching, the plant forms a gall around the larvae. The formation of a large number of galls can reduce potentially the growing and vigour of the plant, thus preventing flowering [82] and, therefore, reducing seed propagation. It has been one of the most promising biological control agents, as in 18 months it expanded over 10 km, reducing in some areas the production of capitulums in 93% [84, 86].

According to Article 44 of Law 43/2002 of 20 November, on plant health, *the introduction into the country, distribution and release of exotic biological control organisms require prior authorisation from the Ministry of Agriculture, Fisheries and Food, upon report of the Ministry of the Environment on the environmental impact and biodiversity condition, both when its purpose is conducting field trials for research and development, as when the release is for biological control or use as biological plant protection product, in accordance with the rules established by regulation.*

Photograph 3.13. Gall formed in *B. halimifolia* after the attack of biocontrol agent *R. californica.* (www.fotolog.com/treebeard/).

4. Cultural methods:

Grazing with goats/sheep:

It can be a method to consider, proving effective only if the infested area is heavily grazed; however, the low palatability of *Baccharis* (goats usually consume young shoots) attached to its toxic potential makes this measure not a very effective one; in fact, it is estimated that about 1% of body weight of fresh weight is lethal to sheep [39]. It should be noted that goats can also destroy other vegetation if proper measures are not taken to protect it [78]; besides, on some types of habitats of interest (rushes, reeds, heathland), the impact can be very negative.

Photograph 3.14. Goats can be appropriate livestock for this type of control method. (Ihobe)

In Urdaibai, there is an area of pastures that has been exploited continuously, and in whose margins the invasive plant has become established, and it has not been able to invade the pastures. It is thought to be due to grazing, although it is not known with certainty.

Promoting competition

1) Improved grassland: the good pasture management, and the fact that they become vigorous and competitive, is an interesting part for a control programme, as they are less susceptible to the invasion of *Baccharis*, especially in swampy areas [78].

2) Reforestation: reforestation as a control method is only successful if good forest management methods are adopted, since the species is also tolerant to shade and can grow and produce seeds under the canopy of trees. If the establishment of a dense vegetation of native species that compete for resources with the *Baccharis* can be made, this method could be effective, especially against seed germination by the shade effect. It requires previous clearing, to weaken the specimens of the invasive species.

3) Crop: in widespread infestations, young plants can be controlled by planting native species, provided the latter are sufficiently competitive to prevent the re-sprout of *Baccharis* [9, 78].

SUMMARY OF THE ADVANTAGES AND DISADVANTAGES OF THE ANALYSED METHODOLOGIES

Type	Method	Advantages	Disadvantages
Physical methods	Manual pull-up	Very selective. It presents low or no impact on non-target species.	It causes alteration in substrate. Residues have invasive capacity (see section on waste management).
	Selective slashing	Very selective. It does not alter the substrate structure.	It requires continuity over time.
	Non-selective slashing	It does not alter the substrate structure.	Affects *non-target* species.
	Stump covering	Very selective.	Medium efficacy. High cost.
	Total extraction by mechanical means	Very effective. It does not require subsequent treatment.	Severe impact on the environment due to the use of heavy machinery. It generates areas of barren land.
	Flooding	It does not require subsequent treatment.	Little selective. It modifies the existing habitat. Residues have invasive capacity (see section on waste management).
	Selective clearing of inflorescences	Low cost. Easy action.	It requires continuity over time. Residues have invasive capacity (see section on waste management).
Chemical methods	Foliar spraying	Low cost. It does not alter the substrate structure.	Possible drift and volatilisation of the herbicide. It affects *non-target* species, the aquatic environment and the ecosystem as a whole.
	Application after cutting	High efficacy. Almost non-existent risk of drift.	High cost. Residues are hazardous (see section on waste management).
	Injection	High efficacy. Almost non-existent risk of drift.	High cost. Residues are hazardous (see section on waste management).
	Application on stumps	High efficacy. Almost non-existent risk of drift.	High cost.
Biological methods	Release of biocontrol agents	Low cost. Very selective.	Potential synergies with other native organisms, potentiality to become pests, etc.
Cultural methods	Grazing with goats/sheep:	Low cost. It can be exploited economically.	The area needs to be grazed intensively. It can be toxic for livestock. It can have a negative impact on native vegetation.
	Improvement of grassland.	Improvement of the area management.	Possible interference with native fauna and flora.
	Reforestation	Improvement of the area management.	It requires previous clearing. Possible interference with native fauna and flora.
	Cultivation	Low cost. It can be exploited economically.	Possible interference with native fauna and flora.

Table 3.15. Summary of the advantages and disadvantages of the different control methods for *B. halimifolia*.

B) selection of the control method

As indicated in previous sections, the selection of one or more control methods will depend mainly on a number of factors:

- The state of the invasion itself (for example, young specimens can be pulled out manually, although not the adult ones)

- The characteristics of the area to handle (fragile habitats and flora can condition the use of some more aggressive methods; the total removal of the plant by manual or mechanical means is only possible in young specimens that do not have a well developed root system, as well as in areas insensitive to soil removal; regarding herbicides, they should be applied only if the specimens cannot be removed by physical methods)
- The objective of the intervention: some methods do not allow the total elimination of a population.

- The available budget: different control methodologies present different costs.

Below are several tables with data that can guide the selection of the control method based on different variables:

Selecting methods depending on the purpose of the action

PREVENTION

PHYSICAL METHODS
The establishment of *Baccharis* can be prevented, for example, by altering the environmental conditions so they are less favourable (flooding).

CHEMICAL METHODS
They are not an option for prevention, as herbicides are used on plants present in the area.

BIOLOGICAL METHODS
It is not a prevention option, since the species must already be present.

CULTURAL METHODS
They can help prevention, increasing the ecosystem resilience.

CONTAINMENT

PHYSICAL METHODS
Physical methods can reduce or prevent the production of seeds, for example, eliminating the plants' capacity to reproduce.

CHEMICAL METHODS
They may contain infestations that are too large to be eliminated normally, applying them around the infested area, eliminating satellite populations, and so on.

BIOLOGICAL METHODS
The use of biocontrol for containment is unrealistic, because the action of these agents is often very slow.

CULTURAL METHODS
They can be a handy low cost tool to keep the population contained.

SUPPRESSION

PHYSICAL METHODS
Physical methods can remove invasive plants, reducing their capacity for competitiveness within the plant community.

CHEMICAL METHODS
Herbicides can remove *Baccharis* populations, allowing the establishment of native vegetation.

BIOLOGICAL METHODS
Biocontrol is an option for widespread and well established invasions, where it is not necessary to act very quickly, and in those situations where no other option is acceptable or possible.

CULTURAL METHODS
As it is not a really selective methodology, it is not an option for elimination.

ERADICATION

PHYSICAL METHODS
The probability of successfully eradicating a *Baccharis* population is higher in smaller areas, where it may be the simplest and least expensive method.

CHEMICAL METHODS
New invasions detected early are good candidates for eradication. Herbicides are a quick and effective option, as they can be applied directly to the *target* species.

BIOLOGICAL METHODS
Biological control does not completely eliminate the host plant, so it is not useful for eradicating *Baccharis*.

CULTURAL METHODS
Cultural methods are not an effective eradication tool in the case of *B. halimifolia*.

Selecting methods depending on the impacts on the environment and society

Action method		Potential impacts on the environment				Potential impacts on society		
		Flora	Fauna	Water	Ground	Landscape	People	Health
Physical	Manual pull-up	LOW	LOW	LOW	LOW	LOW	LOW	LOW
	Selective slashing	LOW	LOW	LOW	LOW	LOW	LOW	LOW
	Non-selective slashing	HIGH	MEDIUM	LOW	LOW	MEDIUM	MEDIUM	LOW
	Flooding	HIGH	HIGH	MEDIUM	HIGH	HIGH	MEDIUM	LOW
	Total extraction by mechanical means	MEDIUM	MEDIUM	LOW	HIGH	MEDIUM	LOW	LOW
	Selective clearing of inflorescences	LOW	LOW	LOW	LOW	LOW	LOW	LOW
	Stump covering	LOW	LOW	LOW	LOW	MEDIUM	LOW	LOW
Chemical	Foliar spraying	HIGH	HIGH	HIGH	HIGH	MEDIUM	HIGH	MEDIUM
	Application after cutting	LOW	LOW	LOW	LOW	LOW	LOW	LOW
	Injection	LOW	LOW	LOW	LOW	LOW	LOW	LOW
	Application on stump	LOW	LOW	LOW	LOW	LOW	LOW	LOW
Biological	Biocontrol agents	MEDIUM	MEDIUM	LOW	LOW	LOW	HIGH	LOW
Cultural	Grazing with livestock	HIGH	HIGH	LOW	LOW	LOW	LOW	LOW
	Promoting competition	LOW	LOW	LOW	LOW	LOW	LOW	LOW

Table 3.16. Summary table of potential impacts of the different control methods for *B. halimifolia*.

Selecting methods depending on the degree of invasion, characteristics of the specimens and the area of action

Dichotomous key for the selection of active control or eradication methods of *B. halimifolia*	
1.1.	Young specimens (< 2 years old and < 50 cm high)....................Manual pull-up.
1.1.	Adult specimens.................... Go to 2.
2.	**2.1.** Isolated specimens or small populations... Total extraction by mechanical means. Selective application of the herbicide.
	2.2. Medium or big populations.................... Go to 3.
3.	**3.1.** Proximity to water courses.................... Go to 4.
	3.2. Away from water courses.................... Go to 5.
4.	**4.1.** Big size mono-stem adults.................... Selective application of the herbicide
	4.2. Big size multi-stem adults.................... Application after cut plus dressings.
	4.3. Area with flooding characteristics.................... Flooding.
5.	**5.1.** Monospecific invasions.................... Go to 6.
	5.2. Mixed invasions.................... Go to 4.
6.	**6.1.** Big size specimens.................... Foliar spraying after clearing.
	6.2. Medium size specimens.................... Foliar spraying.

Table 3.17. Dichotomous key for the control selection methods.

