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MANAGEMENT GUIDE

OF MEDITERRANEAN COASTAL HABITATS AND RELATED SPECIES

European LIFE Habitats Calanques project

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TABLE OF CONTENTS

Foreword	6
■ Context and goals	7
Description of the territory	8
Habitats and species	14
Identified threats	20
The LIFE Habitats Calanques project	24
■ Channelling visitors through trail management	29
Issues and objectives	30
Preliminary studies	31
Conservation management	42
Monitoring and assessment	50
LIFE project feedback	55
■ Management of invasive alien plant species	59
Issues and objectives	60
Preliminary studies	62
Conservation management	71
Monitoring	83
LIFE project feedback	85
■ Reinforcement of awl-leaved plantain populations	89
General issues and objectives	90
Preliminary studies	91
Conservation management	92
Monitoring and assessment	97
LIFE project feedback	99
■ Reinforcement and (re)introduction of goat's thorn milkvetch populations	103
General issues and objectives	103
Preliminary scientific studies	106
Conservation management	114
Monitoring	126
LIFE project feedback	127
■ Communication and awareness	131
Issues and objectives	132
Preliminary studies: development of the communications strategy	132
Conservation management	134
LIFE project feedback	155
■ Assessment	161
Context and goals	162
Assessment of the socio-economic impact of the actions undertaken	162
Assessment of ecosystem services	168
■ Bibliography	173
■ Acknowledgements	181



FOREWORD

An atypical territory, stakeholders, users, the desire to focus energies and skills to innovate and take action together, a fine human and institutional adventure...

Benefitting from a diversity of exceptional natural and cultural heritage, its inhabitants, users, decision-makers and history, Calanques National Park has since its creation been confronted with the extreme pressure placed on the unique biodiversity that it is home to.

In the early 2000s, scientists were alerted to the degradation of the coastal habitats around Marseille. The survival of the populations of certain plants became a cause of serious concern, especially for the three emblematic plant species of the phrygana: the goat's thorn milkvetch, the *Thymelaea tartonraira* and the awl-leaved plantain. The urbanisation of the surrounding environment and, to a lesser extent, excessive tourism and recreational activities, are major causes of the destruction of the coastal habitats and the fragmentation of plant populations.

Since then, many scientific studies have been carried out to characterise these coastal habitats, their plant species, their ecological interdependence and the socio-ecological challenges thanks to, on one hand, the collaborations of the researchers of Aix-Marseille Université (Institut Méditerranéen de Biodiversité et d'Écologie), covering ecology in the broad sense of the term, and, on the other hand, to the financial support of several national or local research programmes (the French Ministry of Ecology, Agence Nationale de la Recherche, the Aix-Marseille Université Initiative of Excellence, Région Sud).

At the same time, constant partnerships with the co-management of coastal natural areas, the GIP Calanques, and the Calanques National Park since 2012, have worked hand-in-hand to effectively develop these studies in order to understand and preserve these remarkable Mediterranean coastal habitats. It was necessary to wait until the launch of the European LIFE Habitats Calanques project to envisage true operations for conservation, restoration and awareness-raising to meet the urgency of the situation and its challenges.

Indeed, the scope of this project accumulates all the constraints related to natural (arid climate, sea spray, heavy rainfall, etc.) and anthropogenic pressures: extreme frequentation by hikers or city dwellers for whom the passage from an urbanised space to an extremely sensitive and protected natural area is not well marked. Thus, there are many threats: off-trail wandering, pollution, and the use of motor vehicles leading to the extreme long-term degradation of sensitive species and areas.

A team of partners was thus formed under the initiative of the National Park and coordinated by the Agence Régionale pour la Biodiversité et l'Environnement, with the significant involvement of the Conservatoire Botanique National Méditerranéen, Naturoscope, the City of Marseille, the Bouches-du-Rhône Departmental Council and Aix-Marseille Université.

An unprecedented plan of action was created and concrete proposals for action were made to the European Commission, which were strongly supported by the French Ministry of Ecological Transition and Territorial Cohesion as well as Région Sud and in close relations with the owners, local associations and economic stakeholders.

Reinforcements of the protected local plant populations, the promotion of local plants, the management of invasive alien plant species, the protection of biodiversity through the development of trails, the regulation of pedestrian and motor traffic, communication, and the participation of all concerned are a few of the actions of this major task that was conducted for the first time within a network, in a relationship of trust and in a coordinated manner. These driving forces of institutional partners, scientists and associations, all united around a common goal, have enabled the implementation of concrete actions to preserve the exceptional biodiversity of this territory while allowing users to discover these environments with respect.

The results and benefits in terms of conservation management are presented in this guide.

CONTEXT AND GOALS

- Description of the territory
- Habitats and species
- Identified threats
- The LIFE Habitats Calanques project

DESCRIPTION OF THE TERRITORY

■ Perimeter of the project

The perimeter of the LIFE project covers a surface area of 105 hectares in the south-east of France, on the territory of the municipalities of Marseille and La Ciotat, in the Bouches-du-Rhône department in the region of Provence-Alpes-Côte d'Azur.



MAP OF THE NATURA 2000 SITE AND THE AREA OF THE LIFE "HABITATS CALANQUES" PROJECT



Key :

- HABITAT DIRECTIVE - FR9301602
- LIFE STUDY ZONES

CALANQUES NATIONAL PARK:

- Terrestrial core area
- Adherence area
- Marine core area
- Adjacent maritime area

Perimeter of the LIFE Habitats Calanques project (in red), within the "Calanques et îles Marseillaises - Cap Canaille et Massif du Grand Caunet" Natura 2000 site and in the terrestrial core area of the Parc National des Calanques © PNCAL, 2017

The perimeter is divided into four distinct entities:

- › Bordered by the city of Marseille, the western part includes the Marseillevyre coastal massif (from Mont Rose to Calanque de Podestat) and the coast of the Mont Puget massif (Morgiou, Sugiton, Pierres Tombées). These massifs are the most southerly limestone ridges in the metropolitan territory. They form a main gateway from the city to the natural area and are served by public transport. A road (route des Goudes) crosses the most westerly sector that leads to Callelongue, the starting point for a Grande Randonnée (GR) hiking trail. It offers gentle slopes and easy access to the sea, which generates heavy peri-urban visitor traffic.
- › The insular sector englobes two archipelagos: (i) the Frioul archipelago, which consists of two rather flat main islands that are accessible to the local population from the port of Marseille and (ii), further offshore, the Riou archipelago, the three main islands of which have a rugged relief. This archipelago has been preserved from visitor traffic since 2003 by the regulations of the former National Nature Reserve before it was incorporated into Calanques National Park.
- › The eastern part, consisting of the Gardiole massif and the Cap Canaille coastal massif, is essentially marked by an abrupt relief. It groups the deep limestone calanques of En Vau, Port-Pin and Port-Miou and those on the siliceous puddingstones of Sainte Fréouse, Figuerolles and Bec de l'Aigle.
- › The Anjarre sandpit is the only site of the project that is not in a coastal location. This sandpit is a continental incursion that is highly unusual due to the presence of marine sand in which marine fossils are still to be found. This marine sand has been driven onto the Marseillevyre massif by the Mistral. A coastal primary garrigue with rosemary (1240-3) has developed on this substrate, where coastal plant species, most of which are protected, have developed (e.g. goat's thorn milkvetch, *Thymelaea tartonraira* and *Helianthemum syriacum*). This exceptional site is bordered by housing and many non-organised peri-urban activities occur there.

■ Environment

Climate

Situated in a very southerly location, the perimeter of the project lies within the temperate Mediterranean bioclimatic stage. The territory is situated in the most arid climatic area of the department, with very low annual precipitation (< 600 mm of water). Periods of summer drought last from June to September, i.e. an average of four months, during which the mean accumulated precipitation is barely 60 to 80 mm of water. This summer drought is accompanied by a period of winter drought. Climate change tends to prolong both periods. The western part and the archipelagos are subject to a significant hydric deficit (330 mm/year in Frioul). A mean precipitation of 360 mm/year has been recorded for Cap Croisette, which is comparable to the rainfall in the regions bordering the Sahara in Algeria.

The mean annual temperature is 14.5 °C, but it can vary from 12 to 15 °C in places, depending on altitude and exposure. The mean monthly temperatures reveal a relatively mild winter, with a minimum in January, and a very hot summer.

The dominant winds are:

- ›› the Mistral (northerly – north-westerly), it accentuates winter cold and increases plant evapo transpiration in summer ;
- ›› warm and humid easterly and south-easterly winds, the origin of most precipitation.

The islands of the archipelagos are buffeted daily by land and sea breezes. The mean annual sunshine in Marseille is 175 sunny days. Nevertheless, clouds are quite frequent on the Calanques massif, especially along the southern coast, where they compensate the drying effects of the Mistral on vegetation.

Biodiversity

The Mediterranean basin is recognised worldwide as a reservoir of biodiversity, notably due to the importance of the species present with respect to its size: 0.8% of the total area of the world's oceans and seas for 7% of the world's known species, including 13,000 endemic species. Similarly, although the Mediterranean basin only represents 1.6% of the land area, it alone accounts for 10% of the world's plant biodiversity. This incredible wealth makes it one of the planet's 25 biodiversity "hotspots" (Myers, 2000), i.e. a place that concentrates both a very large number of rare species and strong anthropogenic pressure on its ecosystems.

Of the more than 900 species identified within the National Park, 38 are protected and 43 are recognised as remarkable. There are also around one hundred protected terrestrial animal species within Calanques National Park.

Geodiversity

The geological history, in close relation to the sea, has led to the construction of a landscape marked by large white limestone ridges or reddish-orange sedimentary rock, plateaus bordered by abrupt cliffs and deeply incised by terrestrial valleys: the calanques. The site is rich in geological elements relating to tectonics (the Sugiton flexure), sedimentology (Soubeyranes cliffs), geomorphology and tectonics (calanques), palaeontology and hydrogeology (Port-Miou). Descriptive data sheets have been made for these sites within the framework of the inventory of the regional geological heritage of Provence-Alpes-Côte d'Azur. The Cap Canaille site is of great palaeogeographical interest. The erosion of the puddingstone is spectacular, with two remarkable types of formation: the "parpelles", in which the most resistant layers are in strong relief, and the "taffoni", large shelters excavated in the cliff under overhanging rock.

Soils

An important particularity of the coast, which very largely consists of limestone substrates, is extremely low soil regeneration. The capacity of limestone substrates to produce soil can be assessed by a simple calculation of the dissolution of the residues contained in the rock by rainwater: in the best case, with 10% of residue in the rock, it would take 20,000 years to produce one litre of earth under current conditions. In the case of Urganian limestone, this regeneration is totally non-existent due to the absence of residue in the rock.

Insularity

The islands of Marseille are important assets that reinforce the value of the territory. They shelter a wealth of flora and fauna whose conservation presents a real challenge both on the local level as well as on the national and European levels. Indeed, insularity combined with the most exposed natural conditions of the Provençal coast (Riou is 3 km from the continent) have contributed to the differentiation of species.

The vegetation of the Marseille archipelagos is low-lying, halophilic or halo-resistant. The islands offer a mosaic of habitats, alternating *Limonium* rock, bare maritime cliffs, lentisk shrublands and matorral, coastal meadows, phrygana and ruderal zones. The rare trees, including Aleppo pine, oleasters and fig trees, are isolated and shaped by the wind. The ornithological interest of these islands is major, because they are the mating grounds of pelagic marine birds.

The common characteristic of all the islands is the fragility of their communities with respect to disturbances, also called an "insularity syndrome", due to the formation of simple trophic networks and the absence of certain groups responsible for an incomplete structure. Moreover, islands often possess a high number of endemic species that are exceptional for world biodiversity, the result of low flows of individuals and their genetic isolation. They thus play a fundamental role as a refuge for flora and fauna.



Riou archipelago, seen from the continent

■ Protection status

Calanques National Park

The entire perimeter of the LIFE project is located within the terrestrial core area of the National Park. This latter was created by decree on 18 April 2012. In the heart of the Aix-Marseille-Provence metropolitan area, it is both terrestrial and marine: it is the only peri-urban national park in Europe and the only one in the Mediterranean to be both terrestrial (continental and insular) and marine.

The territory of Calanques National Park consists of three large areas that benefit from differentiated statutes of protection and management :

- › **the "core area"**: 8500 hectares on land, distributed over 3 municipalities (Marseille, Cassis and La Ciotat) and 43,500 hectares at sea, where special National Park regulations apply in order to ensure the reinforced protection of natural heritage ;
- › **the "adherence area"**: 2630 hectares on land, distributed between 3 municipalities (Marseille, Cassis and La Penne-sur-Huveaune), it forms the territory, in ecological solidarity and geographic continuity with the core area, where the municipalities voluntarily commit themselves to promoting sustainable development with the support of the National Park. The rules of environmental protection are those of common law ;
- › **the "adjacent maritime area"**: 97,800 ha at sea; it is also the transitional area where the Park does not regulate activities but supports its partners for the reduction of pollution and a coherent organisation of usages.

Calanques National Park is a project for a shared territory, materialised by the National Park Charter that details the objectives to meet by 2027. Under the supervision of the French Ministry of Ecological Transition and Territorial Cohesion, the public establishment of Calanques National Park steers the principles of this charter and implements it with the local communities by associating the stakeholders : local populations, professionals, users, associations, etc.

The main missions of the National Park are to :

- › protect the natural, landscape and cultural heritage ;
- › contribute to knowledge, to meet the major challenges facing the Mediterranean ;
- › host the public and transfer knowledge ;
- › control activities and ensure regulations are respected ;
- › contribute to sustainable development and the recognition of the territory.

Natura 2000

The perimeter of the LIFE project also lies within the Natura 2000 sites of "FR 9301602 - Calanques et îles Marseillaises - Cap Canaille et Massif du Grand Caunet" (Special Conservation Area) and "FR 9312007 - îles Marseillaises - Cassidaigne" (Special Protection Area).

This Natura 2000 site includes continental, insular and marine natural environments and was initially divided into 3 sectors: the "Frioul archipelago" sector, the "Cap Canaille and Grand Caunet" sector and the "Calanques and Riou archipelago" sector. The entire site covers 14,215 hectares, distributed over 10,288 ha of continental land, 333 ha of insular land (Riou and Frioul archipelagos and Île Verte) and 3593 ha at sea, i.e. around 1/4 at sea and 3/4 on the continent.

The LIFE project thus comes within the scope of a pre-existing territorial project, the National Park Charter, and includes natural areas subject to specific regulations.

Usages

Many different usages are observed within the perimeter of the LIFE project and mainly concern recreational activities: sunbathing, walking, hiking, climbing, potholing, kayaking, trail biking, paragliding, access to the shore for marine activities (shore fishing, bathing, snorkelling, etc.).

Visitor traffic to Calanques National Park is estimated between 1.5 to 2 million visitors per year, taking into account the passengers of transport shuttles and pleasure boats and the users who come for various recreational activities and sports or who go to the beach. A quantitative study of terrestrial activities, conducted on the western part of the Calanques (Mont Rose, Cap Croisette, Callelongue, Marseilleveyre), shows that 60% of users live near the calanques and that Mont Rose is the most visited site (Le Mire-Pecheux, 2013). The main activities are sunbathing, bathing and walking. In Callelongue, 39% come for hiking. Shore fishing is among the nocturnal activities. For the coast as a whole, walking and climbing are the main activities, while other activities such as cycling, potholing, paragliding and horse-riding remain marginal.

The Frioul archipelago is essentially frequented by visitors from the Marseille urban area, which is characteristic of the peri-urban location of this territory. According to a study conducted in 2000, annual visitor traffic was between 400,000 and 600,000 visitors per year, including recreational boating around Frioul. Concerning terrestrial frequentation in the strict sense, up to 2500 persons may arrive by shuttle on days of heavy traffic, in addition to the pleasure boaters who land on the shore. Up to 1600 persons may be present simultaneously in the natural area and 1200 persons on the shore.



Diversity of coastal usage, here in Port-Miou

HABITATS AND SPECIES

■ Targeted habitats of Community interest

The coastal habitats of the project area possess an exceptional heritage due to their specific floristic wealth, the original character of the floristic composition of some of these formations, and the presence of a very high number of remarkable species.