This table excludes methods such as slashing or cultural methods, since they are methods aimed more at contention than the eradication of *Baccharis*, being useful for young specimens of over 50 cm high, adults, mono-stem and multi-stem specimens, etc.

Selecting methods depending on the degree of invasion, characteristics of the specimens and the area of action

Specimens	Charact. Invasion	Charact. Action area	Methodology proposal	Effectiveness	Cost	Re-treatment
INMATURE Without flowers Height < 75 cm	High density	High fragility	Manual pull-up	High	High	YES*
		Low fragility	Fumigation	Medium/High	Low	NO
	Low density	Independent	Manual pull-up	High	High	YES*
MATURE With flowers or flowering capacity Age > 2 years Height > 75 cm	Isolated specimens	High fragility	Selective application of the herbicide	Medium/high	High	YES
		Low fragility	Cutting and fumigation or re-sprouts	High	Low	NO
			Total extraction with machinery	High	High	NO
	Mixes masses	High fragility	Selective application of the herbicide	Medium/high	High	YES
		Low fragility	Application of herbicide after clearing	High	Low	NO**
	Monospecific masses	High fragility	Selective application of the herbicide	Medium/high	High	YES
		Low fragility	Application of herbicide after clearing	High	Low	NO**

*If seed bank persists.
**Re-sprouts or unfumigated sprouts may remain. In any case, it will require lesser ef.fort.

Table 3.18. Proposal for an elimination method decision chart.

Selecting methods based on approximate cost

Method	Action	Average cost (€/ha)	Maximum cost (€/ha)	Minimum cost (€/ha)
Manual pull-up	On seedling masses	1,800	10,000	600
Cut and application of herbicide on stump	On monospecific masses	3,000	8,000	2,000
	On disperse masses	2,300	3,000	2,200
	On re-sprouts	1,150	4,000	450
Placement of dressing with herbicide (with and without removal of stumps)	On monospecific masses	20,000		
Removal of stumps and coverage with plastic	On monospecific masses	20,000		
Injection		Not assessed		
Fumigation	On monospecific seedling masses	1,500		
	On re-sprouts	800		
Flooding	Hollow digging bucket and reshaping of pits	10,000	12,600	7,650
Selective clearing	On inflorescences (preferably female stems)	775	1,100	450
Waste management				
Removal and burning of remains	Between 25% and 30% of the total cost			
Removal and crushing	It 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	Less than 20% of the total cost			

Table 3.19. Methods decision chart with approximate costs[4].

4 The maximum, minimum and average costs are drawn from different control experiments carried out in the Basque Country, mainly in areas of estuaries and marshes. There may be substantial variations between the municipalities and the characteristics of the environment and degree of invasion.

C) Management of generated waste

Proper treatment of waste can determine the success or continuation of an action, as poor management can lead to the re-invasion of treated areas, or to the inability to complete an action for lack of funds. This is an aspect often not taken into account when planning a project management of *B. halimifolia*, but it is critical and requires a lot of resources (time, staff, budget) in most cases.

Depending on the control method used, different types of waste will be generated: some with re-sprout or germination capacity (for example, uprooted seedlings that can re-root, fruit branches, etc.), material contaminated with chemical products or 'inert' fragments.

Photograph 3.15. Fragment of *B. halimifolia* root with re-sprout capacity. (Ihobe)

In the first two cases, the material must not be abandoned in the environment without taking appropriate measures to prevent outbreaks of re-invasion or contamination. In fact, the biomass should be managed by methods that do not present a dispersal risk of the species, according to the provisions of Article 10.6 of Royal Decree 630/2013:

Royal Decree 630/2013 of 2 August, by which the Spanish Catalogue of invasive exotic species is regulated, states in its Article 10.6 that "*the competent environmental authorities will take measures to avoid the abandonment of plant residues of exotic plant species, except those collected under eradication campaigns, provided they do not pose a risk of dispersal.*"

When choosing how to manage pruning waste, the habitat type where the work is performed will also be very important, whether it is more or less susceptible to movement of equipment or the collection of remains, or accessibility in the case of flood-prone areas in marshes or coastal cliffs.

Plant residues can be removed by different techniques:

1. Pile up: neatly piling up plant waste generated in the elimination works. At this point, a number of considerations should be borne in mind:

- In order to avoid re-sprout of the material collected, **contact with water must be avoided**. In the case of pruning waste, re-sprout is less common. For uprooted seedlings or parts of the root system, it is important to stack them avoiding contact with the ground. Uprooted seedlings can be stacked with the root torn up, after removing the remains of soil. If re-sprout is observed, the pile will simply be turned up to leave the re-sprout specimens in the air, so they will dry quickly.

- Before collecting, **chopping** with hand machinery (chainsaws, brush cutters) used for clearing is recommended. The volume of material collected will be reduced within months.

- The **shade** produced by the material collected prevents seed germination underneath, which can be a method of preventing a re-infestation. On the other hand, it also prevents the germination of other native species, so this aspect will need to be assessed.

- If pruning remains have **inflorescences**, they should be piled at the bottom, burying them with other remains without flowers, to prevent seed dispersal by wind.

- It is not recommended to collect and leave in the environment material containing **herbicide residues** (depending on the method used). In this case, management as hazardous material is recommended.

- In areas where there is no physical or adequate space for collection (e.g., vegetation areas of high interest and fragility, coastal cliffs, walls in canals or sea promenades), a suitable collection point nearby should be found. If necessary, the removal of waste can be done in big sacks, using a pulley system to gather them in an appropriate area.

Photograph 3.16. Remains of *B. halimifolia* accumulated after cut. (Ihobe)

The remains of pruning degrade quickly when piled and are covered by native vegetation (Ihobe)

2. Crushing: The remains are crushed using choppers and subsequent collected. It is a fast and effective system that fully prevents regrowth and significantly reduces the volume of waste.

- It requires the use of **heavy machinery,** which is often impossible to bring to the site; in those cases, the remains need to be taken to a suitable place, making this task even more expensive.

3. Controlled burning: After stocking up the remains, an authorised burning is performed, taking into account the following considerations:

- Care must be taken not to burn **waste with seeds**, as these could be transported by the hot air generated.

- In **damp environments**, such as marshes or riverside areas, burning is very difficult due to the high humidity of the environment.

- Accelerators should not be used, and the risk of fire should be avoided.

Sacks with seedling remains pulled out by the root and prepared for a controlled burn (Technical Office of the Biosphere Reserve of Urdaibai)

4. Incineration: By this method, organic waste generated is burned at high temperatures. It is a very safe and efficient system that completely eliminates this kind of waste.

- It has very high **costs**, so it is not normally the chosen option.

5. Removal to an authorised landfill: Vegetable waste from the removal of the treated material can be removed to an authorised landfill. In general, if they are remains from chemical treatment, the removal must be done when at least 50% of the total life of the herbicide has been consumed. It should not be used as compost.

Transport of pruning remains outside the area of action (Technical Office of the Biosphere Reserve of Urdaibai)

5. MONITORING AND SUPERVISION

Along with the management work of the invasive species, it is necessary to carry out a monitoring task to assess the performance and development, and make decisions regarding management accordingly.

A) Design of a monitoring plan

A monitoring programme must be closely related to the planning and implementation of the management actions. It must include information on all completed and pending development activities, deadlines and resources used, and those that will be required in the near term.

For long-term and/or complex actions (requiring statistically analysis of quantitative variables), it is particularly important that the monitoring is planned from the beginning according to scientific criteria. Hence the importance of generating synergies between the scientific community and management bodies, ensuring the participation of the former from the beginning phase of the project.

Regarding the design of a monitoring plan, there are several important factors to be taken into account [31]:

- The monitoring plan should be planned at the beginning of the project.
- The monitoring plan must be designed according to the spatial and time scale and the objectives of each type of action.
- The simpler a monitoring programme is, the easier it will be to complete.
- The monitoring phase and management operations should be synchronised and continuous processes.
- One of the major limitations of monitoring programmes is the difficulty in determining the cause-effect relationships. To solve this problem, replications and controlled experiments are required, with all variables closely controlled.

The **phases** that make up a complete monitoring programme are described below [31, 44]. These may be adapted to the reality of each project.

1. Objectives of the monitoring plan:

The objectives of monitoring and management must be strictly related. Ideally, the latter should be quantifiable and measurable so that they can be assessed with simple monitoring actions that identify, from the beginning, the variables to be measured, the levels of trust needed, etc.

Among the objectives of a monitoring plan, the following basic objectives are taken into consideration:

- **Assess the effectiveness of control actions performed** (periodic inspection of the intervention area, counting specimens along transects and monitoring plots, etc.).
- **Assess the capacity of recolonisation of *Baccharis*** (counting specimens from seeds, re-sprouts, seed bank estimation, monitoring in nearby areas, etc.).
- **Estimate the recuperation capacity of native communities** (establishing a non-invaded control plot and a treated control plot, monitoring the native vegetation).
- **Check the effectiveness of a control method** (establishment of experimental plots (treated) and control plots (untreated). Monitoring the population in both types of plots.
- **Monitor the control method** (analysing the affection of the method used on non-target vegetation, fauna, soil, water and so on).

The monitoring duration will be established according to the complexity of the objectives:

- **Short term**: monitoring of the eradication method affection on the environment will be performed.
- **Medium to long term** (depending on the invaded area): monitoring of the eradication of *B. halimifolia* in a particular area will be performed.
- **Long term**: monitoring of the observation to detect re-establishment of the species, as well as monitoring of natural vegetation recuperation will be performed.

2. Data collection and analysis:

a) Variables to be monitored

Depending on the characteristics of the management programme, monitoring of the different variables will be performed:

Objective / Temporary magnitude	Short term	Medium term	Long term
Effectiveness of control actions	Percentage of specimens removed	Population trend	Population eradication
Recolonisation capacity	Seedling germination	Recolonisation capacity	Seed bank
Habitat recuperation capacity	Native species presence and density	Habitat characterisation	Habitat recuperation capacity
Control method monitoring	Impact on native flora species	Affection on habitats, bird populations, soil and water	Impact on ecosystem, functionality, habitat recuperation capacity
Method efficacy	Comparison of removal methods, environments, times, etc.		

Effectiveness of control actions applied

Estimate the percentage of specimens of *B. halimifolia* eliminated: short term, it is possible to set one or more control methods in a limited area of the invaded territory (depending on available resources). In this case, monitoring should focus on the effectiveness of the work in each campaign.

This variable is controlled by counting the specimens re-sprouted against the eliminated ones. This will generate a percentage of re-sprout that will provide an overview of the outcome of that campaign. Data collection can be done on the whole surface or on representative sampling units (depending on the surface and resources).

Data should be taken after a period since the application of treatment which will be long enough to allow re-sprout development. In the growing season, this period is usually two months.

Estimating the population trend of *B. halimifolla*: after several years of treatment, it will be possible to estimate the trend of the monitored population. If the sampling plots are permanent, the trend will be readily apparent by comparing the percentages of re-sprout.

Moreover, in a medium or large scale action, it will be possible to compare results between actions performed in different years or seasons, number of treatments, or even different environments. For data to be representative, sufficient replications will be made, so a medium-term monitoring will require more planning and knowledge of the environment.

Determine the eradication or the possibility of eradicating the population of B. halimifolia: this option will be possible in small invasions or with a long-term monitoring in a wider territory. The possibility of eradication depends not only on the effectiveness of treatments, but on the capacity of recolonisation that the target population possesses.

Data collection in the field such as re-sprout, germinated seedlings or coverage of native species are very useful to track the project successfully (Ihobe)

Recolonisation capacity

Detect germination of seedling and estimate their density: once removal of adult specimens of *B. halimifolia* has been carried out, large clearings without vegetation open up, which allow seed germination because of the lack of shade and competition. Annual monitoring to detect the masses of seedlings and estimate their density by unit area.

In the case of large areas, seedlings can be counted in the sampling units and extrapolate the results to the entire area. For the data to be representative, it is necessary to have a representation of all possible environments.

This monitoring is particularly interesting in areas where the seedling manual pulling-up method has been used, since an evaluation of the quality of work and its effectiveness will be allowed, as well as an estimation of the existing seed bank.

Estimate the recolonisation capacity: with an action expanding several years, it is possible to determine the ability of the population to recolonise treated areas by monitoring the mean density of seedlings.

It must be taken into account that the seed bank has a lifespan of 2-5 years, so in a year with favourable conditions for the germination of *B. halimifolia,* high densities of seedlings can be found. Comparing several years may provide a more realistic trend of the recolonisation capacity.

Also, new invasion foci can be detected due to seed dispersal to non-invaded areas. It is advisable to conduct an inspection or observation of potentially invasion-prone areas within 5 kilometres.

Estimate the trend of the seed bank and its sustainability: continuous monitoring in long-term fixed plots in areas where elimination work is constantly being carried out can provide results to determine the sustainability of the seed bank in a particular place.

In multi-year projects it is advisable to establish permanent plots for constant monitoring (Ihobe)

Recuperation capacity of natural habitats

Presence and abundance of native species: after a more or less successful removal action of *B. halimifolia*, native species have room to germinate, provided that a sufficient seed bank exists. Using the same sampling units established for the effectiveness of elimination actions, data about the presence and abundance of all species are taken. To do so, it is preferable to collect data at the most favourable time for native species, depending on the environment or habitat.

In the short term, the need of work to support recuperation of native vegetation can be assessed. This monitoring will also allow you to detect other invasive species that may be favoured by the work.

Identify habitats and the recuperation trend: with data collected in various campaigns, it will be possible to ascertain the habitat created or its trend. Pioneer species will give way to climax species, so it will be possible to determine whether they are recuperating one kind of community or another. The necessary period of development will depend on each habitat.

At this point, it is recommended to draw a map of the action area either by tesseras or vegetation units, so it can be compared to the baseline situation. If the action area is small, it may be sufficient to analyse data from the sampling units (plots and/or transects). In the case of large areas, a more exhaustive inventory is necessary.

Establish the habitat recuperation or resilience capacity against the invasion: long-term, the collected data can be used to determine which habitats are more resistant to the invasion or have greater recuperation and resilience capacity. With a wider range of monitoring years, more realistic trends can be established and a comparison of the treatment needs of the invasive species for the recuperation of the different habitats present can be made.

Control method monitoring

Impact on species of native flora: the annual monitoring may include an assessment of the possible impact of the applied methodology in the surrounding vegetation. The affliction caused by operators stepping on the area and the use of machinery that can damage other flora species, the use of herbicides, etc. are easily observed during monitoring works and can be registered and analysed. This monitoring allows you to take corrective or preventive measures quickly and effectively to avoid these impacts.

Determine the affliction on habitats, bird populations, soil and water: at medium term, particular monitorings can be planned to monitor the impact on different mediums and habitats present in the environment. This monitoring will allow improvements in the different methods to be applied in future actions.

Determining the impact on the ecosystem functionality, habitat recuperation capacity: a large-scale monitoring (spatial and temporal) generally requires a lot of resources and careful planning.

Data collection in the field such as re-sprout, germinated seedlings or coverage of native species are very useful to track the project successfully (Ihobe)

Efficacy of a method

Through pilot tests or test plots, it can be easy to determine the efficacy of one method compared to another, in different environments or seasons. Efficacy will be measured by the percentage of dead treated specimens. It will also be possible to monitor the recuperation of the vegetation and even the impact on the medium.

b) Types of data that can be taken

Data to be taken in the field can have different characteristics:

Data type	Description	Sample unit	Time*
Presence/absence	Presence of *B. halimifolia* in a particular area.	Total surface of the considered area.	F, G
Population census	Total number of specimens in a given area	Total surface of the considered area.	F, G
Percentages of specimens by category	Number of specimens belonging to a certain category (e.g., males and females) per sample unit.	Specific dimension plot.	F
Density	Number of plants per area unit.	Specific dimension plot.	G
Coverage	Vertical projection of vegetation on the ground expressed as an absolute value or ordered in types of coverage (for example, percentages)	Specific dimension plot.	G
Biometric characterisation	Continuous data measurements according to a given variable (height, shaft diameter, etc.)	Specimen (representative sample)	G
Species abundance or diversity	Quantification of the number of species or distribution of their abundance in a given area.	The total surface of the area occupied by the community being tracked.	G

*G = growing; F = flowering

Table 3.20. Data type diagram.

c) Data registry

All data collected in the field, whether about location, extent, abundance or coverage, will be referenced on **maps** or aerial photographs to facilitate further analysis. The use of Geographic Information Systems (GIS) facilitates the monitoring, as it allows analysing the evolution in time and space of multiple correlated variables. On the other hand, data collection in the field can be complemented by photo-interpreting aerial and satellite images.

The **photographic record** of the invaded areas facilitates, in turn, the interpretation of changes, especially if taken from the same point along time.

Some factors may influence data taken, such as the characteristics of the medium (heterogeneous environments, flooded areas, slopes, etc.), accessibility, size of the treated areas, replication of treatments, etc.

d) Analysis and interpretation of data

It is recommended that quantitative data are **treated statistically**, as this allows detecting and documenting with greater precision changes in the variables of the sample over time, although it is not always necessary.

Some results will have immediate interpretation such as the re-sprout percentage in the case of monitoring a control method. Others, such as the number of seedlings or the presence and abundance of native species, allow data comparisons between successive years.

For a more complex monitoring, correlating the results with certain terrain features such as salinity, flooding or habitat type, for example, a more complex planning regarding the number and location of sampling units will be necessary.

Data should be analysed as soon as possible after collection, so that results can be used to refine aspects of the management programme and/or monitoring protocols. Reports shall be made annually, ensuring that the methodology of data collection and analysis is relevant and appropriate to assess progress towards achieving the objectives.

Questions to take into account

- ✓ Is the management plan being carried out as expected?
- ✓ Will the selected plots always be accessible? If fixed, can they be relocated? Can they be signposted appropriately?
- ✓ Is the monitoring action impact acceptable?
- ✓ Is the training level of the staff carrying out the monitoring appropriate?
- ✓ Is the relationship between the necessary costs and time to carry out the monitoring actions acceptable?
- ✓ Are actions in the field and report generation taking more time than expected?
- ✓ Will the observed variables allow detection of changes?
- ✓ Is the frequency of monitoring actions appropriate?
- ✓ Is the number of units chosen for monitoring enough?
- ✓ Are the significant levels obtained with the monitoring plan acceptable?

e) Checking the monitoring strategy

The results and the influence of external factors on the monitoring are also used to check the validity of the strategy set out in the beginning. An early assessment can facilitate decision-making regarding the need to modify any of the points indicated.

3. Reporting:

Generating monitoring reports when finalising a project (or annual reports in the case of longer programmes) is essential to support the decision-making process.

Sections to be included in monitoring reports:

1. Introduction Summary of the work carried out and the objectives set for a specific year.
2. Methods. They describe the nature and methodology of the intervention carried out, the location and number of sampling stations, the statistics used in the evaluation of data, and the description of the methods used for either of the implemented adaptation responses.
3. Results. They will include charts and tables that summarise the results of the data collection (such as a trend analysis of the target species being controlled and of the habitat recuperation) and of the implemented adaptation responses.
4. Discussion. It will document the progress towards meeting the objectives and goals set out in the management plan, the effectiveness of adaptation responses taken and recommendations for amendments to be made in the management strategy or in the monitoring plan for the following year if they were required.
5. Annexes. They will include essential photographic and cartographic documentation concerning the intervention area (before and after the intervention), the invasive species, the methods used, etc.

4. Using the results for decision making:

One of the most tangible benefits of a monitoring programme is to obtain **objective data** to provide managers the information necessary to assess the progress of the programme and the realisation of the goals and objectives, and to support the decision-making process that will determine the actions to be taken to correct any deviations from the original plans, both in management and monitoring.

If a deviation is found in the monitoring plan, there are three possible response options (see Figure 3.6):

a) **Determine that more information is required and continue (or modify) monitoring.** This can occur when the data collected do not allow conclusions or extrapolating trends, when an incident or error has occurred in data collection (for example, by inaccessibility to the plots), or in the management operations.

b) **Identify and implement a corrective action.** In relation to management, the need for rework in the intervention areas, for modifying the intervention method, for introducing measures to support habitat recuperation, etc. can be observed.

c) **Modify the project goals and objectives.** This option will only be considered as a last resort, when monitoring results evidently point to the impossibility of achieving the expected results (action failure).