The perimeter of the project groups vegetation from the "semi-arid" bioclimatic zone adapted to supralittoral conditions that combine drought due to very low precipitation and associated with high temperatures (xerophilic vegetation), salinity due to strong exposure to sea spray (halo-resistant vegetation), violent winds whose desiccating effect is accompanied by an erosive action on the soil and rock (wind-shaped vegetation), and skeletal soils. The habitats that concentrate the most protected species and the greatest biodiversity are located on the coast. Whilst the vegetation of the Calanques is calcicolous, that of Cap Canaille is silicicolous following the incursion of siliceous puddingstone. Moreover, the bioclimatic position of Cap Canaille enables the installation of species from the thermo-Mediterranean zone, such as the fan palm, oleaster, carob tree and myrtle, which is at the limit of the western area.

A salinity gradient, which is geographically translated into distance from the coast, structures the coastal plant communities from the *Limonium* coastal rocks to the inland pine groves. The areas mentioned for each habitat presented below are those comprised within the project area. LIFE Habitats Calanques intervenes in 7 terrestrial habitats of Community interest, i.e. 38% of the total area of coastal habitats with Community interest of the Natura 2000 site.



Coastal pine forest - Pierres Tombées

The Aleppo pine forest [9540-3.1; 29.3 ha = 28% of the area] (Mont Rose, Marseillevyre, Morgiou, Sugiton, En Vau, Port-Pin) corresponds to a thermophilic population installed on the coastal slopes with southern exposure on skeletal soil. The trees, which are often much older than their size would seem to indicate (over 180 years old), are wind-shaped and grow under extreme pedological conditions, infiltrating their roots into the numerous fissures of karstic formations. These "rock-clinging" pines are an emblematic element of the Provençal limestone coast.

Endemic *Limonium* spp. coastal rocks [1240-1 and 1240-2; 22 ha = 22.2% of the LIFE perimeter. This habitat is present along the entire shoreline. On essentially limestone (rocky cracks and micro-ledges) or siliceous mineral substrates, it develops on the lower part of rocks and limestone cliffs. It is subjected to sea spray and extreme drought. Consisting of halophytic herbaceous species, the vegetation is dominated by *Crithmum maritimum* and *Limonium pseudominutum* (national protection, LC-IUCN FR). Concerning the archipelagos, the phytosociological status of certain plant formations has never been described due to original micro-local conditions. The floristic compositions are highly original and contribute to the local heritage value.



Limonium rocks - *Crithmum maritimum* and *Limonium pseudominutum*

The coastal primary garrigue with rosemary [1240-3; 14 ha = 13.8% of the zone] constitutes a transitional zone between the phrygana and continental garrigues. Located in the zone of maximum wind and sea spray influence, it develops on dry, very superficial soil that is generally rather stony or sandy and very poor in organic material. Perennial species, such as rosemary, which are often wind-shaped near the sea, or the lentisk under more favourable conditions, ensure essential ecological functions such as the maintenance of the soil.



Coastal garrigue – Cap Croisette

The **phrygana** [5410-1; 9.6 ha = 9.2% of the zone] is unquestionably the most endangered habitat due to its gradual disappearance.

The plant formations of the coastal phrygana correspond to the phytosociological association of *Astragalus tragacanthae-Plantaginetum subulatae* Molin. 1934 (Noble & Baret, 2019). This characterisation is still in effect according to the "Habitat" Directive of the European Union and falls under habitat type 5410: "West Mediterranean clifftop phryganas" (Davies et al., 2004; European Commission, 2013) to which belong various rare and protected plants including *Astragalus tragacantha* L. (Fabaceae), *Thymelaea tartonraira* (L.) All. subsp. *tartonraira* (Thymelaeaceae), *Plantago subulata* L. (Plantaginaceae), *Limonium pseudominutum* (Plumbaginaceae), *Senecio leucanthemifolius* subsp. *crassifolius* (Asteraceae), *Silene sedoides* (Caryophyllaceae), *Helianthemum syriacum* (Cistaceae), *Sedum litoreum* (Crassulaceae), *Anthemis secundiramea* (Asteraceae), *Teucrium polium* subsp. *purpurascens* (Lamiaceae), which highlights the importance of this habitat on the peri-Marseille coast and notably in Calanques National Park.

PROTECTION STATUS AND RATINGS OF STRUCTURAL SPECIES OF THE PHRYGANA

Main indicative species of the habitat	Protection status	Red list assessment France (IUCN, 2019)	Red list assessment Provence-Alpes-Côte d'Azur (Noble et al., 2015)
<i>Astragalus tragacantha</i>	National	EN	EN
<i>Plantago subulata</i>	Regional	LC	LC
<i>Teucrium polium</i> subsp. <i>purpurascens</i>	Regional	VU	VU
<i>Thymelaea tartonraira</i> subsp. <i>tartonraira</i>	National	NT	EN

It is a naturally limited habitat. In the project area, it is confined on the continent to a narrow coastal strip of less than 100 m in width and spreads over nearly 10 km of shoreline (between Mont Rose and Podestat) and is sparsely distributed throughout the Marseille archipelagos. The three structural plant species of the phrygana, *Astragalus tragacantha*, *Thymelaea tartonraira* subsp. *tartonraira* and *Plantago subulata*, possess optimal ecological niches that are slightly different but which globally occupy an intermediate position on the salinity gradient between the halophilic species zone and the garrigue zone.



Phrygana – Mont Rose

Coastal cliffs [8220-19; 7 ha = 6.6% of the zone] (Soubeyranes). As refuge areas, they are sites of major interest for the reproduction of sedentary rupestrian birds, for the food supply of wintering migrating birds consisting of rare mountain-dwelling species, and for the transit of bats. Numerous protected plant species, rare for France or relictual on the scale of their species range, are localised in these wild coastal cliffs, on the cliff face, at the foot, or on ledges. The structural species of these environments has not been determined.

Rocky slopes [8210-1; 6 ha = 5.8% of the zone] (Callelongue, Port-Pin) essentially with southern exposure, on average slopes in the study zone with narrow, shallow fissures. This environment is characterised by a mosaic of rocky environments and stripped garrigue, which makes this habitat highly permeable to visitor traffic.

The coastal meadow [6220-2 (priority); 2.3 ha = 2.2% of the zone] is very rare on the site. It presents an exceptional floristic cortège with numerous annual species and remarkable bulb plants, at least five of which are rare and protected: *Anthemis secundiramea*, *Allium chamaemoly*, *Hedysarum spinosissimum* subsp. *spinosissimum*, *Myosotis pusilla* and *Teucrium pollium* subsp. *purpurascens*. This is recognised as a priority habitat for Europe. The structural species are *Brachypodium retusum* and *Brachypodium distachyon*.

Limestone scree slopes [8130] are not very present (0.7 ha) in the project zone. It is the main habitat of *Arenaria provincialis*.



Coastal cliffs – Calanques of Cassis and Cap Canaille

■ Conservation status

On the European scale considered with a 10 x 10 km² grid, France is the only country whose 1240 - "Coastal rocks with Limonium" habitat has an unfavourable general assessment, although it is 3rd in surface area (37.5 km²) after Greece and Italy and contributes to 9.6% of the surface area of this habitat of Community interest in Europe. France is also the only country whose 5410 - "Phrygana" habitat has an unfavourable conservation status in its general assessment even though it contributes to 18.7% of the presence of this habitat (19.3 km²). Along with Italy, they currently share an unfavourable conservation status. The management actions of the LIFE project contribute to the improvement of the conservation status of these habitats.

Thus, the phrygana is the key habitat of the project, just as it is that of Calanques National Park, given that it is almost exclusively localised on this site (88% of presence) in France. This habitat presents a rather unequal conservation status within this territory. It is in rather good condition in the Frioul archipelago but is quite clearly degraded on the western continental coast of the Calanques.

■ Main structural species of the phrygana

➤ GOAT'S THORN MILKVETCH

The goat's thorn milkvetch (*Astragalus tragacantha* L., 1753), the only thorny vetch of the Mediterranean coast, is a perennial plant that belongs to the Tragacantha DC section of the Fabaceae family. This line originated in the Near East, probably during the Pliocene (5.3 to 2.6 million years before the present), and diversified during the Pleistocene (2.6 million years before the present) after a large expansion through the Mediterranean regions followed by geographical isolation in coastal and mountain habitats (Hardion et al., 2010; Hardion et al., 2016). The distribution of the goat's thorn milkvetch, a western steno-Mediterranean species, is highly fragmented on the capes and islands of south-eastern France, north-eastern Spain and south-western Portugal (Valsecchi, 1994). In France, it is only known in the Bouches-du-Rhône and Var departments. It appears in the form of a cushion-shaped shrub that is densely branched with leaves divided into 12 to 24 pubescent folioles and thorns originating from petioles that are lignified after the fall of the folioles. The flowers are white and hermaphroditic and appear in February to early May. Fructification takes place in June to August and the fruit (pods) contain 1 to 12 seeds.



Goat's thorn milkvetch in bloom

> **AWL-LEAVED PLANTAIN**

The awl-leaved plantain (*Plantago subulata* L., 1753) is a perennial plant of the Plantaginaceae family. In the strict sense, according to the conception of the genus by the French Mediterranean flora (Tison et al., 2014), it is only observed on the north-western shores of the Mediterranean Sea (France, Spain, Italy). In France, it is only observed in the departments of Pyrénées Orientales, Bouches-du-Rhône and Var; a single very ancient observation made in the Alpes-Maritimes (Ardoino, 1879) has never been repeated. The awl-leaved plantain has narrow needle-shaped leaves (1-2.5 mm wide), with small hermaphroditic yellow flowers compacted on cylindrical ears. It flowers from May to the end of June and the fruit (bilocular capsules) develop in July and August.



Awl-leaved plantain in bloom

> **THYMELAEA TARTONRAIRA**

The *Thymelaea tartonraira*, a member of the Thymelaeaceae family, is a steno-Mediterranean species that is found in France, Spain, Sardinia, Sicily, Greece and North Africa (Danton and Baffray, 1995). It is a woolly shrub with slightly thick, largely obovate or oblong sessile leaves covered with hairs. It flowers from December to May. The yellow flowers are small and inserted among the leaves in the upper part of the branches. The ovoid fruit remains closed in a persistent perianth. It grows on rocks and rock beds or dry sandy soil, most frequently near the coast but it may reach an altitude of 1000 m.



Thymelaea tartonraira

IDENTIFIED THREATS

Mediterranean coastal habitats are naturally constrained by extreme climatic factors. Summer drought is a factor that limits the regeneration of plant species. Numerous young plants dry up due to a lack of water and heavy evapotranspiration that is amplified by the desiccating effects of violent winds. The seedlings that survive the first summer have a sufficiently well-developed root system to guarantee water and the persistence of the individual, but growth will be very slow. Periods of rainfall are generally short and very violent, leading to soil leaching and the erosion of the environment. These natural constraints are compounded by anthropogenic threats that have a cumulative effect. This pressure results in the fragmentation of the natural habitats, curbs the viability of the populations, and degrades the functionality of coastal ecosystems.

■ Urbanisation

The gently sloping Marseille coast has been largely destroyed by construction related to urbanisation and roads. The remaining coastal habitats that contributed to the designation of the Natura 2000 site are limited to a coastal fringe one hundred metres in width. This coastal area is thus the scene of numerous interactions with the city.



Urbanisation has caused the loss of wide expanses of natural areas as well as the fragmentation of coastal habitats. Here, the village of Goudes.



Phrygana fragmented by trampling and vehicle parking – Cap Croisette

■ Trampled vegetation

Coastal habitats on gentle slopes naturally present a weak physical barrier to pedestrian and motor traffic. Even when limited, the latter leaves traces of crushing that low, slow-growth vegetation finds difficult to repair. Repeated trampling leads to the increasing degradation of crushed individuals and, after their disappearance, to almost irremediable soil erosion.

By creating a capillary network of footpaths, wandering in the natural area creates a fragmentation of habitats: the continuous surface of the habitats diminishes and the distances between the habitat fragments increase, leading to the isolation of habitat spots and the modification of the properties of the environments that separate them. Fragmentation generally leads to a reduction in the numbers of plant and animal populations as well as to changes in their spatial distribution, which disturbs the flow of genes and threatens the functionality of coastal ecosystems.

■ Lack of user knowledge

The FHUVEL sociological surveys conducted in 2013 concerning the representation of the natural heritage by users shows that, when questioned about the Calanques, the majority of users mention that it is a privileged place for wild nature and a source of freedom and peace near the city. The fragility of the natural environments of the Calanques and archipelagos is highlighted as well as their effective or threatened degradation, but the users' knowledge of the flora and fauna is feeble or lacking. Likewise, when the cause of the threat to nature is mentioned, it tends to be attributed to other persons than oneself. There is a rupture between the "poor behaviour" of each and their consequences on nature, with little awareness of the cumulative effects related to heavy frequentation.

■ Proliferation of invasive alien plant species (IAPS)

The IAPS identified on the coast (*Opuntia* spp., *Carpobrotus* spp., *Medicago arborea*, *Agave americana*) are crassulescent or woody plants that are highly resistant to drought, wind and sea spray. Their exceptional capacity for colonisation and invasion can lead to the total covering of native vegetation. Proliferations of IAPS are observed, notably including the prickly pear (*Opuntia* sp.), in protected habitats that are already degraded by pedestrian wandering. The IAPS are generally located in peri-urban areas, having escaped from gardens or which have been planted by users who "garden" nature in an approach towards the appropriation of the natural area. We thus find patches of IAPS in locations at a certain distance from the urban fringes, probably the consequence of the dissemination of seeds, but also due to deliberate "wild" planting (e.g. in Calanque des Pierres-Tombées).



Clump of century plants (*Agave americana*) and a pigface (*Carpobrotus* spp.) carpet near a cabin in Calanque de Marseilleveyre

■ Polluted sea spray

Sea spray pollution in the Calanques is very significant due to the discharge into the sea of wastewater from the water treatment plant (STEP) of Marseille and 15 neighbouring municipalities (1 million inhabitants and numerous industrial activities). These surfactants (found in industrial or household products, including detergents) are discharged and transported via the spray from the surface of the sea to the terrestrial coastal vegetation, causing leaf necrosis that can lead to the death of individual plants.

The effects depend on exposure to prevailing winds and the nature of the foliar cuticle, the foliar surface, phenology and salinity tolerance. Certain species seem to be highly vulnerable: goat's thorn milkvetch, *Thymelaea tartonraira*, awl-leaved plantain and sea lavender, but also lentisk, Phoenician juniper and Aleppo pine.

Specific action aiming to reduce the discharge of surfactants and hydrocarbons in wastewater are already provided for in the public territorial policies in response to the National (BOE of the MEE No.2016/15 of 25 August 2016) and European (Directive 2000/60/EC) Framework Directives. Created in 1987 on the basis of a physico-chemical treatment and managed by Métropole Aix-Marseille-Provence, the STEP has since 2008 incorporated a biological treatment that has improved the treatment of wastewater, including surfactants, with a mean annual reduction of 95.7% of detergents in 2015.

■ Soil nitrophilisation and ruderalisation of insular habitats

The exponential demographic growth of the yellow-legged gull (*Larus michahellis*) nesting on the Marseille islands between 1980 and 2005 (respectively 5300 and 20,428 nesting couples) is at the origin of a disruption of the entire insular ecosystem: (i) through the trampling and uprooting of plants to build nests, and (ii) their droppings that cause an enrichment of the soil in phosphate and nitrate. These chemical changes lead to the appearance of opportunistic nitrophilic plants at the expense of the native vegetation. The main identified cause for the development of the gull population is the provision by man of abundant food resources via household waste landfills. A study conducted by the PNCAL in 2015 showed that the numbers had sharply reduced (10,340 nesting couples) with the hypothesis that this decline was due to changes in the management of waste dumps by the covering, burial and incineration of waste.

One of the major issues, included in the National Park's triennial action plan, is to define a management plan to limit the process of habitat degradation by gulls, but also the introduced populations of rabbits and rats. A study piloted by the PNCAL, complementary to the LIFE project, provides a response to this issue.