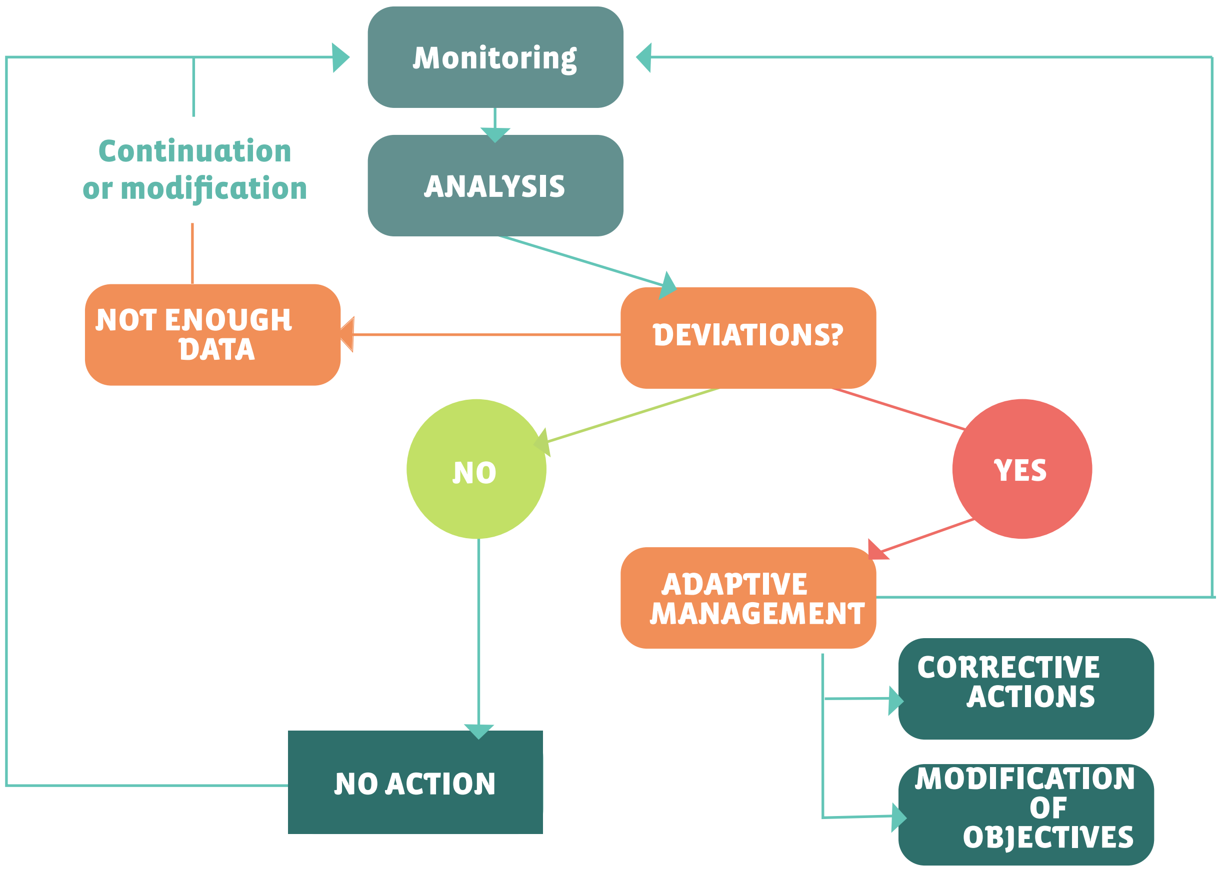


Figure 3.6. Conceptual framework of a monitoring plan in the context of adaptive management.

6. MAINTENANCE AND RESTORATION

The main objective of a conservation strategy is the preservation of the ecosystem and its functions, and of the native community [37, 80].

Following an intervention on a population of *Baccharis halimifolia*, resources can be freed or niches can be opened that favour re-invasion and new invasions by other species [55, 56, 80] and/or the structure of the soil and vegetation can be altered [36, 92]. Therefore, it is necessary to perform maintenance and/or restoration tasks in the intervention areas.

While **maintenance** prevents re-invasion of the controlled species and of other invasive species, **restoration** seeks recovery of native species regenerating the community structure and the ecosystem functions.

B. halimifolia has a high capacity for regeneration and produces large seed banks, so the eradication or control in the short term may require multiple interventions over many years [35].

A) Maintenance

The monitoring results (Section 5) indicate the need for rework or maintenance of the intervention area. The degree of future interventions will be marked by the initial objective of the strategy, but, in general, it should always be avoided to return to the baseline position.

Thorough surveillance of the intervention area for a period of at least two years is critical to detect new infestations by lasting seed germination in the soil or specimens emerging that were hidden or were undetectable in the previous phase. Given that the seed bank of *B. halimifolia* can last from 2 to 5 years, observation should cover the entire period in which the seeds are viable.

Photograph 3.17. *Cotula coronopifolia* spreading across *B. halimifolia* treated areas (Ihobe)

Maintenance work may incur **elimination of specimens that have re-sprouted and elimination of seedlings** germinated in the intervention area. After eradication, annual maintenance focused on the selective elimination of new pioneering colonies is essential.

Growth of other invasive species should also be forecast when opening niches and areas devoid of vegetation suitable for the establishment of new invasions. Other aspects to consider are the increased erosion or landscape impact due to the loss of vegetation cover.

The **conservation of good state of habitat and plant communities** affected will favour the maintenance of the treated areas. For this, it is important to avoid any disturbance involving a possible reintroduction of the species, such as opening of clear areas due to clearing, fires, soil movement, etc.

B) Restoration

Regeneration of native plant communities after an intervention may depend on several factors [5]:

- The availability of a consistent native seed bank.
- The history of land use in the area.
- The proliferation of other invasive species.

- **Restoration** requires a thorough knowledge of [57]:
  - Biotic attributes of the area to be restored and reference data to assess its development.
  - The changes suffered by the ecosystem (both natural and anthropic).
  - The factors that increase susceptibility to invasion, as well as potential barriers to natural recovery.

After treating an invaded area, the recovery of natural vegetation depends largely on the development of new propagules, either by germination of the seed bank stored in the soil or by dispersal from intact vegetation patches from surrounding areas. Maximising the **recruitment potential of natural vegetation** is of fundamental importance, and that is to be considered prior to the application of treatments on species to control/eradicate, in order to not counteract it [57].

Since *B. halimifolia* is favoured by altered marsh habitats, the invaded areas may be areas that were formerly under tidal influence and that were filled for agricultural and other types of use, and later abandoned. A restoration project may therefore comprise a severe action in the medium, such as soil movement to cause re-flooding of land or the creation of artificial wetlands. In other cases, such actions are not viable (dikes and dikes marshes, gardens, etc.), so the implementation of native vegetation through planting or seeding should be promoted. In this case, it is essential to use always native species with guarantee of origin, to prevent new invasions.

In the case of coastal cliffs, restoration actions should be directed to the recovery of plant communities affected.

· In the context of recovery projects of Plaiaundi and Jaizubia it was possible to remove all the masses of *B. halimifolia*. After subsequent maintenance tasks after the actions, most of the area has been fully recovered with native vegetation. However, the detection of some *Baccharis* specimens meant new actions had to be performed to prevent propagation [33].

· In the context of the LIFE project: Restoring habitats of Community interest in estuaries of the Basque Country - LIFE8NAT/E/000055, several treatments to eliminate *B. halimifolia* were carried out in 2011 in almost the whole area affected in the Urdaibai Biosphere Reserve. The data obtained after monitoring show a good recovery of native vegetation. Although a significant presence of *B. halimifolia* has been detected, it shows lower abundance and coverage along with a decline in the seed bank [10]. These results let us assume that the continuation of the control campaign and subsequent maintenance activities aimed at eliminating the reappearance of *Baccharis* might be sufficient. However, the presence of three other species of invasive exotic flora, *Aster squamatus*, *Cortadería selloana* and *Cotula coronopifolia* [103], might result in new management problems.

Restoration of habitats affected by *B. halimifolia* in the BAC

On the other hand, it is important to note that estuaries and marshes have high recovery potential, and in some cases no action may be needed to restore affected habitats. Finally, a long-term monitoring should be planned to identify carefully indicators and sampling areas that should always include not invaded control areas.

7. THE PROJECT AS BIOLOGICAL INVASION VECTOR

The control and eradication actions of *B. halimifolia* themselves can become an introduction or dispersal pathways of this species or of other potentially invasive exotic plants. As a result, all projects must be planned, based on a thorough understanding of the biology and ecology of the species, of the techniques to be employed, of the clearing measures and of the proper management of plant residues.

Among the possible introduction or dispersal pathways derived from a *Baccharis* management programme, we find:

A) Introduction or accidental dispersal of seeds or fragments of *B. halimifolia* with capacity to re-sprout

The seeds of this species are able to disperse several kilometres through the pappus they have, which favours dispersal by wind. Therefore, the use of certain machinery or vehicles in invaded areas can result in seed dispersal by the turbulence generated.

The workers themselves, both through clothing and footwear or equipment used in the management work, may act as dispersal vectors if these items are contaminated with seeds.

Photograph 3.18. *B. halimifolia* seeds dispersed by wind. (Ihobe)

B) Generation of unshaded areas

Because the seeds of *B. halimifolia* activate with light, the generation of unshaded areas will favour establishment of the species from the seed bank present in the soil.

Also, germination or establishment of other invasive species which cannot tolerate shade can be promoted.

C) Generation of bare soil areas

The removal of vegetation cover can promote recolonisation of the area by other invasive species present in adjacent areas due to a reduction or elimination of existing competition with species that were present previously.

Photograph 3.19. Area of bare soil after control actions of *B. halimifolia*. (Ihobe)

D) Generation of herbicide resistance

Although the emergence of resistance in *B. halimifolia* has not been documented yet, repeated use of the same herbicide could lead to its generation. Thus, the most tolerant specimens would remain, reducing treatment efficacy.