Yellow-legged gull nest in a necrosed goat's thorn milkvetch on Frioul

THE LIFE HABITATS CALANQUES PROJECT

■ The LIFE programme

Since 1992, the European Commission has supported environment and climate projects through the LIFE programme: the financial instrument for the environment. This programme aims to finance and promote innovative operations to halt the loss of biodiversity in Europe. It is updated approximately every six years by proposing a new budget and new orientations. An annual tender process launched by the European Commission enables the holders of public and private projects to apply according to the new modalities and sub-programmes proposed.

LIFE Habitats Calanques is a "Nature"-type project which is part of the "LIFE Environment" sub-programme. The aim of these projects is to conserve and improve the environmental status of natural habitats within the Natura 2000 network.

■ Objectives

The project was validated by the European Commission in May 2017 and its deployment began in July of that year. It has set goals to:

- › Restore the goat's thorn milkvetch and awl-leaved plantain populations,
- › Channel visitors by improving the trail network to reduce the impact of trampling on coastal vegetation,
- › Manage invasive alien plant species in priority sites on flat terrain or cliffs,
- › Raise awareness and share knowledge from the peri-urban areas bordering Calanques National Park up to the international level.

■ Actions

These goals can be broken down into five main types of action for a total of twenty-four: preliminary actions, conservation actions, monitoring, communication and awareness raising, and actions related to project monitoring.

A. PRELIMINARY ACTIONS

A1 - Definition of a communication strategy concerning the conservation of coastal habitats

A2 - Creation of a state-of-the-art report on knowledge and practices at the European level

A3 - Analysis of the zones and methods of intervention for actions to improve the environment

A4 - Preliminary studies for the large-scale restoration of goat's thorn milkvetch populations

A5 - Preparation of interventions on Invasive Alien Plant Species (IAPS)

C. CONSERVATION ACTIONS

C1 - Restoration of the ecological continuities of habitats through trail development in natural spaces and cuts in closed environments

C2 - Reinforcement of goat's thorn milkvetch populations and reconnection among populations with mycorrhizal seedlings

C3 - IAPS uprooting campaigns

C4 - Cultivation of local plants for the restoration of some IAPS uprooting sites

C5 - Restoration of the insular phrygana through the reinforcement of a structural species: *Plantago subulata* (Reinforcement and conservation nursery)

C6 - Strengthen surveillance, direct information, awareness-raising and control

D. MONITORING THE IMPACTS OF THE PROJECT'S ACTIONS

D1 - Assessment of the restoration and survival of the coastal habitats placed under protection

D2 - Assessment of phrygana restoration determined through the success of the restoration of *A. tragacantha* populations.

D3 - Assessment of the IAPS uprooting campaigns

D4 - Monitoring of the reinforcement operation for *Plantago subulata* populations in the insular phryganas

D5 - Assessment of the socio-economic impact of the actions undertaken in the context of the project on the local economy and population

D6 - Assessment of the impact of the project on the restoration of ecosystem services

E. PUBLIC AWARENESS-RAISING AND TRANSMISSION OF RESULTS

E1 - Awareness campaigns for the general public, institutions, local communities and school pupils

E2 - Development and sharing of support tools for the management of coastal habitats for managers, decision-makers and private individuals in France and Europe

E3 - Networking on the local, national and European

F. PROJECT MONITORING

F1 - Technical, administrative and financial management of the project, project flow chart, reporting organisation, project financial audit

F2 - Compilation of information to complete the tables of indicators provided by the European Commission

F3 - After LIFE

■ Partners involved

To treat the many problems described above in a concerted fashion, ten territorial stakeholders have proposed to develop a European LIFE project to preserve the most threatened coastal habitats of Community interest in the Calanques: LIFE Habitats Calanques.

Accompanied by over twenty supporting partners, these players have defined a precise organisation for the good coordination and conduct of the project. LIFE Habitats Calanques benefits from 7 associated beneficiaries who are specifically responsible for the implementation of the 24 actions of the project.

The Agence Régionale pour la Biodiversité et l'Environnement Provence-Alpes-Côte d'Azur (ARBE) is the project coordinator and is responsible for actions of communication. It is the guarantor of the sound management of the project to the European Commission.

Calanques National Park (PNCAL) is the land manager of the Conservatoire du Littoral. It is responsible for surveillance, trail development and invasive alien plant uprooting operations. Through its knowledge of the territory, the establishment has provided technical, logistics and consultancy support for all actions undertaken.

The Bouches-du-Rhône Departmental Council (CD13) provides technical assistance for management operations, notably for trail redevelopment and uprooting.

The Conservatoire Botanique National Méditerranéen (CBNMed) is responsible for the restoration of awl-leaved plantain populations, and is in charge of monitoring the species, trail redevelopment work and post-uprooting vegetation. It is the referent for invasive alien plant species.

The City of Marseille (VDM) is responsible for the cultivation of goat's thorn milkvetch and local plants. It provides technical assistance in particular for communication and uprooting operations.

Aix-Marseille Université (AMU) is in charge of preliminary studies concerning trail redevelopment, the restoration of goat's thorn milkvetch populations and the monitoring of plant communities and populations.

Naturoscope is responsible for public awareness operations, in particular for school pupils.

The European Commission, the Direction Régionale de l'Environnement, de l'Aménagement et du Logement Provence-Alpes-Côte d'Azur, and Région Sud are the co-funders of the LIFE Habitats Calanques project.



■ Global budget and financing

The provisional global budget for the LIFE project has been estimated at €3,862,925 with distribution depending on the actions undertaken.

PROJECT ACTIONS	EUROS	%
Channel visitors by improving the trail network to reduce the impact of trampling on coastal vegetation	€1,337,824	34.6
Raise awareness and share knowledge from the peri-urban areas bordering Calanques National Park up to the international level	€803,529	20.8
Project management	€628,64	16.3
Manage invasive alien plant species in priority sites on flat terrain or cliffs	€516,829	13.4
Restore the goat's thorn milkvetch and awl-leaved plantain populations	€405,342	10.5
State-of-the-art reports and assessments of Ecosystem Services, Perceptions, Sustainable Development and Socio-economic Objectives.	€107,336	2.8
Training	€107,336	1.6

The principal co-funders have financed 71% of the budget, whilst the associated beneficiaries have contributed to 29% of the expenditure. These figures must nevertheless be put into perspective with the real budget, which is being prepared at the time of writing this guide.

CO-FUNDERS	EUROS	%
European Commission	€2,317,755	60
DREAL Provence-Alpes-Côte d'Azur	€300,000	8
Région Sud	€100,000	3

CONTRIBUTION OF ASSOCIATED BENEFICIARIES	EUROS	%
ARBE	€158,719	4
PNCAL	€402,793	10
CBNMed	€32,851	1
VDM	€159,802	4
AMU	€60,629	2
Naturoscope	€16,687	0
CD13	€313,689	8
TOTAL	€3,862,925	100 %

CHANNELLING VISITORS THROUGH TRAIL MANAGEMENT

- Issues and objectives
- Preliminary studies
- Conservation management
- Monitoring and assessment
- LIFE project feedback

ISSUES AND OBJECTIVES

■ Context

Hiking activity has been constantly increasing since the 1970s (Leonard, 2006). The profile of hikers has changed, going from an autonomous population of developer hikers, creators of an activity and its supports (trail creation and blazing) to a population of consumers of pre-equipped trails and associated products and services (hiking guidebooks, guides, etc.). This activity satisfies the motivations related to the exercise of a physical and sports activity (health, physical fitness, conviviality), but also fulfils the need for contact with nature (Lefevre & Thierry, 2011). Contrary to other nature-based sports and recreational activities, it is also accessible to everybody (low-cost activity, variable difficulty according to the chosen itineraries, etc.) (Lefevre, 2000).

Although hiking is confirmed as the preferred mode of discovery of the territory by Calanques National Park, the wandering of visitors in the natural environment can, in certain contexts, have a non-negligible impact on the landscapes, flora and fauna (trampling, disturbance, destruction of habitats, pollution, etc.) and the functioning of ecosystems (soil settlement, erosion) as detailed in the introduction (see "identified threats"). In terms of regulations, off-trail hiking is prohibited in the Frioul archipelago (municipal byelaw No. 2021_00418_VDM); it has continued to be tolerated until the present in the zones of the terrestrial core area that are accessible to the public. Visitors are nevertheless strongly encouraged to remain on the trails through the installations, signage and the awareness messages of park agents. Since 2021, environmental inspectors are also authorised to issue fines to those persons who circulate in explicitly protected areas.

Wandering is generated by different factors that depend on the profile of the person concerned. It may be related to a lack of trail readability, inconvenience, or to the fact that it does not meet users' expectations in terms of layout or destination. A continuously adjusted equilibrium must be found by the managers of natural areas to meet the public's desire for nature while guaranteeing the preservation of the environments and landscapes. Indeed, the trails must open the gates to the territory to those who use them. They thus participate in the determination of the relations that are established between this territory and its users. The trails also help to solve the paradox that faces national parks, i.e. to make nature and its heritage accessible to the public while guaranteeing their preservation against direct and indirect degradation related to human presence.

■ Objectives

The unsuitability of the existing trails to the different types of users leads to the creation of a capillary network of footpaths that criss-cross and fragment the environment. The restoration of the ecological continuities of fragmented coastal habitats thus requires the development of the existing trails of the Calanques coast in order to channel visitor traffic along attractive and well-developed trails, and thus avoid dispersion throughout the natural area. The improvement of the quality of trails is not an end in itself, but a means to preserve coastal habitats.

It is not necessarily a question of constraining users to remain on the trails, but to incite most of them to do so through appropriate development. In certain particularly sensitive areas, access must nevertheless be strictly restrained in order to regenerate the environment.

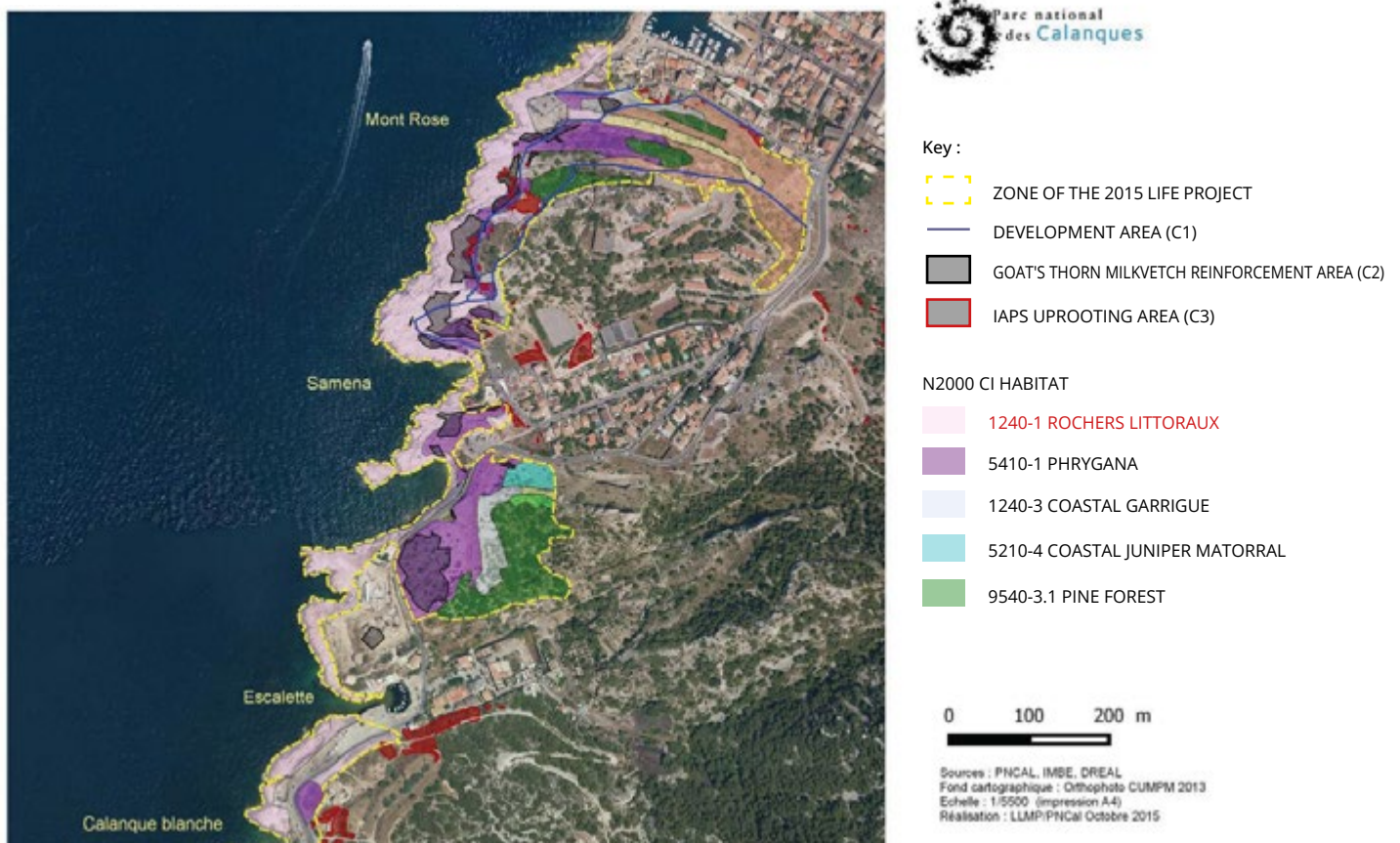
PRELIMINARY STUDIES

Trail development was preceded by an extensive phase of diagnosis and study that began in 2015 during the drafting of the initial proposal. This pre-diagnosis will later be completed and deployed on the launch of the project through the intervention of a diversity of players and a range of methods that enable the co-construction of practical modes of development. The goal of this phase of work is to refine the localisation of the sites to be developed and to define the broad principles of development.

■ Pre-identification of degraded sites

A pre-identification of the sites was established in the context of the initial request (Grant Agreement). The general principles of site selection are the ecological issues, the level of anthropogenic pressure that generates degradation, as well as landscape issues. This pre-selection is mainly based on the mapping and estimation of the state of conservation of the habitats of Community interest.

PRE-IDENTIFIED AREAS OF INTERVENTION MONT ROSE-ESCALETTE (POINTS 3 AND 4)



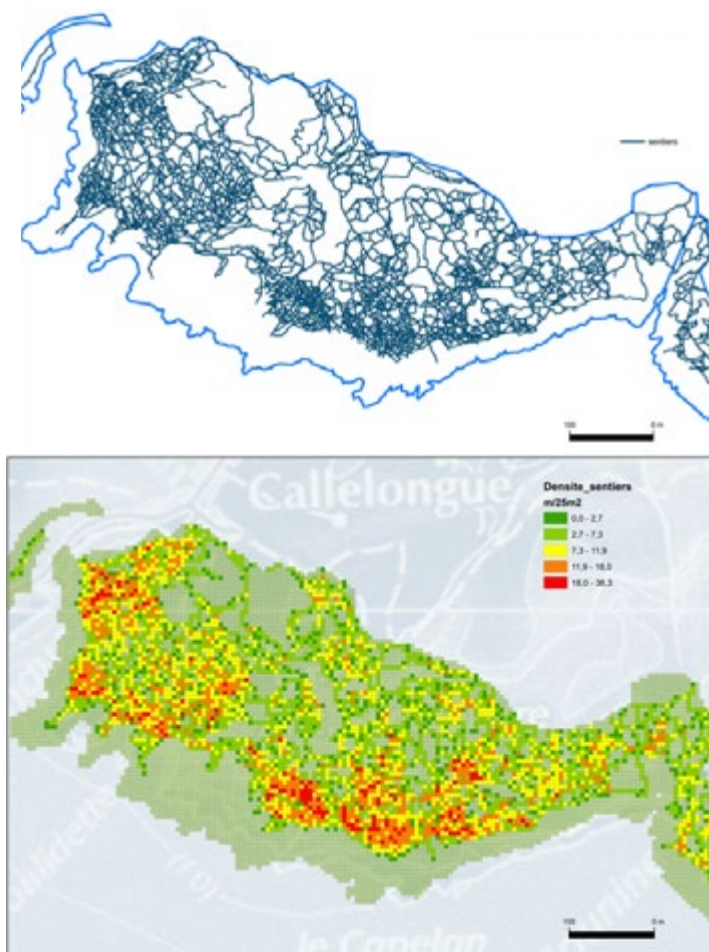
Extract from the Grant Agreement, Mont Rose-Escalette sector: "development areas" in the form of linear trails in the initial application in 2017. Source: PNCAL, IMBE, DREAL (2015)

■ Identification of degraded sites, map of the trail network and description of the degree of openness of the environments

In order to specify the issues related to these spaces for provisional development, a technical study of the pre-identified sectors was conducted by Aix-Marseille Université.