Photograph 3.20. *B. halimifolia* seedlings re-sprouting from seeds. (Ihobe)

E) Creation of new foci of invasion from mismanaged plant waste

It is important to follow the guidelines in the waste management section, to avoid creating new foci of invasion. Seedlings uprooted and any others remaining in contact with soil and moisture are susceptible to root again and continue their development.

8. DISSEMINATION AND COMMUNICATION

Communication and dissemination activities play an important role in control programmes of invasive exotic species. To report more effectively on the activities, objectives and benefits to be obtained with the elimination of *B. halimifolia*, **it is recommended that dissemination activities** are articulated in a strategic communication framework and **are conducted from the beginning of a management programme for the species**.

Here are some of the useful key elements to develop a large scope communication and dissemination strategy [56, 72] on *B. halimifolia*. However, specific conditions of each initiative (spatial and time scale, objectives of the same, and available resources) will be the ones to determine the suitability of partially or fully adopting the proposed scheme.

A) Starting diagnosis

Full knowledge of the problems generated by *B. halimifolia* is a must to convince and involve the largest possible number of bodies in the (active and/or passive) management of the species.

Probing the perceptions and attitudes of the different key actors, select the most appropriate communication channels and have an initial framework for evaluating the impact of the communication strategy (changes in perceptions and attitudes).

B) Identification of intended target groups: generation of an influence map

To plan the intensity of the communication effort and tailor the message in a timely manner, it is desirable to identify key bodies and stakeholders depending on factors such as interest, the power to change and the influence of their views and actions.

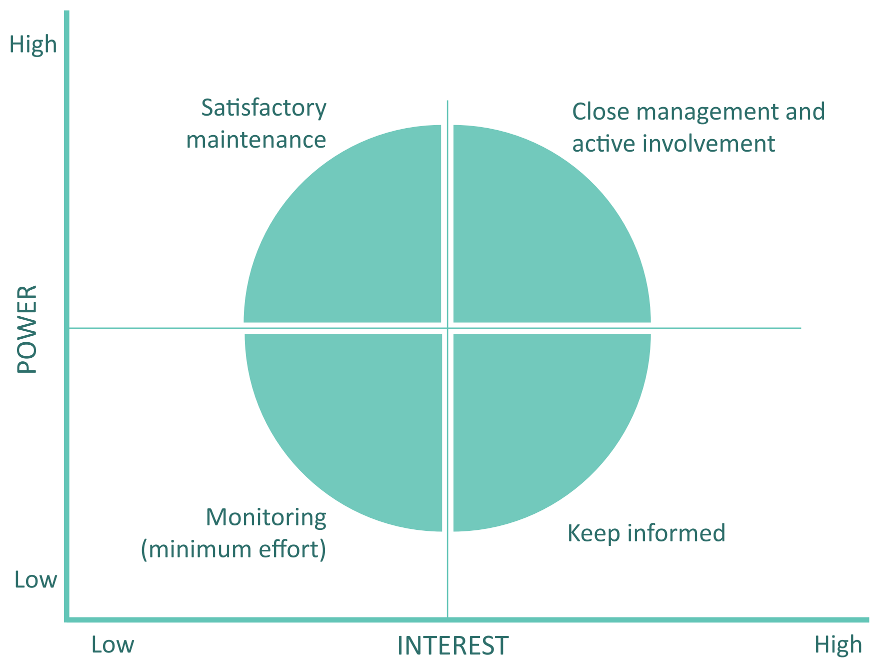


Figure 3.8. Diagram of an influence map.

These factors may vary depending on the territorial and temporal context (cultural, political, etc.), on the type of management to be performed (prevention, control, etc.) and on the "weight" of each body or actor.

It is therefore appropriate to apply the analysis to specific contexts, depending on the expected type and degree of management (specific objectives of the management programme).

C) Setting objectives

The objectives will be set based on the management programme to be carried out and on the knowledge gained on the key bodies and stakeholders.

Examples of communication objectives:

- To inform target groups about the management programme: what it is, its objectives, reason for its creation, etc.
- To disseminate the progress made and the results achieved during the activity.
- To provide a document base and reference material to carry out future initiatives or studies.
- To strengthen the link between scientific research and management strategies.
- To create reference material for administrative officials at different levels.
- To increase political support to management and control of *B. halimifolia*.
- To encourage businesses (commercial, agriculture and forestry sectors) to adopt techniques and practices compatible and consistent with the management of *B. halimifolia*.
- To promote the participation of specific groups in *B. halimifolia* observation activities.
- To conduct an effective, transparent and understandable by the general public communication about the problems associated with *B. halimifolia*.

D) Definition of messages

Messages should summarise the "essence" of the management programme, highlighting the benefits and added value it contributes. Regardless of its information or action-oriented character, the message must be relevant and specific to each target individual, positive, credible, concrete, accessible and reliable. Inaccurate, exaggerated or incorrect information can discredit an entire media campaign, damaging the management programme.

It is advisable to synthesise the existing information on *B. halimifolia*, integrating it into a series of key messages adapted to both target individuals and the channel chosen for dissemination. Ideally, the messages should be updated according to the response of the management programme target group.

Finally, it is appropriate to take into account the level of connection between the sender and recipient of the message, including the possibility of using intermediaries when this level is low.

A proposal of some management programme key messages, identifying managers, target audience, programme phase, etc. is included in Annex 4.4.

E) Selection of communication tools

There is a wide spectrum of available communication channels. When choosing the most appropriate, it is advisable to weigh up the communication objectives, the type of message and recipient, the characteristics of the channel itself, and the associated costs. It is also important to note: a) that a correct combination of media and message can significantly enhance the impact of the communication; and b) which novel communication channels may reach traditionally unattended audiences, although previous analysis of costs and benefits of reaching those audiences is advisable.

1. Passive channels:

- **Press, radio and television:** They can play an important role in reaching a wide spectrum of target individuals. Press releases and articles disseminated must be adapted to the language of the media and provide relevant and understandable information and data to try to attract attention. It is always advisable to send the information in writing, establishing direct and possibly continued contact with the media.

- **Project portal on the Internet:** in addition to providing direct information, it serves as a tool for disseminating other materials (news, publications, videos, event publicity, etc.). To facilitate working with the media, it is desirable that it includes a specific section for this target group. Moreover, the portal itself (provided with an intranet) can facilitate internal communication between the parties involved in the project.

- **Information material:** it includes brochures, videos, etc. It may contain information with different levels of detail, which can reach target groups or areas through selective distribution (direct external communication). However, it has the disadvantage of being quickly outdated regarding content and of having a fairly limited outreach.

- **Reference material::** accessible technical publications available in electronic format may serve as documentation for the work of specific groups (technicians, researchers, administrators, NGOs, companies, etc.).

Channel	Impacting	Continuous	Communicative	Far-reaching	Inexpensive
Press	Yes	No	No	Yes	No
Magazines	Yes	No	No	Yes	No
E-bulletins	No	Yes	Yes	Yes	Yes
Brochures	No	No	No	No	Yes
Television	Yes	No	No	Yes	No
Videos	Yes	No	No	No	Yes
CD-Rom	No	No	No	No	Yes
Web & Blog	No	Yes	Yes	?	Yes
Reference material	Yes	No	No	No	No

Table 3.22. Passive dissemination channel types.

2. Active channels:

Sometimes, intensive communication with strategically influential groups can be much more effective than superficial communication with many target groups. In this context, active and and two-way communication channels can be more effective, because they favour a direct and/or interpersonal interaction with the target group.

Face-to-face communication and **visits to institutions** are indispensable if we are to actively involve specific target individuals or establish agreements. Another alternative are the **events** that temporarily join specific groups, such as **symposiums, forums, workshops**, etc. However, due to the limitations imposed by presence acts (travel costs, organisation, etc.), a possible solution would be to hold **virtual meetings** (webinars). Finally, the **thematic distribution lists** allow the maintenance of active communication between their subscribers, as well as the exchange of information.

For **surveys** (e.g., the perception of the problem), despite the smaller outreach and more time needed, telephone contact is much more effective than e-mail.

Photograph 3.21. Guided tours with students in the framework of the LIFE+ Estuaries of the Basque Country (Ihobe)

Photograph 3.22. Forum for discussion and exchange of information between administrations organised in LIFE+ Project and estuaries in the Basque Country (Ihobe)

Channel	Impacting	Continuous	Communicative	Far-reaching	Inexpensive
Face-to-face	Yes	No	Yes	No	No
Forums	Yes	No	Yes	No	No
Conferences	Yes	No	Yes	No	Yes
Workshops	Yes	No	Yes	No	No
Symposiums	Yes	Yes	Yes	No	No
Telephone calls	Yes	No	Yes	No	No
Visits to organisations	Yes	No	Yes	No	No
Mailing	No	No	Yes	Yes	Yes
Distribution lists	No	Yes	Yes	No	Yes
Webinars	Yes	Yes	Yes	Yes	**Yes**

Table 3.23. Active dissemination channel types.

F) Development of a communication strategy

To manage *B. halimifolia*, making stakeholders involved is a key element, since it is a long-term commitment rate that each of them assumes. For this, it is appropriate:

- To imprint a **permanent**, interactive and feedback **character** in the communicative process.
- To adopt a bottom up approach to increase the level of participation of the different target groups, to facilitate the establishment of agreements and to amplify the dissemination of messages.
- To plan actions in the short, medium and long term, **publicising** the project and **its results at the end of each phase**.
- To establish a communication team who prevents the transmission of distorted information and designs communicative activities with formats that encourage interaction between experts and target groups.
- To establish strategic alliances with relevant actors in the communication field sector, and which are socially relevant to the management programme.

Finally, it is necessary to provide the communication strategy with sufficient resources, to ensure its continuity throughout the entire programme. The quality of information, the time invested and the funds used are strictly related and, long-term, involving key actors will be more effective and inexpensive than developing campaigns conducted only through the media.

G) Monitoring and assessment

Dissemination measures have to be evaluated to verify the degree of compliance with the presented objectives and their scope. This calls for reliable monitoring indicators which will also allow the detection of possible failures and the implementation of the corrective actions that apply. Comparison of the final results with those collected at initial diagnosis will allow the detection of whether the desired changes in the target groups have taken place.