The first objective of the study was to establish a map of the network of paths, footpaths and trails. The pathways were thus blazed based on a sub-metre GPS (Mobile Mapper field Android, MM50) with a precision of 80 cm to 1.50 m. In the field, the layout depends on their delimitation by the vegetation. The description of the trails is quite faithful to that seen in the aerial orthophotographs for certain sites, such as Sugiton, due to the well-marked delimitation of the borders by the vegetation. On other sites, sites as Goudes, the absence of delimitation by vegetation reduces the readability of the different trails observed in the field. Added to this are the multiple trail layouts in limited areas, i.e. a high density. Consequently, trail layout could not be performed by photo-interpretation but uniquely using the GPS. A total of 119 linear kilometres of trails were established for a total surface area of 79.71 ha. These linear layouts do not enable us to distinguish zones of heavy trampling from zones of light trampling. It appeared more pertinent to create a map of the density of trails according to a 5 m x 5 m grid that enables the calculation of a length of trails over a surface area of 25 m².

CALLELONGUE-MOUNINE SITE



Layout (top) and density of trails in the Callelongue-Mounine sector (bottom). Source: IMBE (2018)

The second objective was to describe the degree of openness of plant formations (i.e. the proportion of bare soil surface present within diverse plant formations) that follow each other inland from the coastal limit. This analysis is based on photo-interpretation from high-resolution (HR) aerial orthophotographs over a total surface area of 79.71 ha. The degree of bare soil surface within the various formations is observed on the basis of a 5 m x 5 m grid for the project sites.

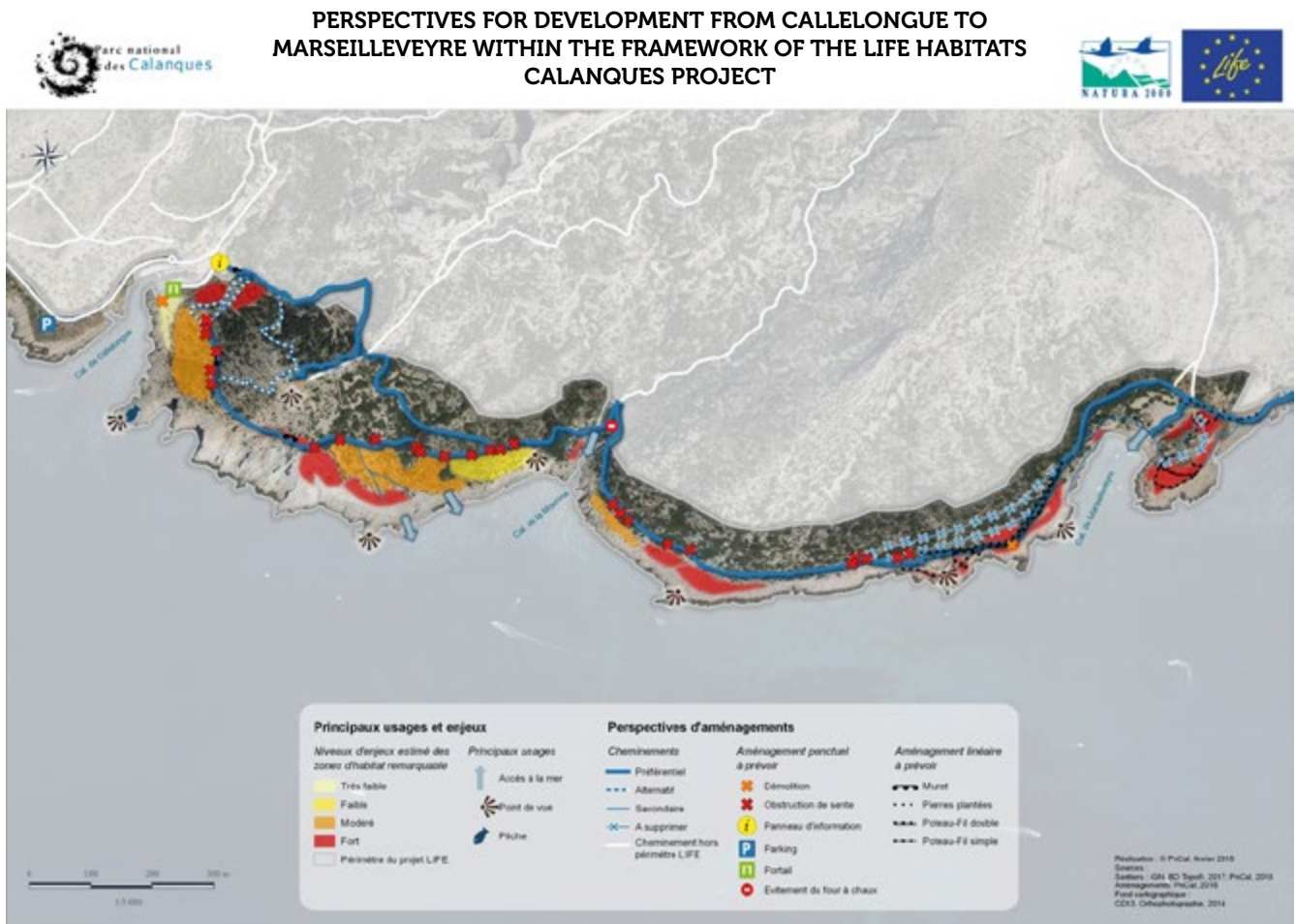
SOIL OCCUPATION CATEGORY	TOTAL SURFACE AREA (IN HA)	% OF TOTAL CATEGORIES
Continuous low shrub formation	8.61	11
Sparse low shrub formation (50% soil, 50% vegetation)	9.31	12
Majority of soil with presence of vegetation (soil > 50%)	18.4	23
Tree formation	12.98	16
Nitrophilic formation (meadow related to the presence of human or urban activity)	2.08	3
Construction	0.78	1
Road	2.15	3
Rock	24.34	31
Scree	0.59	1
Sand	0.47	1
TOTAL	79.71	100% (79.71ha)

Plant formations succeed each other from the rupestrian formations on the coastal strip towards the shrub formations that are characteristic of valley bottoms. Plant formations characterised by a high degree of openness (> 50% of bare soil surfaces) thus represent 35% of all the plant formations identified for the study area (categories 1 to 5). The degree of openness of plant formations can be associated with various factors, most of which are related to the very nature of these environments: an essentially mineral soil (stony mats, rocky slabs, rocks), very hard limestone that is difficult to colonise, exposure to ecological factors (violent wind, downpours and soil leaching, etc), recurrent rainwater runoff. Factors of human origin, notably including trampling, contribute to the reinforcement of environmental openness. Indeed, all these formations are crossed by hikers to obtain access to the sea or to a remarkable viewpoint.

■ Diagnosis of degraded sites and prefiguration of trail development

On the basis of the identification of the most degraded sites, a second phase of work sought to establish a diagnosis shared by the project's partners concerning the ecological issues of the sites and the understanding of coastal usages. On certain key sites, a visitor traffic study was conducted to understand the various visitor profiles and their activities at different times of day and periods of the year.

Field visits were also organised to each pre-identified site. Organised by Calanques National Park (PNCAL), these latter systematically brought together the owner or manager concerned, the Conservatoire Botanique National Méditerranéen (CBNMed), one or several PNCAL field agents (sectors), as well as, more sporadically, the Agence Régionale pour la Biodiversité et l'Environnement (ARBE). It was notably a question of spatialising and characterising the most remarkable coastal habitats, as well as the issues related to pressures and usages (typology of usages, elements of understanding of the presence of footpaths, the logic of trail layout in the natural area). It was also a question of describing the developments to be undertaken and to determine the location of monitoring points (eco-counters, plant monitoring quadrats). This information was recorded on an observation sheet and a paper map, and each visit was the subject of a report sent to the stakeholders concerned.



Extract from the report on a field visit: map of the shared diagnosis and perspectives for the development of the Callelongue -Marseilleveyre sector (PNCAL, 2018)

Reflection concerning the landscape integration of developments was also initiated and concretised by the organisation of a field visit with an inspection of the sites (DREAL). Indeed, trail development can be more or less integrated into the landscapes they belong to. Thus, wooden fencing (ganivelles), frequently associated with dunes, is preferably installed in sandy environments. Wood barriers are generally associated with mountainous terrain or rural areas, where wood is traditionally used. Conversely, minerals are more commonly admitted in limestone coastal landscapes like the Calanques.

Finally, a meeting that brought together institutional stakeholders (Métropole Aix-Marseille-Provence, ARBE, CD13, the City of Marseille, the Office National des Forêts, the Conservatoire du Littoral) and representatives of users' associations (Excursionnistes Marseillais, the Syndicat National des Accompagnateurs en Montagne, the Comité Départemental de la Randonnée Pédestre) was organised in June 2018 to share the diagnosis and readjust the project with respect to the observations of the main users of the site. This enabled the improvement of the alignment of the proposals with the usages on each site, but also fostered the acceptability of future developments.

Generally speaking, this concerted and empirical approach, based on field visits and the appreciation of the "expert opinion" of a group of stakeholders, was decisive for the identification of the sites to be developed.

■ Governance

One of the difficulties of the development project consisted in land distribution within the perimeter of the LIFE project. Indeed, the sites targeted by the development actions involve four different owners: the City of Marseille (Sugiton), the Bouches-du-Rhône Departmental Council (Mont Rose, Callelongue-Marseillevyre, Morgiou, Anjarre), the Conservatoire du Littoral (En-Vau, Port-Pin, Frioul) and one private owner (Cap Croisette). By convention, the National Park manages the land of the Conservatoire du Littoral located in the core area of the park and is the project owner of the developments conducted on private land.

In order to ensure the coherency of the actions undertaken, both in the choice of the proposed developments and in the coherency of the landscape, to respect project deadlines and to facilitate the work of each project owner, it became necessary to conduct the developments in a coordinated fashion between the various owners-managers of the land concerned.

For this purpose, it was proposed that CD13, the City of Marseille and the National Park should associate within a procurement group.

A procurement group is a contractual association of legal persons under public or private law to meet a common need in terms of the purchase of works, supplies or services. This association is materialised by the elaboration, the vote by community deliberating bodies, and the signature of a founding agreement.

Signed in February 2019, the agreement fixed the terms of operation of the procurement group for the LIFE Habitats Calanques project, and notably its purpose: the issue and execution of a project management contract, including an initial phase of technical definition and reglementary studies and a second phase of works supervision, and a works contract covering the execution of the defined developments.

» **its coordination:** lthe PNCAL was designated as the group coordinator and was charged with conducting the procedures for the conclusion of public contracts and to steer their execution on behalf of the other members. The coordinator is only responsible for the attributions defined in the agreement, the members of the group thus maintain the responsibility to ensure the execution of the contracts for the items that concern them and to ensure the reception of the works for which they remain the project owners.

» **its scope:** i.e. the nature of the services expected for each of the contracts and the breakdown of the financial responsibility of each of the members.

» **its governance:** a monitoring committee consisting of group members is charged with monitoring all the services undertaken. Each member has one representative. The committee is chaired by the coordinator. The monitoring committee is responsible for coordinating and harmonising the execution of the services provided to each project owner (validation of company consultation files, the choice of providers, validation of the schedule, validation of preliminary designs).

» **its terms of payment:** each project owner settles the payments due to the contractors, for the amounts engaged for the land of which they are the owners.

» **its duration:** the agreement ends after the settlement of the amounts due for the contracts concluded within its framework.

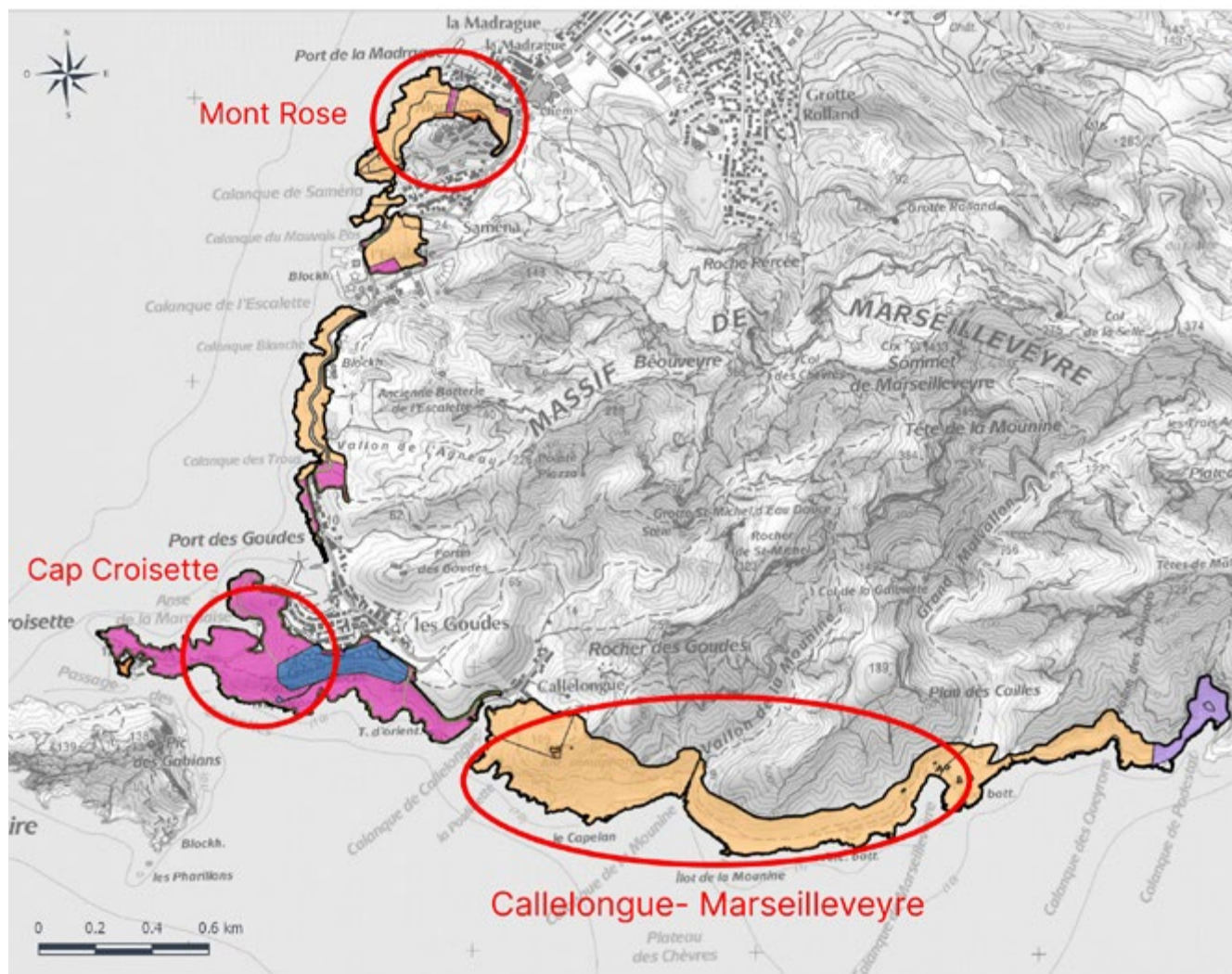
The constitution of a procurement group thus enabled the launch of a single tender process for project management common to all project owners. The procurement group has proven to be highly efficient to coordinate and ensure the implementation of the works within the specified period. Beyond the increased coherency provided by this solution, it has also ensured economies of scale and the reduction of costs related to the procurement process.