ANNEXES

1. Recommendations for the use of herbicide products

2.* Examples of monitoring plans for *Baccharis halimifolia

A) Monitoring plan provided in LIFE08NAT/E/000055 Project and recuperation of natural habitats.

B) *Baccharis halimifolia* mapping in estuaries and on coastal cliffs of Bizkaia and Gipuzkoa.

3. Glossary

4. Proposed actions to improve the management and knowledge *Baccharis halimifolia*

1. Establishment of a Working Group on *Baccharis halimifolia.*
2. Strengthening of inter-institutional collaboration and coordination mechanisms.
3. Research.
4. Proposed dissemination messages about the problem.

ANNEX 1.

RECOMMENDATIONS FOR THE USE OF HERBICIDE PRODUCTS

Objective

This annex is intended to **guide** users of this manual on the use of herbicide products for the control and elimination of *Baccharis halimifolia*. Before deciding on the product, the method of application and the safety measures to be applied, current regulations and the manufacturer's recommendations for the selected product must be consulted and complied with.

Preliminary considerations

When selecting the type of herbicide to be used, it is advisable to consider the following characteristics [85]:

- Effectiveness on the target species.
- Dissipation mechanisms (persistence, degradation, mobility by air or water towards other organisms).
- Behaviour in the environment (in soil, water and vegetation).
- Toxicity to birds and mammals, aquatic organisms and other non-target organisms.
- Application considerations.
- Safety.
- Human toxicity.

Some of this information is usually available on the safety data sheets of the products.

Identification of risks

During a control action of invasive species, the following risk circumstances derived from the use of herbicides may occur:

- Product spillage during handling, transport or application.
- Product drift to the environment during or after application.
- Pollution from inadequate waste management.

Preventive measures

The following preventive measures for the use of herbicides, extracted from the Contingency Plan prepared for the Life+ Basque Estuaries Project [51] are summarised below.

Personnel and material to be used

- The handling and application of the product will be performed by qualified and authorised personnel, who must be in possession of the necessary qualifications for handling plant protection products (basic and/or advances applicator title).
- The equipment and materials for the application should be periodically checked and maintained.
- All operators should be provided with the necessary PPE required by the applicable regulations in force.
- The creation of a Health and Safety Plan and an Environmental Plan setting out an analysis of the action area and that defines concrete measures to protect the environment is recommended.

Worker with the necessary safety equipment (Basque Government)

Transport and storage

- Before starting an action, it is recommended to analyse the access condition to the areas of application.
- Personnel carrying the product passing near surface water channels should be avoided.
- For transporting the product, sealed containers including systems that avoid spillage will be used.
- The herbicide product will be stored in stainless steel, fibreglass, plastic or glass lining containers, at room temperature, away from extreme temperatures.
- The containers will be inspected prior to transportation.

- The containers will be placed vertically and with the nozzle at the uppermost, and will be secured properly.
- The product will be correctly identified and should have the appropriate safety data sheet.
- In cases where access is only possible by water (by boat or similar), the herbicide will be transported pre-mixed in cylinders with a capacity that will not exceed 5 L.
- The product storage places will conform to the provisions of the regulations in force, away from water courses and on high ground, and they will be equipped with natural or forced ventilation and an exit point, and also avoiding direct sunlight on containers.

Product preparation and handling

- Plastic trays will be used for transferring the product.
- The product mix and transfer between containers will be preferably made in the premises dedicated to storing the product storage, prior to transport of the product.
- If preparation in the field is needed, sealed containers equipped with absorbent material should be used.
- In any case, manipulators should always have absorbent materials at hand.
- It is recommended to avoid clogging the containers in which the mixed product will be transported.
- The containers will be kept locked when the product is not being applied.

Safety equipment to prepare the herbicide mixture. (Ihobe)

Product application

- Actions will be scheduled so that product contact with water is avoided.
- Before applying the product, the weather forecast should be analysed.
- The herbicide product will not be applied under conditions of rain, wind and/or fog.
- We recommend using a harmless dye to know where the product has been applied.
- The product instructions for use on the herbicide label should be followed.

Worker applying the herbicide on stumps of *B. halimifolia* (Ihobe)

Waste management

- Remains of product and materials used in its application which will not be used in subsequent applications, as well as absorbent materials that have been used, will be placed in tanks different for each type of waste, and will be delivered to a licensed waste manager.
- The company carrying out the work shall be registered in the Register of Small Producers of Hazardous Waste.

ANNEX 2.

EXAMPLES OF MONITORING ACTIONS FOR BACCHARIS HALIMIFOLIA

Introduction

This sections introduces a summary of two actions related to the monitoring of species *Baccharis halimifolia*, focused on its management.

On the one hand, the monitoring plan applied in project Life+ Basque Country Estuaries (LIFE08NAT/E/0055) for monitoring the elimination of *Baccharis halimifolia* in the three project areas in the four-year project is presented. On the other hand, a summary of a mapping and inventory work on the species to facilitate its mid-long term identification and monitoring is presented.

A) Monitoring plan provided in LIFE08NAT/E/000055 Project [50].

Objectives: 1) General: To monitor the LIFE project actions with an impact on the environment. 2) Specific: a) To analyse quantitatively and qualitatively the results of the eradication actions of *Baccharis halimifolia*; b) To assess the degree of regeneration of habitat areas treated in the different environmental conditions that the action fields present; c) To track the eradication method focusing on assessing the afflictions of herbicide use in the environment.

Duration of the monitoring plan: From 2010 to 2014.

Areas in which the eradication works are developed: 1) Interior marsh of Urdaibai 2) Bidasoa islands 3) Lea marshes

Phase I. Preliminary analysis.

Objective: To know the eradication actions and the results obtained in Urdaibai, to detect improvements and lessons learned to be applied to the present project.

Tasks: Data collection and analysis.

Phase II. Monitoring the impact of eradication methods in the environment.

Objective: To analyse the impact of eradication methods of invasive vegetation in the environment, especially the use of herbicide.

Tasks:

1. Monitoring the impact on substrate (active component durability)

   Task: Soil analysis to detect possible traces of glyphosate and possible herbicide mobility due to tidal flow in all three sites.

   No. of sample plots for each site: 3. Sampling points in every plot: 2. One located in the substrate susceptible to receive glyphosate residues during application and the other in the muddy adjacent area.

   Sampling: At the time of application and 5 days after at the first point and 10 days after at the second point.

2. Monitoring the impact on flora

Task: To determine the effect of eradication methods have on native vegetation and its regeneration process by analysing: a) the affliction caused by the application of the herbicide on the stumps and the way the trunk is cut and removed; and b) indirect afflictions derived from the product application (clearings and clear cuts, trampling, stepping, use of machinery, etc.)

Sample unit: 3 m^2 plots in disperse *Baccharis halimifolia* occupation treated during the first year. Choice and quantity will depend on the type of habitat, accessibility and number of stumps.

Measurements: 2. The first one during the herbicide application work, and the second one at 2 months.

Floristic composition and vegetation cover data of native plants will be taken and a temporary monitoring will be made

Phase III. Determination of plots and transects.

Objective: To establish the points of data collection for the analysis of project results.

Tasks: To determine: a) the sampling area, depending on the progress of the eradication work; and b) the number of sampling points according to the affected area and the campaign.
Sample unit:

- Permanent plots of 9 m^2, marked and geolocated.
- 50 m long transects with stations every 10 m (1 m^2 plots) randomly located, mapped and geolocated.

Minimum number of plots and transects		
Department	Plots	Transects
Urdaibai	25	30
Txingudi	10	20
Lea	5	15

- Location criteria: 1) Habitats threatened by *Baccharis halimifolia*: saline pastures of *Juncetalia maritimi* (1410), alluvial forests of *Alnus glutinosa* and *Fraxinus excelsior* (91E0*) and reedbeds of *Phragmithes australis*. Also: Harvest fields (6510), thermo-Atlantic and Mediterranean halophile scrubland (1420), Pioneering annual vegetation in marshes (1310). 2 *Baccharis halimifolia* density, disperse and monospecific mass areas. 3) Accessibility of the plots, as quality of the work performed is to be determined.

Phase IV. Revision of plots and transects.

Objective: Data collection.

Tasks: Take data from each sampling unit and campaign. Parameters:

1) Number of young specimens from the seed bank of *Baccharis halimifolia*.

2) Number of *Baccharis halimifolia* stumps per size (<50 cm and >50 cm) and responsiveness (with or without re-sprout) to herbicide application.

3) Floristic composition and coverage based on an index of abundance-dominance from a simplified version of the Braun-Blanquet scale: + present species; 1: 1-10%; 2: 11-25%; 3: 26-50%; 4: 51-75%; 5: 76-100%.

Phase V. Monitoring the work and presentation of results.

Objective: To provide scientific advice throughout the project, based on continuous monitoring of activities and by providing information.

Tasks: a) Ongoing advice and dialogue with the project managers, the company responsible for the eradication work; and b) Delivery of monitoring reports that include data collected in the field and their analysis, comparative analysis of campaigns carried out in previous years, as well as suggestions for improvement or any information deemed relevant.

B) Baccharis halimifolia mapping in estuaries and on coastal cliffs of Bizkaia and Gipuzkoa [60].

The objective of this study is to determine the current distribution and degree of invasion of *Baccharis halimifolia* on the Basque coast. For this, a mapping in non-prospected areas of the coastline that could be invaded by this species is made, focusing efforts in areas of estuaries and marshes, as well as on coastal cliffs. This prior information is considered essential for monitoring and subsequent elimination work.

This work consists of the following phases:

Phase I. Bibliographic compilation

Objective: Getting an initial mapping of the distribution of the species.

Tasks: a) Compilation of the previous work on the presence of *B. halimifolia* on the coast of the Basque Country; b) contact with forest rangers in the affected areas; c) request for information to municipalities environmental technicians; d) queries to sector consultants and professionals.

Phase II. Fieldwork for mapping *B. halimifolia* in estuaries and coastal cliffs of Bizkaia and Gipuzkoa

Objective: Contrast and expansion of the initial mapping.

Tasks: Covering of estuaries and cliffs under study, as well as locations in old citations to verify the presence or absence of the species. In accessible areas, detailed mapping of the their distribution is made, but if this is not possible, their presence or absence is registered. Data of interest are collected: size of specimens, approximate density, presence of seedlings, etc.

Time: October-November

Phase III. Mapping creation in Shape format with GIS mapping software

Objective: To get digital mapping in digital and manageable format.

Tasks: Mapping digitisation in Shape format, including the additional information collected in the field for each foci or mapped specimen.

Phase IV. Drafting of the report

Objective: To get a summary report and conclusions of the work done.

Tasks: With the data and observations obtained from the bibliography compilation and field work, a report is created that analyses the general distribution, distribution per areas and types of habitats, protected areas, etc.

ANNEX 3. GLOSSARY

Abiotic: In the field of biology and ecology, this refers to that which is not, or is not the product of, living beings, such as inert factors (climate, geographical or geological) present in the environment and affecting ecosystems.

Allergenic: (= Allergen) Substance that can induce a hypersensitivity (allergic) reaction in susceptible persons who have previously been in contact with the allergen.

Allochthonous: (= Exotic) Living creatures that have been introduced into an ecosystem or environment that is not their natural distribution.

Anemochory: Type of propagule dispersal where the wind produces transportation.

Anthropisation: Intervention by human societies that has an impact on natural elements.

Anthropogenic: Effects, processes or materials that are the result of human activities, unlike those that have natural causes without human influence.

Achene: Type of nut formed from one carpel and indehiscent (it does not open when maturing), containing a single seed.

Autochthonous: (= Native) Living creatures natural to the ecosystem in which they are, as opposed to allochthonous.

Biocontrol: (= Biological control) Method of controlling pests, diseases and weeds that consists of using living organisms in order to control other organism populations.

Biogeography: Interdisciplinary science that studies the distribution of living creatures on Earth and the processes that originated it, change it and can make it disappear.

Biotic: Set of species of plants, animals and other organisms that occupy a given area.

Cambium: Meristematic plant tissue specific to woody plants, located between the inner bark and the wood.

Capitulum: In plants, an open or racemose inflorescence in which the stems expand at the tip, forming a thick disk.

Cardiotoxic: Substance that is toxic to the heart muscle.

Carpel: Modified leaves that form the female reproductive part of the flower of angiosperm plants.

Clearing: To remove debris (branches, dry leaves and other remains of plants in forests and gardens).

Containment: (Regarding IES management) To prevent invasions to spread to other areas free of the IES in question. It involves methods that prevent reproduction and dispersal of propagules, the invaded area perimeter treatment and elimination of small satellite populations.

Control: The action carried out by the competent or authorised body, or supervised by it, with one of the following purposes regarding an invasive exotic species: reducing its distribution area, limiting its abundance and density, or preventing it from spreading.

Crowdsourcing: It consists of outsourcing tasks which traditionally were performed by an employee or contractor, to a large group of people or a community through an open call.

Cypsela: A dry indehiscent single-seeded fruit formed from a double ovary of which only one develops into a seed.

Datum: Term applied in several areas of study and work, specifically when a relationship to some important reference geometry is made, be it a line, a plane or a surface (flat or curved).

Deciduous: Plants that drop their leaves in a particular season.

Disturbance: Alteration of the normal development or order or something.

Dormancy: It occurs when the seed is separated from the fruit and the metabolic activity in the embryo is reduced and at rest. The function of dormancy is to consume the least possible amount of nutrients.

Endemism: It is the ecological state of a species being unique to a defined geographic location and that cannot be found naturally anywhere else in the world.

Eradication: Process aimed at the elimination of the entire population of a species.

Establishment: It refers to the process followed by an exotic species in a new habitat with successful reproduction and likelihood of continued survival.

Gall: Tumour-like structures induced by insects and other arthropods, nematodes, fungi or bacteria; it is the plant's response to the parasite with an abnormal growth of tissue that attempts to isolate the attack or infection.

Gauge: a measurement unit used to measure the thickness of very thin materials. It is expressed in microns multiplied by four. For example, 25 micron thick (0.025 mm) is the equivalent to 100 gauge.

Generalist: A species that can grow in a wide variety of environmental conditions and can use a great variety of different resources.

Georeferencing: Neologism that refers to the association of something with locations in physical space (represented by point, vector, area, volume) in a given coordinate and datum system.

Geotextile: Permeable and flexible fabric of synthetic fibres (usually polyester or polypropylene).

Glyphosate: (N-phosphonomethylglycine) Non-selective broad spectrum herbicide that is absorbed by the leaves (not by the roots). Its action lies in that it suppresses the ability of plants to produce aromatic amino acids.

Halophile: Adjective applied to organisms that live in environments with large amounts of salts.

Hybrid: The specimen resulting from reproductive crossing of different species specimens, being at least one of them a catalogued species.

Hydrochory: Type of propagule dispersal where the water produces transportation.

Inflorescence: Arrangement of flowers on the tip of the stem branches wave; the limit is determined by a normal leaf.

Introduction: This refers to movement, by human action, whether voluntary or accidental, of a species outside its natural distribution area. This movement can be either within a country or between countries or areas beyond national jurisdiction.

Invasive (invasive exotic species): Exotic species introduced or established in an ecosystem or natural or semi-natural habitat which is an agent of change and threatens native biological diversity, either by its invasive behaviour or by risk of genetic contamination.

Inventory: Document registry of goods and other things belonging to a person or community, done with order and precision.

Latency: It occurs when the seed is separated from the fruit and the metabolic activity in the embryo is reduced and at rest. The function of latency is to consume the least possible amount of nutrients.

Levee: Wall or construction to contain water.

Metadata: Data describing other data. In the fields of telecommunications and IT, it refers to non-relevant information for the final user but which is important for the system managing the data.

Mitigation: (Regarding IES management) Actions addressed to compensating the effects derived from the invasion of an exotic species.

Monospecific: In botany or zoology, adjective describing a genus which contains only one known species.

NTIC: New technologies of information and communication.

Palatability: Quality of plants, usually grasses, regarding their utility as food for livestock.

Pappus: A modified calyx, composed of scales, bristles, or featherlike hairs, in plants of the composite family, such as the dandelion and the thistle.

Pericarp: Part of the fruit that covers its seed and consists of the fertilised ovary.

Phenology: Science that studies the relationship between climatic factors and cycles of living creatures.

Seedling: A young plant sporophyte developing out of a plant embryo from a seed. Seedling development starts with germination of the seed and finishes when the sporophyte develops its first cotyledon leaves.

Propagule: Any part or structure of an organism produced asexually, that can develop separately to produce a new organism which is similar to the one that formed it (spores, stolons, rhizomes, bulbs, etc.).

Resilience: The ability of communities to withstand, adapt and recover from environmental disturbances, acquiring new tools.

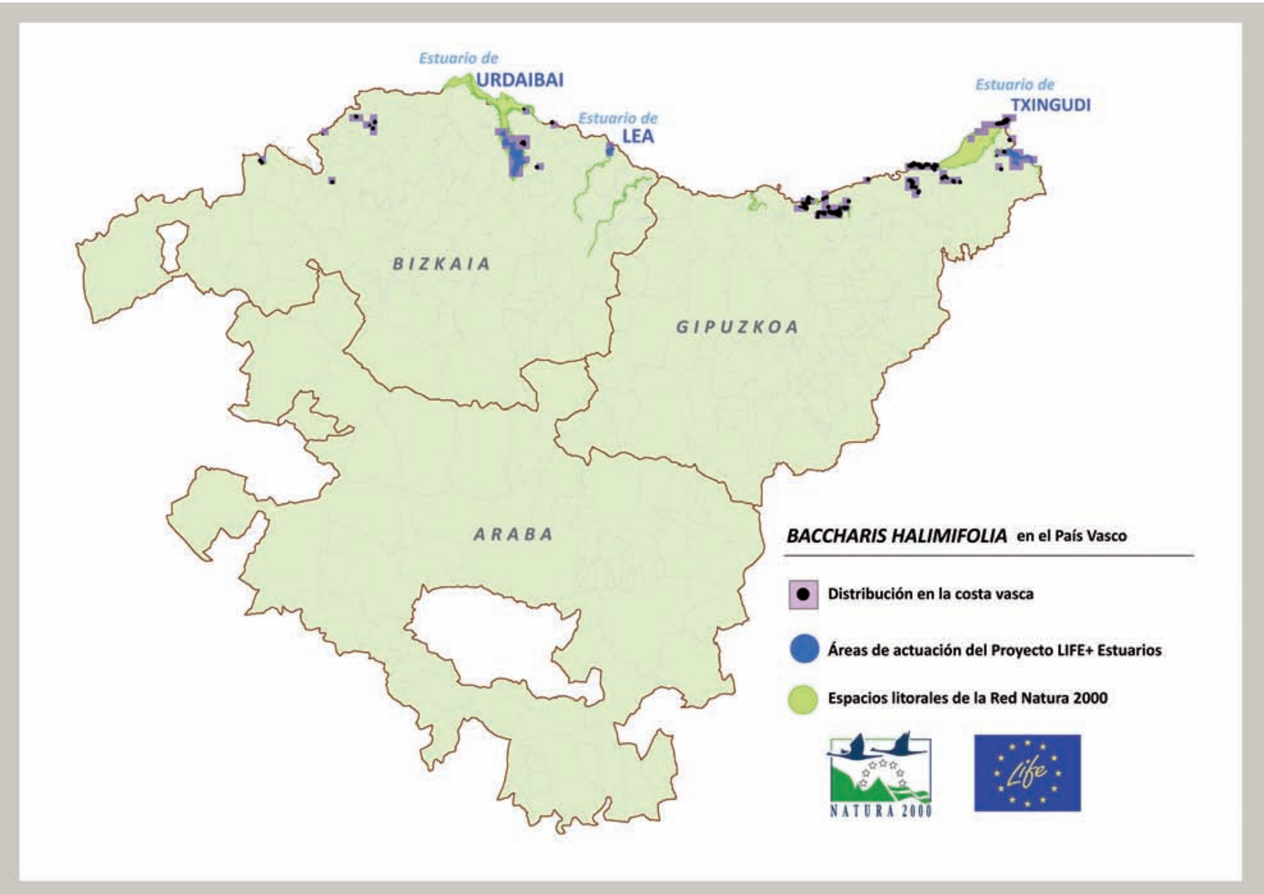
Risk analysis: It refers to the scientific and technical evaluation of (risk) probability and consequences of the introduction and establishment of an exotic species in the natural environment and of the measures that can be applied to reduce or control those risks.