However, this being the first procurement group for intellectual services concluded by structures with distinct administrative standards, this approach required a very large number of visits between the services of the City of Marseille, the CD13 and the PNCAL.

NB : it is important to identify, from the beginning of discussions, a competent contact person for the procurement and/or legal departments of each project owner in order to avoid possible disagreements within a particular structure.



LAND DISTRIBUTION WITHIN THE LIFE PERIMETER FROM THE SOUTHERN COAST TO PODESTAT



An example of land distribution among three sites within the perimeter of the LIFE project (PNCAL, 2022)

Key:	LAND DISTRIBUTION			
[---] LIFE PERIMETER	[Blue] MUNICIPALITY OF MARSEILLE	[Purple] ENEDIS	[Red Circle] SITES OF HEAVY WORKS	
	[Yellow] CONSERVATOIRE DU LITTORAL (CDL)	[Pink] PRIVATE OWNER (SCI GOUDES)		
	[Orange] DEPARTMENT			

■ Development design and authorisation procedures

In order to precisely define the technical solutions for the developments, to conduct studies prior to obtaining works authorisations and to monitor their proper execution, the project owners concerned engaged a project manager. A call for tenders was launched and the proposals were assessed according to a price criterion (40%) and a criterion of technical value (60%). The latter criterion was divided into a certain number of sub-criteria: the planned works methodology (45%), the expertise and qualifications of the provider with reference to the contract (25%), the consideration of environmental and landscape issues (15%), the response to a situational exercise (10%) and presence in the works phase (5%).

Project management was attributed to a solidarity group mandated by the Topo*Grafik landscaping agency in charge of the design and general supervision of the project, associating the ECOxygène bureau of engineering studies for technical expertise and support for jobsite monitoring, the Symbiodiv environmental consultancy for inventories of flora and the drafting of the Natura 2000 impact study, and the expertise of the Ligue de Protection des Oiseaux Provence-Alpes-Côte d'Azur for faunistic inventories.

■ Design and studies by the project manager

This project management contract included a design and study phase. This phase of work enabled the final definition of the perimeter and toponymy of the sites that would be the object of development works within the framework of the project. Nine sites were thus retained: Frioul (Pomègues), Mont Rose, Cap Croisette, Callelongue-Marseilleveyre, Morgiou, Sugiton, En-Vau, Port-Pin and Anjarre.

The diversity of the means and the expertise brought in by the diagnosis and studies phase enabled a certain number of development principles to be defined and fixed, which constitutes one of the sustainable benefits of the LIFE project. The latter are characterised by strong attention to efficacy, quality, durability and the reduction of the impact of the technical solutions presented, as well as the integration of the developments into the landscape.

The conception and implementation of the works programme was devised so as to create the least possible impact on the natural habitats and on the species found there, as well as on the landscapes, by the following means:

- › fitting pathways onto existing trails and avoiding the creation of new trails ;
- › the use of materials found on site (stones, plants, earth) ;
- › minimal artificialisation through the use of habitual equipment for the development of natural sites (wooden fencing, posts and wire) ;
- › preference for the dry-stone technique (steps, low supporting walls) ;
- › respect for bird nesting periods and the periods of activity of the reptiles present on the site ;
- › implementation of measures of locating and/or protecting zones, or even individuals, to avoid impacting them during the works.



The marking of protected species prior to heavy works at Mont Rose: *Sedum hirsutum* (left), *Astragalus tragacantha* (right)

The developments to be made on each site were defined by the provider on the basis of the diagnostic elements detailed above and completed with the land surveys conducted by the project manager. The choice of the development solution was then adapted to each site with respect to the user profile, their numbers, the environmental context of the situation, the materials present on site, etc. An impact assessment of the trail restoration project under Natura 2000 was also conducted.

These studies gave rise to the drafting of several works programmes validated by the project owners within the framework of the procurement group: "preliminary design" (AVP) version followed by the "project" (PRO) version.

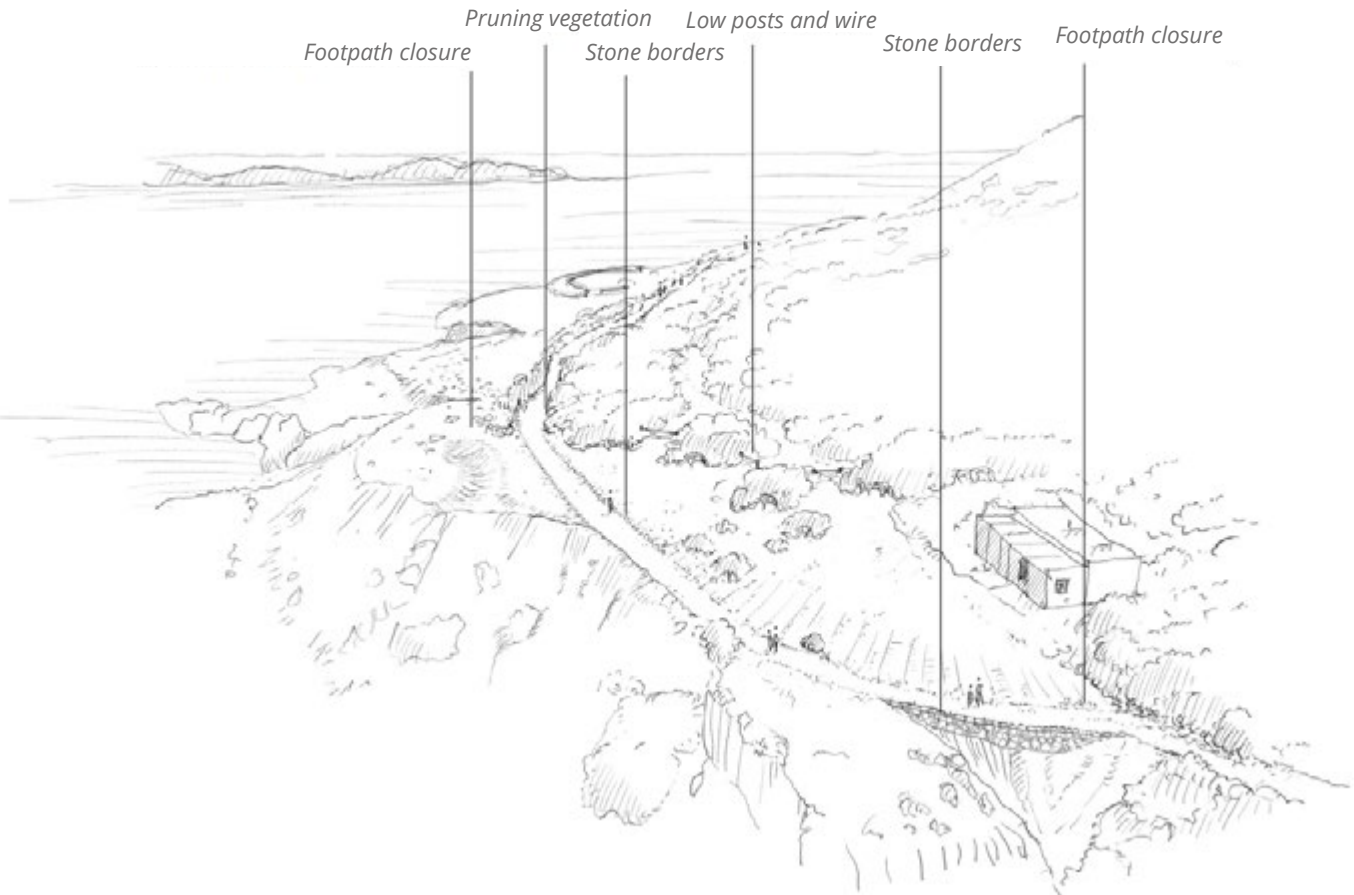
DEVELOPMENT PERMIT FILE CALLELONGUE - MARSEILLEVEYRE



PROJET	Site	Section	Propriétaire	N° planche	Échelle
	CALLELONGUE - MARSEILLEVEYRE	Batterie	CD 13	CM_12	1/1000

Extracts from the development permit file (PRO version) validated by the project owners in the purchasing group committee (Topo*Grafik, 2019) - EXTRACT 1

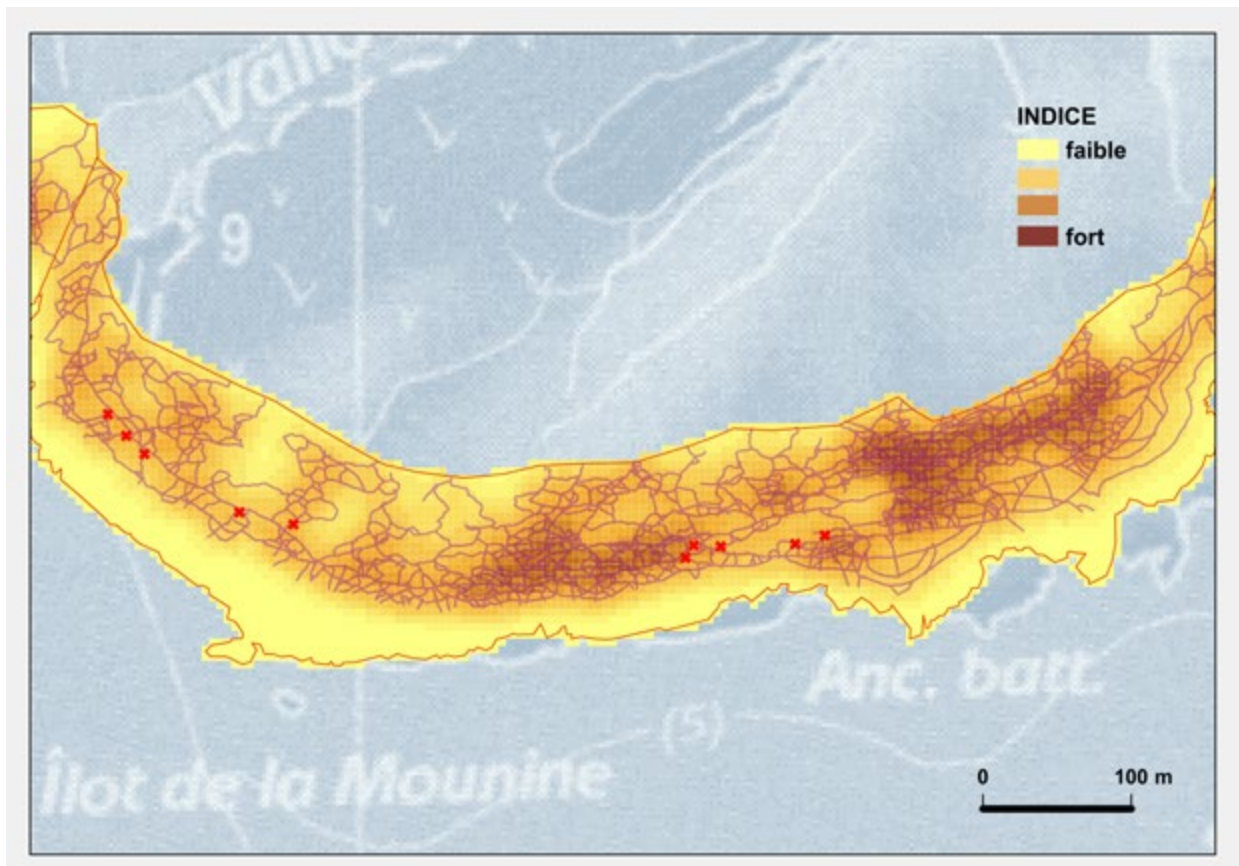
**SKETCH 06
RETURN TOWARDS BATTERIE MARSEILLEVEYRE**



PROJECT	Site	Section	Owner	Board no.	Scale
	CALLELONGUE-MARSEILLEVEYRE	Batterie		CD13	CM_13

*Extracts from the development permit file (PRO version) validated by the project owners in the purchasing group committee (Topo*Grafik, 2019) - EXTRACT 2*

NB : the solutions for development were confronted with the diagnosis of the degree of openness of plant formations to verify the theoretical efficacy expected of the developments, in particular with the closure of footpaths. A trail neighbouring index was calculated to this effect. A high value implies a strong reduction in the density of trails after closure, thus a strong impact of closure on the density of the neighbouring trails. Conversely, a low value implies a weak impact of closure on the density of neighbouring trails.



MAP OF THE NEIGHBOURING INDEX

Callelongue-Marseilleveyre; few trails (light yellow) numerous trails (orange) - x (in red): locations of trail closures - top: neighbouring index calculated for the current trail network (IMBE, 2019)

■ Administrative authorisations and technical aspects

The development permit application file was prepared by the project manager in compliance with the requirements of the contract. As the National Park is a Public Administrative Establishment, administrative authorisation was granted by prefectural decree on 10 February 2020. The call for tenders for the works contract was published a few days later.

Considering the location of the sites concerned (core area of the National Park, site listed under the law of 1930, Natura 2000 site), the examination of the file was the object of a request for assent from the Director of Calanques National Park, a favourable opinion from the Departmental Commission on sites, perspectives and landscapes, and an impact assessment on the species and habitats of Community interest.

The project manager also prepared the technical documents for the tender file (special technical specifications, the unit price list, the provisional schedule, etc.) for the works contract.

CONSERVATION MANAGEMENT

■ Objectives of the works

The works identified in the prior study phase were implemented in two ways: light work that did not require special techniques or equipment, executed in-house by the owners, and the heavy works that were entrusted to specialised companies and supervised by the project manager.

The project management common to all project owners enabled all development work to be planned within the framework of consultation on the scale of the territory. Common goals and principles of development were thus fixed for all sites. The project provides for developments consisting of:

› **close the main degrading footpaths:** within the context of trail management, it may be necessary to eliminate undesirable former trails or to erase the traces of erosion due to public wandering. The simple obstruction of the entry to the footpath is insufficient in most cases. It must be accompanied by the erasure of the first few metres of the footpath. It is also essential to consider the closure in both directions of pedestrian traffic on the main trail and at each extremity of the footpath to be closed. As far as possible, the obstruction must be made with materials present on the site (rocks, faggots, tree trunks, etc.). These installations must dissuade the public from using the footpath and help the path to heal naturally.



Light footpath closure work by rocks on the Callelongue-Marseilleveyre (CD13) sector; to the right, by posts and wire and plant debris in Sugiton (City of Marseille)

► **Improve the practicability and readability of the trails made attractive by work on the viewpoints, comfort and quality of the path:** first, this consists in freeing the path of the main obstacles, including rocks or concrete on the path, vegetation, etc. When necessary, one-off works may be undertaken on the trail to enhance its readability, practicability, safety or the respect of the layout: steps to compensate for a steep slope, supporting installations (walls, wattle fences) to compensate the instability of the trail, and ground treatment (paving, slabs, cobblestones) to reinforce and protect the trail from erosion and trampling. These installations aim to guide the walker along a well-defined path. They are used in sectors that are often open and where the trail base is not clearly delimited by the vegetation, as is the case on the Calanques coast, where several options of circulation are often possible.



Heavily eroded trail before (left) and after (right) levelling work and the completion of installations (retaining walls) in Sugiton

› **take the context into account:** visitor traffic to the site, user numbers and behaviour, will necessarily influence the choice of the development. The choice of the width of the trails is a function of the type of users, their number, direct environmental issues (ecological, cultural, landscape), the ambiance of the feeling of confinement generated by lush vegetation (closed pine forest with no view) or rocks. The trail must also be enlarged at points of interest to enable walkers to stop there. As for the other components, the slope must be adapted to the types of users who follow the trail. Finally, in order to be appreciated, a trail must offer a varied layout that gives an overall idea of the sector it crosses and enables the discovery of its most interesting particularities – relief, vegetation, monuments, viewpoints – in relation to the outreach approaches of the territory. It is also preferable to offer layouts of different lengths thanks to alternative or linking trails. The technical characteristics of the trails must also be considered in relation to the outreach approaches of the territory. However, trail development must also lead the public to spontaneously change their behaviour, without this appearing as a constraint, and not necessarily with systematic recourse to signposting.



Extract from the booklet "Mont Rose, un petit monde", a creation by TerraNostrum in partnership with Calanques National Park

› **defend the most sensitive sectors that require active preservation:** in certain cases, the installation of a temporary or definitive barrier along the path may be necessary to protect sensitive areas or to avoid the creation of secondary trails. Several technical solutions are frequently used in natural areas: posts with single or double wire, stakes with crossed wire, wooden fencing, wood barriers or dry-stone walls.



Protection via posts and wire on the Callelongue-Marseilleveyre path (left), protection via wooden fencing (ganivelles) at the Anjarre sandpit (right)

Specific signposting has also been developed within the framework of the LIFE project to mark areas of plant regeneration (no-go areas) and to inform the public of the project for the reinforcement of goat's thorn milkvetch populations.

Parc national des Calanques

Ici, on protège l'astragale de Marseille !

L'astragale de Marseille (*Astragalus tragacantha*) est une plante protégée présente presque exclusivement dans les Calanques. Pour faire face au déclin de ses populations, des plantations sont réalisées dans le cadre du projet LIFE Habitats Calanques.

« A l'abri dans mon enclos »

Pour permettre aux minuscules plantes de pousser tranquillement, des enclos ont été mis en place. Ils seront enlevés dès que les astragales auront atteint une taille suffisante.

Pour protéger l'astragale de Marseille, merci de rester en dehors des enclos !

« Papiers d'identité s'il vous plaît »

Une étiquette jaune est associée à chaque plant. Elles peuvent ressembler à un déchet abandonné mais ne vous méprenez pas : ces étiquettes servent de carte d'identité et permettent aux scientifiques de suivre la croissance de chaque astragale.

Les étiquettes jaunes ne sont pas un déchet, merci de les laisser en place !

Logos: LIFE, ARBC, and other project partners.

Ne pas franchir

Zone de régénération de la végétation

Logos: LIFE and NATURA 2000.

Signposting of a no-go area installed within the framework of the LIFE project

■ Light works

Light works were executed in-house by the technical teams of the managing owners, by a local association for trail management, the Excursionnistes Marseillais, and a social integration establishment. Beyond their direct objective of channelling the public, these works provided the opportunity to raise awareness and mobilise them around the project and to place the various owners in the situation of managers of the future developments provided by the LIFE project. As this development does not require administrative authorisation, and therefore the production of complex technical files, they can be executed without the intervention of a study office, but via the expertise of the project owners alone.

The choice of light development was the subject of a prior field visit and was guided by the question (i) of their potential functionalities: "Is light development sufficient to reach the objective of limiting wandering?", (ii) their nature: "Is it really a question of light development that can be considered as regular trail maintenance?", and (iii) "Can the technical skills be successfully mobilised in-house or with partners?"

For the CD13, these works concerned the Morgiou sector (reinforcement of steps and footpath closure), the GR hiking trail between Callelongue and Marseilleveyre (small footpath closures) and the Roy d'Espagne sandpit (creation of a no-go area through the installation of wooden fencing and signposts). For the City of Marseille, these works concerned the bottom of the Sugiton Calanques (small footpath closures). For the National Park, they concerned the Cap Croisette site.

These initial developments marked the launch of works in January 2019.



In-house creation of steps by the CD13 in Morgiou (left), footpath closures by the Excursionnistes Marseillais in Callelongue (right)

■ Heavy works


The works contract was attributed to EIFFAGE, which mobilised a certain number of subcontractors for specific services: the installation of posts and wire, the conveyance of materials to the site, the ecological supervision of the jobsite, etc. The co-action of several companies on the same site, even at a few day's interval, required the intervention of a Safety and Health Protection Coordinator in charge of taking the necessary measures to limit the risks that an activity may incur for another party. In the case of the LIFE Habitats Calanques project, this mission was entrusted to Bureau VERITAS.

The companies completed the work of grading and delimiting the trail base, the completion of retaining and crossing works, as well as the creation of no-go areas and the renaturation of footpaths. The most extensive works concerned the Sugiton, Callelongue-Marseilleveyre, Mont Rose and Port-Pin sites.

WORKS DESIGNATION	UNITS	QUANTITIES
GRADING AND TRAIL LAYOUT		
Manual trail grading	m ³	143
Backfilling	m ³	97
Grading by rock scaling	linear metre	46
Pruning vegetation	day/man	31
Installation of stone borders	linear metre	130
RETAINING AND CROSSING WORKS		
Creation of steps (unit)	unit	365
Creation of a retaining wall	m ²	125
Installation of block borders	linear metre	215
NO-GO AREAS		
Moving and installing large blocks of rock	unit	56
Installation of posts and wire	linear metre	2 220
Installation of wooden fencing	linear metre	35
RENATURATION		
Closure of footpaths and degraded areas	m ²	3 640
Removal of wood retainers	linear metre	40
Removal of concrete masses	unit	4
Removal of posts and wire	linear metre	170

**ESTIMATION OF THE OVERALL VOLUME OF WORKS PER ITEM,
ACCORDING TO THE PROJECT MANAGER**

*(Topo*Grafik, 2020)*

 **NB :** Organised by the provider within the framework of the project management contract, weekly job monitoring was conducted from the beginning to the end of the works. This monitoring was particularly important to ensure the quality of the finish and the overall resistance and harmony of the development of each site, which are the guarantee of their durability over time.



Creation of a retainer wall in Marseilleveyre before / after (top / bottom)



Post and wire installation in Marseilleveyre

MONITORING AND ASSESSMENT

Steered by Aix-Marseille Université, there are several methods to monitor the efficacy of trail development and/or closures: a study of frequentation by eco-counters and the monitoring of the dynamics of plant cover by photo-interpretation and phytocological surveys. The purpose of this monitoring is to verify the efficacy of the action, to enable readjustments where it proves necessary and to provide objective feedback to be shared with the other managers of natural areas.

■ Traffic monitoring by eco-counters

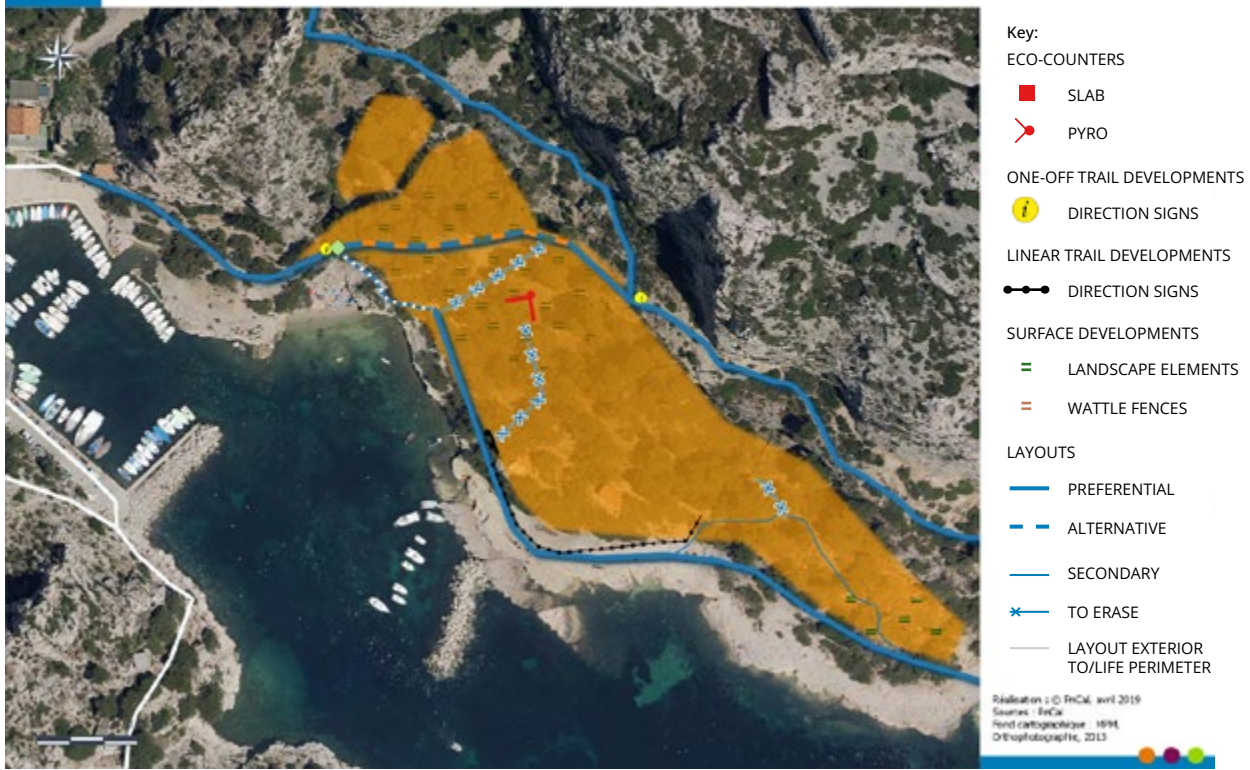
Fifteen eco-counters were installed in July 2019 on five of the nine sectors concerned by heavy works (Callelongue-Marseilleveyre, Sugiton, Frioul, Mont Rose and Morgiou). These devices count the number of passages on closed footpaths in the context of the development work, to transmit data in real time and to analyse the data by comparing the frequentation of a pre-works time period (July 2019 - February 2020) with an equivalent post-works period (July 2021 - February 2022). The expected result is to observe a decrease in the frequentation of closed footpaths, the necessary condition for the restoration of fragmented or eroded environments.

The series of eco-counters mobilised consists of 11 PYRO eco-counters with a range of 1 to 15 m, including a fixed part in the wooden posts, and 4 SLAB counters. All materials used were supplied by Éco-compteur and installed by the Office National des Forêts.



PYRO eco-counter camouflaged in a wooden post at the entrance to a footpath closed off by rocks, Callelongue-Marseilleveyre sector

LIFE HABITATS CALANQUES SUGGESTED LOCATIONS OF ECO-COUNTERS

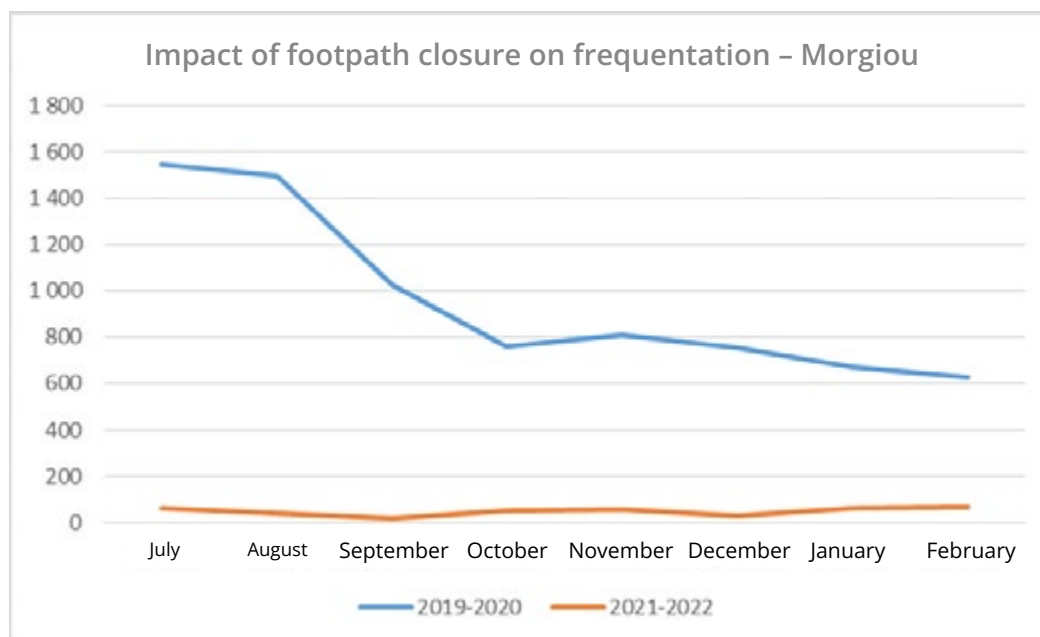


Eco-counter installation principle, here in Morgiou: the eco-counter measures pedestrian traffic on footpaths that have been closed by development works (rockfill, posts and wire, walls) (PNCAL, 2019)

The comparative analysis of visitor traffic before/after work on closed footpaths yields the following:

- Six eco-counters indicated a decrease in traffic on the closed footpaths of the Calalongue-Marseilleveyre and Morgiou sectors. Four of these appear to have provided reliable data, the last two probably presented counting errors of undetermined origin.
- Four eco-counters signaled an increase in visitor traffic in the Frioul, Mont Rose, Sugiton and Marseilleveyre sectors. Four two of these, this seems to be due to the colonisation of the posts by insects (ants, bees, earwigs). For another, this is due to a material problem (over-counting). For the last, this could be due to a seasonal problem of crossing a barrier into a no-go area, which remains to be confirmed.

Generally speaking, the installations seem to have led to a decrease in visitor traffic on closed footpaths. The comparison of the data of the six eco-counters for which it is possible to make a comparison (5- to 8-month period) shows that the frequentation of closed footpaths decreased by an average of 600% after the completion of the works.




The Morgiou eco-counter revealed a drastic decrease in frequentation after the closure of the footpath with 628 passages in February 2020 compared with 70 passages in February 2022.

Concerning the last five eco-counters:

- › Three did not yield data due to a material problem or equipment damaged during installation.
- › Two were positioned on trails conserved by the installation layout. Located on the Mont Rose and Marseilleveyre sectors, these two eco-counters testify to the effect of the diversion of frequentation towards blazed trails (respective increase of 6 to 75% of frequentation on blazed trails after the closure of footpaths).

Based on usable data, the closure of footpaths by trail development effectively led to a decrease in visitor traffic, which was divided tenfold on certain pathways. Thus, it is an effective management measure. However, the recurrence of technical problems related to the counting technology used, plus the impossibility to equip all closed footpaths with eco-counters suggests that these results should generally be considered with prudence.

 **NB :** this monitoring method incurred significant costs for the purchase and installation of the equipment and data tele-transmission. Moreover, the majority of eco-counters could not usefully contribute to the monitoring due to various reasons: defective equipment, equipment damaged during installation, over-counting due to the colonisation of the equipment by ants or by the presence of vegetation in front of the sensor, and vandalism. For this purpose, "slab" eco-counters seem to be more reliable than "pyro" eco-counters, with only one in four defective "slab" counters compared with eight out of eleven defective "pyro" counters. This may be explained by the technical characteristics of the slabs that prevent both vandalism and colonisation by insects.

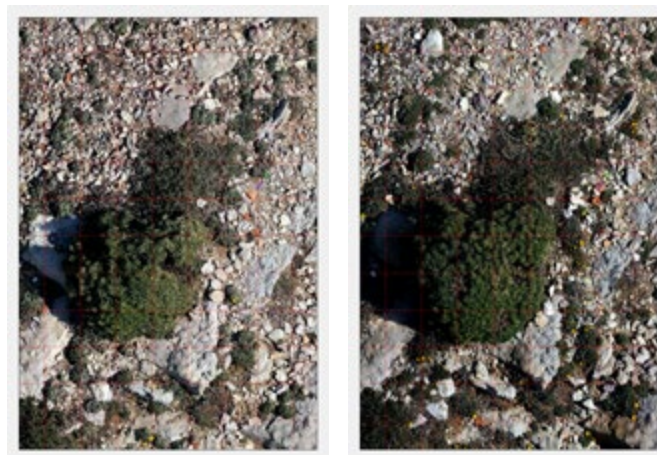
Good equipment installation methods, in-house management and regular equipment monitoring in the field are thus necessary to gather reliable and usable data. Other tracking models based on direct observation at regular intervals could be complementary and enable operators to compare the results while appropriating the technical issues related to the eco-counters.