Stand: Basic forestry unit. It is an area comprising a more or less homogeneous culture in terms of age, species composition and condition.

Stem: It refers to the trunk of trees (mono-stem: a single trunk; multi-stem: multiple trunks).

Suppression: (Regarding IES management) To reduce the size and abundance of the populations of the IES (i.e., density and coverage).

Transformer: In relation to invasive exotic plants, species that produces changes in the character, condition, form or nature of ecosystems in a significant area in relation to the extension of that ecosystem.



ANNEX 4.

PROPOSED MEASURES TO IMPROVE THE MANAGEMENT AND KNOWLEDGE OF *BACCHARIS HALIMIFOLIA*

While drafting the document "*Baccharis halimifolia* Management Manual", some action proposals to improve the management and knowledge of invasive species were emerging. This annex presents some of the proposals aimed at strengthening inter-institutional collaboration, scientific knowledge and dissemination.

1. Establishment of a working group on *B. halimifolia*

The need to create a framework that serves as a link between the many administrations and agencies that have duties or powers in this area, or that ensures consistent application of the provisions has been established. In response to this need, the mechanisms to be employed could take the form of a commission with advisory functions, consisting of representatives of all institutions involved.

This body could be formed by permanent and *ad hoc* members involved in specific cases and cover the following functions:

- *To serve as a catalyst for cooperation between administrations in the area of control of Baccharis.*
- *To make recommendations regarding research, technology transfer and management actions related to the control of Baccharis.*
- *To facilitate the exchange of information, so that each member agency is informed of the recommendations and proposals on the management of Baccharis.*
- To provide a forum for the development of coordinated inter-institutional strategies.
- To inform as required to the competent authorities.

On the other hand, each member of the commission should:

- *Coordinate activities related to Baccharis within the entity it represents.*
- Share with the commission their technical experience.
- *Cooperate in initiatives addressed at obtaining funds for the control of Baccharis.*

Also, and with the coordination of the Ministry of Agriculture, Food and Environment, the commission itself could be responsible for developing the national strategy on *Baccharis halimifolia*.

Despite how complex it may seem, such an initiative has already been carried out in Spain, in the case of the zebra mussel. In early 2002, a Joint Monitoring Committee was established, and a Working Group was formed in 2004 in the Committee of Wild Flora and Fauna. In addition to representatives from the affected autonomous communities, from the Ebro Hydrographic Confederation and from the Directorate General for Biodiversity of the Ministry of Environment, this group incorporated from the beginning the presence of experts and advisors from the different administrations [54].

2. Strengthening of inter-institutional collaboration and coordination mechanisms

The construction and development of a network is an asymmetric and variable process in which maintaining very strong horizontal communicative dynamics that feed the possibilities of sharing proposals, decisions and actions plays a key role [65].

The main activities of networking are based on the exchange of information and joint planning and programming with all counterparts of the activities to be carried out to control *B. halimifolia*. Thus, the structure of a network should take into account at least the following areas and objectives:

Area 1. Transfer of knowledge.

Objectives

- To provide information for the prevention and control of *B. halimifolia* revealing their own experiences and offering advice on the management of this species.
- To create a reliable mapping and database on *B. halimifolia* fully accessible and updated.
- To promote ongoing training of administrators and users.
- Actions
- To build an information portal on *B. halimifolia*.
- To compile and disseminate information on the species.
- To organise training courses on control and prevention techniques of *B. halimifolia.*

Area 2. Early warning system.

Objective

- To establish a notification and early warning system for B. halimifolia.
- Actions
- To develop a GIS that can capture and show in real time data related to the species detection points.
- To create a periodic e-bulletin for the network members.

Area 3. Administrative and technical procedures.

Objective

- To harmonise the administrative and technical procedures among the different sectors/actors.
- Actions
- To provide the necessary legal information (competencies and authorisations) to act on the species.
- To generate connections with other sectors/actors for their integration in the working network.
- To hold sector and cross-sector meetings.
- To elaborate criteria and priorities for the management of *B. halimifolia.*

Area 4. Internal communication.

Objective

- To systematise communication between members of the network to facilitate the flow of information on common actions, funding opportunities, monitoring activities and evaluation, etc.
- Actions
- To elaborate and disseminate activity reports.
- To enable an Intranet in the web portal, provided with the following tools: a) enabled safe access; b) shared document files; c) access to updated planning and management documents.

Exchanging information not only provides the knowledge to act, but also helps to strengthen collaborative networks and generate political support and commitment. On the other hand, efficient coordination is based on access to updated and accurate information, which needs to be collected and archived rigorously in a clear way and be fully accessible so all sectors/actors involved can contribute and/or extract the data required each time.

To this end, building a web portal on *B. halimifolia* which gives the network participating bodies the ability to enter information independently and in a regulated manner would be a desirable step. Besides helping to centralise information, avoiding duplication of data and expenditure, an Internet portal can integrate other useful tools, not only to transfer knowledge, but also to: a) host an early warning system; b) train in the management of the species (training activities on prevention and control techniques of *B. halimifolia*); c) facilitate internal communication; and d) disseminate and raise awareness of the need to control the species.

Proposal of content and tools for a web portal on *B. halimifolia*

- General information on the species (taxonomy, description, ecology, eco-physiological attributes of interest for its management, invaded habitats, abundance, population status, impacts).
- Species distribution and mapping (downloadable database and visualisation of maps at different scales).
- Document base (control methods and management experiences, scientific articles, reports, examples of informative campaigns and key information messages).
- Description of the normative and competence context.
- Contact directory (experts, those responsible for the management, etc.).
- Thematic distribution list (it allows group members to communicate through a single e-mail address they have registered with).
- GIS with detection points of the species associated with an observation/monitoring system.
- Regular e-bulletin to be distributed among the members of the network.
- FAQs: system to display frequently asked questions and answers.
- Virtual board/directory (it allows sending and publishing information which is visible for all, such as calls for voluntary activities).
- Surveys and questionnaires (they allow to obtain information or opinions from users' participation).
- Selected links to sites of interest which can be accessed from the portal.
- Videoconferences/webinars: (they facilitate 'virtual meetings', training activities, etc.).
- Intranet for internal communication.

The tools available for building networks are many and of different types. Beyond the virtual dimension, it would be advisable to promote initiatives and/or specific working groups under the framework of networks such as Udalsarea 21, or similar activities open to the participation of the largest possible number of sectors and involved actors.

3. Research

To have a greater chance of success with managing *Baccharis halimifolia,* it is necessary to structure and plan interventions based on the best scientific information. A better understanding of the ecology of the species may help identify more effective methods of control. On the other hand, management's operations themselves have an impact on the environment, which must be evaluated to achieve full recovery of the affected habitats. Including the participation of researchers from the beginning of the project could enhance the quality of monitoring, with a positive impact on the effectiveness of the management project.

Below, there is a proposal to implement some research topics that can bring new perspectives to the management of Baccharis:

- Studies on spatial distribution of the species within the affected habitats.
- Studies on physiological tolerance.
- Studies and trials on the use of glyphosate to determine the minimum dose and better assess its effectiveness and its potential negative effects on the environment and the species that inhabit it.
- Studies on restoration of the affected areas.

4. Proposed dissemination messages about the problem

Effective dissemination programmes can help educate the public about the need to address the problem and ensure support and funding from government agencies. To achieve this, we suggest condensing and transmitting information through a set of **key messages** that will be developed taking into account the type of target audience and the most appropriate channel to be used to send them. Some examples are shown below:

Example 1.

- Aspect to disseminate: The *B. halimifolia* management programme favours native biodiversity.
- Message nature: informative.
- Communication type: external general.
- Programme phase: initial.
- Message: The Basque Government is working on the recovery of several wetlands in partnership with the European Life Programme [61].
- Target audience: General public.
- Activity example: Press release on the project launching.

Example 2.

- Aspect to disseminate: Need to manage *B. halimifolia*.
- Message nature: informative.
- Communication type: external general and external direct.
- Programme phase: initial.
- Message: The threat: invasion of *B. halimifolia*.
- Target audience: Decision makers from the Administration, nursery managers, gardeners, etc., and the general public.
- Activity example: Dossier, leaflets, information on the web, etc.

Example 3.

- Aspect to disseminate: Shared management of *B. halimifolia* is key for success.
- Message nature: focused on action.
- Communication type: external and internal direct.
- Programme phase: initial.
- Message: Making a difference: together for the environment.
- Target audience: Decision makers from the Administration (all levels), project technicians, researchers.
- Activity example: Organisation of forums, training seminars, web portal, distribution lists, webinars, etc.

Example 4.

- Aspect to disseminate: Management programme's achievements.
- Message nature: informative.
- Communication type: external general (message 1), external direct (message 2).
- Programme phase: intermediate.
- Message 1: Invasive plant *B. halimifolia* under control at the Urdaibai reserve [62].
- Target audience: General public.
- Activity example: Press release summarising the programme's main achievements. Information on the programme web.
- Message 2: LIFE+ Project and estuaries in the Basque Country: control and elimination of *B. halimifolia* in Urdaibai.
- Target audience: Researchers, technicians.
- Activity example: Scientific communications in conferences and seminars.

Example 5.

- Aspect to disseminate: Participation of the community is necessary for the observation task.
- Message nature: focused on action.
- Communication type: external direct.
- Programme phase: all.
- Message: Stop the invasion! Join the observation network.
- Target audience: Nursery, researchers, other groups carrying out activities in the natural environment.
- Activity example: Creation of a data transmission-reception system on the web. Dissemination through the web, mailing lists, leaflets, direct contact with target groups.

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