■ Monitoring by photo-interpretation

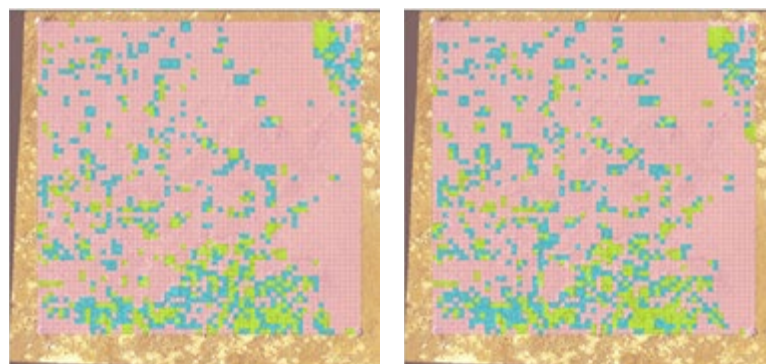
The purpose of this study is to monitor the dynamics of the vegetation in the degraded sites that benefitted from various developments, including a no-go area. For each site, several photographs were taken above quadrats of 100 m² (10 x 10 m) in order to assess the extent of plant cover, by surface area gained or lost over the mineral surface between two photo campaigns before development work (2020) and after (2022).

Two methods were tested to assess the dynamics of plant cover after frequentation. The first method of supervised classification based on satellite photos relies on an automatic classification by segmentation. The validity of the results depends on the degree of confusion between the spectral signatures that characterise the vegetation and those that characterise the mineral. The results obtained were disappointing due to the confusion of classes between, for example, the shadows cast by minerals and the vegetation, the brown colours of the vegetation and those of the ground, or the colour variations of the rock. These confusions falsify the results and their interpretation. Therefore, this method was discarded.

The second method, by photo-interpretation, is based on a regular grid that is superimposed over an assembly of photos per quadrat. Thus, the grid traces the reality of the photo assembly. The surface of each grid is wedged between the minimal surface and the first quartile of the surface distribution. The choice of the surface depends on the relationship between the most precise analysis possible and the number of grid elements to complete. According to this method, one environment predominates in the majority of grid elements. This initial condition ensures the monitoring of changes in environments by minimising observer bias.



Grid comparison of the changes in environments between 2020 (left) and 2022 (right) in a detail of a 100 m² quadrat




Grid comparison of the changes in environments between 2020 (left) and 2022 (right) in a 100 m² quadrat. Beige grid elements represent the "mineral" category. Green grid elements represent the "vegetation" category. Blue grid elements represent the mixed "mineral/vegetation" category.

For example, for the Marseilleveyre site, the 3 environment categories evolved between 2020 and 2022 according to the same order of magnitude. The "mineral" category covers a large area of 69.82% of the quadrat, and is partially colonised by 0.25% of vegetation ("vegetation" category) and becomes 3.86% mixed (mixed "mineral/vegetation" category). The "vegetation" category covers 8.84% of the quadrat, with a non-significant regression of respectively 1.58% for the mixed "mineral/vegetation" category and 0.36% for the "mineral" category. Finally, the mixed "mineral/vegetation" category, which covers 11.11% of the quadrat, is colonised by 2.58% of vegetation and indicates a regression of the mineral environment by 1.58%.

2020	2022			Total
	Mineral	Vegetation	Mixed	
Mineral	69.82	0.25	3.86	73.94
Vegetation	0.36	8.84	1.58	10.78
Mixed	1.58	2.58	11.11	15.28
Total	71.77	11.67	16.56	100

The monitoring of the changes in the environment of the Marseilleveyre site thus reveals a very low progression of vegetation (3% for a surface area of 100 m²) over the monitoring period of 2 years following the development work. This is not surprising because coastal plants, moreover on a limestone substrate, naturally develop very slowly due to the extreme conditions of habitat (xericity and salinity, accentuated by the action of the winds). Paradoxically, it is these extreme conditions, working as environmental filters, that enable the occurrence of rare plants on the coast that are not very competitive compared with other plants. This is the reason why monitoring must be performed over a longer time span, of at least 5 years, but ideally 10 years in order to observe a significant recovery of plant cover.

 **NB:** from a practical point of view, the installation of permanent markers on the coast to materialise the quadrats was conditioned by the presence of sufficiently solid and large rocky slabs. Despite the mineral nature of the calanques, the ideal configuration for the installation of quadrats is difficult to find (unsuitable microtopography, flakiness of the rock, presence of protected species), especially on the narrow coastal strip. Thus, certain markers were installed too close to future trail developments due to the lack of a suitable rocky slab further inland; certain installations were extended beyond their initial layout due to the instability of the terrain. The grid for phytoecological monitoring is a square of 1 m per side. Consequently, a 10 cm shift in the marker leads to a 10% reading error. This skews the observations and the interpretation of their analyses.

The very rugged topography and very unstable earthy or rocky slopes prevented the installation of quadrats. Thus, no pre-works T0 observation was carried out at Sugiton, which is detrimental given the heavy visitor traffic to the site.

LIFE PROJECT FEEDBACK

Works schedule

All the actions related to this objective were conducted between 2018 and 2022 according to several major phases of work: diagnosis and preliminary studies (2018-2019), works (2020-2021), monitoring and assessment (from 2022).

		2017		2018				2019				2020				2021				2022				
		III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	
Preliminary studies	Map of the trail network and assessment of the degree of openness of plant formations																							
	Field visits and shared diagnosis																							
	Purchasing group prefiguration																							
	Project manager: design and studies																							
	Application for authorisations																							
Conservation management	Light works																							
	Heavy works																							
Monitoring	Monitoring via eco-counters																							
	Monitoring by photo-interpretation																							

■ Heavy works

The costs related to trail development were the most important expenditure items for the LIFE project. Thus, heavy works contracting alone amounted to nearly one million euros.

The following table details a certain number of costs that the manager must take into account during works scheduling. These figures are given for indicative purposes and the costs can vary considerably with the difficulty of site access and the means used to convey materials.


PROJECT MANAGEMENT	UNITS	PRICE INCL. TAX
Conduct of landscape and naturalist studies	fixed price	€64,700
Jobsite monitoring	fixed price	€66,200
EXECUTION OF WORKS		
Manual grading	m ³	€400
Rock scaling	m ³	€500
Post and wire installation	linear metre	€120
Installation of border blocks	linear metre	€300
Installation of wooden fencing	linear metre	€180
Creation of a retaining wall	m ²	€720
Creation of steps	unit	€360
ECO-COUNTER INSTALLATION		
Wooden post "pyro" counter range 15 m	unit	€4,000
"Slab" counter	unit	€2,100
Tele-transmission licence	month	€30
Eco-counter installation*	fixed price	€800
Spare battery (2 years)	unit	€120

Costs related to trail development (indicative)

■ Overall results

Development work within the framework of the LIFE project enabled the rehabilitation of 5700 metres of main trail and 73.8 hectares of coastal habitat, i.e. nine hectares more than the initially planned surface area.

The works were generally well accepted locally. Users appreciate the increased readability and comfort provided by trail development. The only sites where there were difficulties were at Marseilleveyre, where the abandon of former trails remains difficult and where wires were cut once and replaced by the CD13, and Mont Rose where regular degradation is observed. On this site, it was decided to regularly maintain the high posts and wire (1 m height), especially on the Mont Rose side. However, the decision was made not to replace the wires of low posts (50 cm height) on the large Saména slab. To the extent that their height is not dissuasive but indicative, and considering that wires will in all likelihood be vandalised again as a sign of protest by a minority, and that the degraded posts are more detrimental for the perception of users, it was considered that these repairs were of no value.

 **NB :** on Cap Croisette, LIFE was the spark for a more global site requalification project. This intention was initially marked by the adoption of a conservation measure by the director of the PNCAL to enable the establishment to conduct works on a private property. A barrier was then installed to close access to motor vehicles (except for authorised users).



Unorganised parking on sensitive coastal habitats in Cap Croisette, summer 2020 (top), installation of a motor vehicle traffic restriction barrier (bottom), summer 2021

The efficacy of no-go areas has been generally proven wherever they have been well installed (solidity, readability) and where they receive rapid maintenance. In July 2021, a decision by the Supervisory Board of Calanques National Park reinforced this efficacy by prohibiting, except with authorisation by the director of the National Park, the access and circulation of persons on the natural areas protected by no-go zones, materialised by wooden fencing, posts and wire or other equipment in the core area of the National Park. In very specific cases, these measures have been reinforced by strong measures to restrict visitor traffic, for example with the experimental establishment of a permit to visit Calanque de Sugiton for the 2022 summer season (quota system).

However, even when perfectly established and maintained, no-go zones do not guarantee that an environment will not be violated. It must be accepted that a percentage (the smallest possible) of persons will continue to step over or walk around them. The observation of persons within the no-go zones should not justify immediate over-equipment. It is initially important to see whether this level of frequentation, which is sanctioned when it is observed, is sufficiently low to enable vegetation to recolonise the environment. This requires monitoring over time, or at least an objective observation over several years. It is essential to allow time for the trail installations to have an effect, to enable the changes in usage that they imply to be assimilated by the users, and for the vegetation to recover.

■ Outlook

All of the installations made within the framework of the LIFE project must be regularly maintained to ensure their sustainability. Each owner/manager is responsible for this management; however, the National Park has a duty of care and diligence. The measures deployed to sustain the management of the installations are to be implemented and enhanced, such as the organisation of training for dry-stone construction and trail maintenance that will bring together the technicians of the associated beneficiaries from 2023.

It should also be noted that under the impulse of LIFE, the project partners have undertaken more global reflection on the trails. After the completion of the works in spring 2021, the project owners undertook works on the sites adjoining the perimeter of the LIFE project in an approach to prevent wandering and to improve the coherency and comfort of the trails. Indeed, the contrast between the newly equipped zones and the untreated trails was particularly conspicuous. The approach to works thus gains from reflection on the global scale of the trail, especially for walking trails.

In 2022, through funding obtained within the framework of the France Relance scheme, the National Park called for project management to design developments for an estimated value of 60,000 euros dedicated to the fight against erosion: access trail to the Callelongue signal station, the Morgiou coastal trail, Sormiou, access to Col de la Gardiole, the Sainte Frétoise sector. The National Park, the municipalities of Marseille, Cassis and La Ciotat, and the CD13 also filed a joint dossier to respond to the "Coastal trail – Seaview" project to envisage the creation of a continuity of trails between the south point of Marseille and Bec de l'Aigle to La Ciotat. At the same time, the City of Marseille also launched a project for the requalification of access to Sugiton.

As the layout of a trail cannot be designed without giving thought to the means of access to this path (entrance points, parking, public transport), Calanques National Park and its partners also studied the improvement of the area's public transport service.

MANAGEMENT OF INVASIVE ALIEN PLANT SPECIES

- Issues and objectives
- Preliminary studies
- Conservation management
- Monitoring
- LIFE project feedback

ISSUES AND OBJECTIVES

■ Context

An invasive alien plant species (IAPS) is a species of flora introduced by voluntary or accidental human activity outside of its original territory, which rapidly colonises its new territory due to efficient reproduction and which has the capacity to rapidly spread over a large territory.

In 2019, the Plateforme Intergouvernementale Scientifique et Politique sur la Biodiversité et les Services Écosystémiques (IPBES) noted invasive alien species as one of the five direct factors for change that have the greatest impact on biodiversity.

Locally, through their simple presence or invasive behaviour, these species can:

- › **compete with native species and threaten rare species or remarkable habitats**, particularly in island systems: this competition can lead to the banalisation of the flora and a reduction of the diversity of plant formations, or even the establishment of mono-species formations;
- › **consequently modify the structure, functioning and the composition of ecosystems** – disruptions of other links in the food chain, notably including pollinators, the modification of biogeochemical cycles due to the characteristics of the IAPS (allelopathy, nitrogen fixation, etc) – and thus induce a risk of the loss of adaptation of the latter;
- › **foster genetic pollution** (genetic introgression).

These observations form the main arguments of the institutions acting in favour of biodiversity to justify the deployment of public policies designed to put an end to the introduction and propagation of these species.

The Grenelle de l'Environnement programming act of 3 August 2009, which provided for the "deployment of plans to combat terrestrial and marine IAPS", rooted these debates into the national legal system. The resulting National Strategy for Biodiversity (SNB) incited national parks to focus the management of their territories on the problems of IAPS. In 2014, the national Mediterranean and Alpine botanical conservatories (CBNA and CBNMed) published a strategy concerning IAPS in the Provence-Alpes-Côte d'Azur region (Terrin, Diadema & Fort, 2014) accompanied by a version for the attention of managers (Cottaz, 2018).

The Calanques National Park (PNCAL) naturally onboarded these topics into its charter and regular missions before its involvement in the LIFE Habitats Calanques project. When the project was launched, the territory numbered 80 invasive alien plant species. In order to define the priority species and intervention sites, the principles of the regional strategy developed by the CBNMed were applied on the territorial scale. This revealed the need to intervene on the coastal fringe, which concentrates very high conservation challenges due to the presence of protected plant species, and which presents a strong dynamic of colonisation by four IAPS: century plant (*Agave americana* - Agavaceae), pigface (*Carpobrotus sp* - Aizoaceae.), prickly pear (*Opuntia sp.* - Cactaceae) and moon trefoil (*Medicago arborea* - Fabaceae).

■ Objectives

The perimeter of the project is located at the gates of one of the largest urban agglomerations in France. The objective of the total eradication of IAPS would be unrealistic on the territorial scale over the mid-term, all the more so because certain species are still massively used and acclaimed by the inhabitants and users and are present in the areas around the core area of the National Park.

Thus, the objective is to identify and treat in priority, by manual uprooting, the sites for which an intervention makes sense from an ecological point of view and which have good chances for long-term success. Within the framework of the LIFE project, there are two distinct contexts for intervention: so-called "flat" sites and "cliff" sites:

- › for flat sites, the objective is to carry out the uprooting tasks in-house, i.e. by mobilising the agents of partner bodies, with the support of voluntary operations;
- › for cliff sites, uprooting requires rope access work and/or specific logistic means to assess plant residue. These works are thus entrusted to specialised companies. This type of intervention on vertical environments is not frequent and constitutes one of the main experiments of the LIFE project. The objective is to test the feasibility of this type of task over large areas, and to benefit from feedback concerning their value and limitations.

■ Authorisation

Contrary to the execution of development work, uprooting work is considered as a management task and is thus not subject to authorisation for the owners/managers. However, as the evacuation of residue from certain sites with difficult access requires the scheduling of helicopter transport, specific overflight authorisations were delivered in the form of individual decisions by the director of the National Park. An individual decision by the director was also required to authorise the harvest in the core area of the National Park of the seeds and cuttings of species targeted for replanting on certain uprooting sites.

Lastly, the installation of ground markers to materialise the post-uprooting monitoring quadrats, consisting of a works project as such, involved the formalisation of an impact assessment of the works in the Natura 2000 "Calanques et îles marseillaises - Cap Canaille et Massif du Grand Caunet" natural environments. This assessment, conducted by the PNCAL, the organiser of the Natura 2000 site concerned, also included the markers to be installed within the framework of other actions of the project (D1 and D4 monitoring), it being the same operational mode in the field.



Agave americana

PRELIMINARY STUDIES

Analysis of the abundant bibliography available concerning the subject revealed all the complexity of the parameters governing IAPS management operations, including those with a direct impact on the means to be deployed:

SPECIES-CENTRED FACTORS	SITE-CENTRED FACTORS	OPERATOR-CENTRED FACTORS
<p>Detectability of the species (time spent searching for it)</p> <p>Aptitude for reproduction, persistence of seeds in the soil (frequency of repeat operations)</p> <p>Capacity for seed dispersion (foreseeable distance from the sources of recolonisation to be treated)</p>	<p>Ecological issues concerned</p> <p>The cost-risk ratio of the intervention on the surrounding natural heritage</p> <p>Accessibility to operators and any necessary machines</p> <p>Visibility of the action to the general public to facilitate communication</p> <p>Areas / volumes to be treated</p> <p>Possible sources of recolonisation in the surrounding area</p>	<p>Human resources available at the time of the works (priority with respect to other tasks during the same season)</p> <p>Level of operator training (for uprooting techniques or in the case of rope access work)</p> <p>Financial means to commit to the works</p>

In addition to these initial parameters concerning the feasibility of an IAPS management operation are those concerning what could be called intervention stakes. As mentioned in the introduction to this chapter, the strategy proposed by the CBNMed and CBNA in 2014 prioritises interventions according to the conservation issues of the sites concerned, the presence of habitats or rare and threatened taxa, and the threat category of the IAPS concerned for these sites. Finally, the last link in this complex chain concerns the plant residue: possibility of storage on site, burial, shipping to a storage centre / suitable treatment, etc.

It is through the cross analysis of all these criteria that the IAPS management tasks of the LIFE project were determined.

Ranking intervention sites

Objectives

The objective is to rationalise the available means of intervention for the sites considered to be priority and whose feasibility is considered acceptable. Thus it is not a question of simply aiming to eradicate IAPS, which would be both unrealistic from the technical point of view and inappropriate from the socio-cultural point of view, but a targeted control of IAPS in the sectors where there is confirmed competition with conservation issues, or more precisely with habitats of Community interest. This repositioning is necessary from both a technical and a semantic point of view: the manager does not have the means to intervene everywhere, nor is it necessarily urgent to do so everywhere, and it is also important to conduct fair and necessary interventions without giving the impression of an absolutist crusade.

Methodology recommendations

A double multi-criteria approach was conducted on all sites likely to be concerned by an IAPS management project within the PNCAL territory:

- › assessment of a level of the need for intervention depending on the supposed dynamics of the IAPS present on the site, crossed with conservation issues: Do IAPS pose a direct more-or-less short-term threat to the state of conservation of rare or threatened species or habitats?
- › assessment of a level of feasibility depending on site accessibility and the possibilities of post-uprooting recolonisation by the treated IAPS: Does a well-supervised intervention have a chance of long-term success?

The criteria mobilised for this ranking phase and their modalities are indicated in the table below. The decisions taken for the procedure within each criterion, most of which are qualitative and therefore complex to discretize, were fixed according to expert opinion.

Criterion		Procedure	
Intervention stakes	Dynamics	<p>LOW : numbers / areas stable or with limited growth for several years.</p> <p>AVERAGE : site with confirmed recruitment, limited perspectives for extension due to the configuration of the site or the biology of the species</p> <p>HIGH : site that is emerging, newly discovered or with strong and confirmed progressive dynamics.</p>	
	Conservation issue	<p>LOW: at least one habitat of Community interest and one challenged plant species. Reduced typicity / low numbers</p> <p>AVERAGE : at least one habitat of Community interest and several challenged plant species. Satisfactory cohorts / numbers</p> <p>HIGH : at least one habitat of priority Community interest and one highly challenged plant species. Typical cohorts / important numbers, good general state of conservation.</p>	
Feasibility	Accessibility	<p>GROUND LEVEL</p> <p>FALL-PROTECTION INSTALLATION</p> <p>SUSPENSION</p>	<p>LOW : immediate proximity to a carriage infrastructure.</p> <p>AVERAGE : no carriage track, limited pedestrian approach time, or maritime access.</p> <p>HIGH : final approach time necessarily on foot and over 30 min.</p>
	Risk of recolonisation	<p>LOW : site far from possible sources of recolonisation and essentially barochorous species concerned.</p> <p>AVERAGE : site distant from other IAPS sites but which can be recolonised thanks to the fauna or human intervention, whether voluntary or not.</p> <p>HIGH : site contiguous with possible IAPS dispersion sites, species concerned, zoochorous, anemochorous or with confirmed vegetative multiplication</p>	

Criteria and associated procedures for the assessment of the levels of intervention stakes and feasibility

MANAGEMENT OF INVASIVE ALIEN PLANT SPECIES

By applying this reading grid to each IAPS site within the perimeter of the LIFE project, it was thus possible to determine those for which intervention was necessary, justified and feasible:

Site		Confirmed IAPS	Supposed Dynamics	Areas of natural habitats concerned	Ecological stakes HCl: habitats of Community interest PPPS: protected perennial plant species*		Enjeu d'intervention
Friou Archipelago	Pomègues Sémaphore	<i>Opuntia stricta</i> 300m ²	Average	1,1 ha	High	HCl: Rocks with <i>Limonium</i> (2 472 m ²) PPPS : <i>Echium calycinum</i> , <i>Ephedra distachya</i> , <i>Teucrium polium</i> subsp. <i>purpurascens</i>	HIGH
	Ratonneau - south of Hôpital Caroline	<i>Opuntia stricta</i> 300m ²	Low	2 ha	High	HCl: Dry meadows (3 444 m ²), Rocks with <i>Limonium</i> (6 412 m ²) PPPS : <i>Ephedra distachya</i> , <i>Limonium pseudominutum</i> , <i>Malva subovata</i> , <i>Teucrium polium</i> subsp. <i>purpurascens</i>	HIGH
<i>Agave americana</i> 50m ²		Low	Average				
Western coast	Calanque du Mauvais Pas	<i>Carpobrotus</i> sp. 50m ²	High	0,1 ha	Average	HCl: Phrygana (288 m ²), Rocks with <i>Limonium</i> (191 m ²) PPPS : <i>Astragalus tragacantha</i> , <i>Plantago subulata</i>	AVERAGE
		<i>Agave americana</i> 20m ²	Low				
Calanques de Sormiou	Sormiou north shore	<i>Agave americana</i> 50m ²	High	8 ha	Average	HCl: Limestone scree (13 183 m ²), Limestone cliffs (13 552 m ²) Rocks with <i>Limonium</i> (2 095 m ²) PPPS : <i>Teucrium polium</i> subsp. <i>purpurascens</i>	AVERAGE
		<i>Medicago arborea</i> 50m ²	Average				
		<i>Agave americana</i> 50m ²	High				
	Sormiou Cancéou	<i>Opuntia stricta</i> 10 à 50 m ²	Low	2 ha	Average	HCl: Limestone scree (372 m ²), Limestone cliffs (1 964 m ²) Rocks with <i>Limonium</i> (19 095 m ²) PPPS : <i>Limonium pseudominutum</i>	HIGH
Riou Archipelago	Jarre	<i>Opuntia stricta</i> 500 m ²	Average	0,5 ha	High	HCl: Rocks with <i>Limonium</i> (1 965 m ²) PPPS : <i>Limonium pseudominutum</i> , <i>Teucrium polium</i> subsp. <i>purpurascens</i> , <i>Thymelaea hirsuta</i>	HIGH

Extract from the intervention stakes level analysis table

We also observe through this analysis that the nature of the IAPS concerned is in fact not very important. The threat level indicated in the regional strategy (Major, Moderate, Emerging, etc.) is an average, a trend assessed on the regional scale. This criterion did not seem to be sufficiently precise for analysis at this scale: indeed, each IAPS can behave differently according to the territory, e.g. more dynamic on a limestone substrate than on a siliceous substrate, in a coastal location or inland, etc. For example, this is the case for *Oxalis pes-caprae*, which is very dynamic in siliceous Provence but much less so on limestone. Nonetheless, this plant was observed on Frioul at the start of the project and was immediately the subject of an intervention.

The determining element in this stage of ranking is thus the prior flora and fauna habitat diagnosis of the site: what is the state of conservation of the ecosystem? Can a problem related to the presence of an IAPS be treated to enable the ecosystem to recover its functionality? If yes, what site parameters should be taken into account to truly bring a gain in biodiversity and avoid doing more harm than good?

In view of this, it is important to recall that the habitat map created within the framework of the Natura 2000 objectives document (DOCOB) is at the heart of this work and that it is therefore essential that this map be drafted in the most rigorous way possible.

Lastly, the figures above do not mention any criteria concerning the evacuation of plant residue or what will become of this green waste. It nevertheless became evident that these questions are such determining factors that a works project can only be envisaged if we already know how to answer them.



Proliferation of prickly pear on the Hôpital Caroline cliffs (Frioul-Ratonneau) before the uprooting operations of the LIFE Habitats Calanques project.

■ IAPS inventory between Sainte-Frétouse and Bec de l'Aigle

Objectives

This site had been identified in the initial LIFE proposal as one of the priorities of intervention due to its singular nature and, at the time of drafting, the absence of an equivalent in the literature. Nevertheless, the estimates of the surface area occupied by the IAPS were rather imprecise, dated, and also lacked a feasibility analysis for a management operation on these unstable terrains.

The first step of this focus on the siliceous cliffs of Cap Canaille thus consisted in updating the occurrence data for the IAPS along the coastline, on the vertical parts of the coast only, classified as a habitat of Community interest and therefore the only areas on the site that were eligible under the LIFE project. A visit to the upstream environments of the cliffs was also made to assess the degree of colonisation of these sites and consequently the risk of post-uprooting recolonisation. The intervention area is represented in the figure below; the proposed layout enables the restitution of the photos by possible sector of intervention.



Location of sectors concerned by IAPS mapping on the cliffs between Sainte-Frétouse and Bec de l'Aigle

Methodology recommendations

As this work treated more or less vertical environments (cliffs, rocky slopes, etc), a "classic" restitution on an IGN type map (SCAN25, Orthophoto®) was not considered as pertinent. Indeed, the squashing or distortion of the relief on this type of medium does not enable a precise and appropriate reading of the realities of the terrain. Moreover, this work must be able to feed the specifications of future uprooting operations for specialised companies: the "photo" type rendition is all the more readable and comprehensible when it can easily be completed with other logistic information (access routes, storage zones, etc.).

To meet these constraints, it was decided to reconstitute these data on photographs of the cliffs taken from the sea to obtain full, flat views. The location of the IAPS populations is then directly represented on these photographs. This way, the geolocation of these observations does not follow the usual standards in terms of mapping: only the position of the photograph is georeferenced. Indeed, the GPS plotting of each individual or group of individuals on the cliff face would be at least as time-consuming (given the quantities) as it would be unreadable, because the points would be superimposed one over the other due to the vertical nature of the environment.

To obtain a usable result, it was necessary to take into account the multiple constraints inherent to this site:

- ▶ the absence of faultless anchor points at the top of the cliffs (very few trees, very flaky rock), and thus the impossibility to equip rope access workstations to descend and prospect the cliffs over the distance under consideration;
- ▶ regularly windy sector that complicates the use of a drone with a strong risk of collision with the cliff face, whether it be piloted from the top of the cliffs or from the sea. In the first case, one must add the physical constraint of the relief at the crest of the cliff that blocks the signal between the device and the pilot. The second case is complicated by the constraint of a sea landing on a vessel whose stability is difficult to maintain on the often choppy seas, which is a very difficult operation that requires much greater precision than on land. In both cases, the use of a drone is tributary to an overflight authorisation for a site with very high relative stakes for birdlife; a prefectural decree concerning the presence of a couple of Desmarests cormorants covers a significant part of the site;
- ▶ cliff faces consisting of relatively flaky and unstable puddingstone, which are highly irregular with no clear verticality but often small ledges making any progress dangerous for rope access workers due to the risks of falling rocks caused by rope friction. Moreover, the few sectors equipped for climbing are rather old and not very well maintained. Engaging professional operators to work under such conditions cannot be considered.



For all these reasons, it was finally decided to prospect the area with binoculars from the sea on a vessel following the cliffs. This yielded an overview of the cliffs and a better assessment of the relative IAPS coverage as well as the feasibility of a management operation on such a site. After the completion of this maritime prospection, a team of rope access workers attempted a descent down one of the sections presenting the highest conservation challenge and which was already equipped with via ferrata / adventure sports facilities. If the conservation stakes of the zone in question have indeed been confirmed (discovery of new individuals of goat's thorn milkvetch and *Thymelaea hirsuta*), the intervention stakes and feasibility were considered to be too low. There was a confirmed risk of doing more harm than good to the ecosystem (strong risk of erosion), whilst the dynamics of IAPS in these environments seems stable and does not represent a short-term threat.



These complementary investigations (macro scale from the sea and then a more precise sample via rope access) enabled the confirmation, independently of the ecological stakes of the site, that it was not reasonable, or even dangerous, to conduct works under such circumstances.



Location on photo of the clumps of prickly pear on the cliffs of Sainte-Fréousse

Definition of uprooting protocols

SPECIES	UPROOTING PROTOCOL	MATERIAL AND EQUIPMENT	MANAGING RESIDUE
<p>Prickly pear <i>Opuntia stricta</i></p> 	<p>Ground-level cutting and then uprooting individual plants is recommended. These operations must enable the removal of the root system, which can be particularly extensive, especially in rocky sectors.</p> <p>Concerning rope access worksites, it is important to point out that the spiny glochids can be trapped in the ropes.</p> <p>Before any intervention, it is necessary to verify the subjacent substrate in order not to provoke serious post-elimination erosion phenomena. If the substrate shows a risk of flaking, it is recommended not to remove the prickly pears in one operation, but to proceed with progressive uprooting in order to allow time for the native species seed banks present in the soil to develop and limit erosion.</p>	<ul style="list-style-type: none"> - garden gloves worn under thick washing-up gloves to protect from glochids (spines) - a hoe and/or a firemen's axe with a pick at the opposite end to avoid the need of picking up cut fragments directly with the hands - potholing suits provide almost total protection but imply work operations outside of the summer season 	<p>No fragments of prickly pear should be left at the end of work, as this will almost certainly ensure the revival of the species. It is not recommended to export the plant litter because the seeds of other local species may be found in it, as well as ground invertebrates that contribute to the natural degradation of these seeds. The necessary repeat operations will take care of eliminating new shoots and will exhaust the <i>Opuntia</i> seed bank.</p>
<p>Century plant <i>Agave americana</i></p> 	<p>As the century plant mainly propagates via a vegetative process, manual uprooting of the stump is recommended, making sure to remove the small rosettes that are in formation, more or less buried, and which follow the root filaments of the mother plant and rhizomes. Concerning these, which are often of an imposing size, it is recommended to initially cut (e.g. using a saw-knife) the leaves as close as possible to the stump to enable it to be uprooted more easily. It may be useful to keep the leaves at the top of the plant for leverage.</p> <p>A prior quick cut of the leaf tips, which are likely to cause the most injury, gives easier access to the heart of the stumps. Small individuals may be uprooted using a pickaxe only. For larger individuals, the additional use of a miner's bar enables the heart to be uprooted little by little. The trunks of the largest individuals can be cut with a sabre saw to facilitate transport.</p>	<ul style="list-style-type: none"> - a pickaxe (for small individuals) - pruning shears to cut the tips of leaves - a sabre saw to cut the leaves - a miner's bar to uproot the plant by exerting leverage - PPE, especially reinforced protective clothing, is essential given the very harmful nature of the spines. Certain persons may have a rather serious reaction to the sap of century plants. Therefore, it is important to protect the arms and stomach when handling them and the eyes when cutting them. 	<p>The exportation of residue to waste treatment plants is not necessarily a priority as the species does not grow from cuttings like other crassulescent species. Nevertheless, the volume of the leaves and stumps of certain individual plants may dictate their evacuation, including from a landscape point of view (visual impact). Moreover, the fibres contained in the leaves are highly resistant and persist over time before degrading entirely.</p>

SPECIES	UPROOTING PROTOCOL	MATERIAL AND EQUIPMENT	MANAGING RESIDUE
<p data-bbox="247 450 421 501">Moon trefoil <i>Medicago arborea</i></p> 	<p data-bbox="517 423 842 703">Ground-level cutting and then uprooting individual plants is recommended. Nevertheless, these operations must not be carried out on individuals bearing fruit because these could fall, especially during transport, and replenish the ground seed bank or, even worse, generate colonies in new environments.</p>	<p data-bbox="868 423 1107 551">- a pickaxe (for small individuals) - a winch system for the largest individuals</p>	<p data-bbox="1155 423 1426 703">Moon trefoil can be destroyed by grinding and thus supply a product that is potentially usable in green spaces (RCW). The usefulness of leaving this mulch on site should be considered due to its high nitrogen content and its physical-chemical impact on the soil.</p>
<p data-bbox="247 999 421 1050">Moon trefoil <i>Carpobrotus edulis</i></p> 	<p data-bbox="517 972 847 1379">Manual uprooting of pigface is effective and relatively simple. Before any intervention, it is necessary to verify the subjacent substrate in order not to provoke serious post-elimination erosion phenomena. If the substrate shows a risk of flaking, it is recommended not to remove the pigface mat in one operation, but to proceed with progressive uprooting in order to allow time for the native species seed banks present in the soil to develop and limit erosion.</p>	<p data-bbox="868 972 1131 1050">Uprooting pigface can be done by hand without any specific equipment.</p>	<p data-bbox="1155 972 1426 1561">The efficacy of the control is increased when the residue of the species is removed from the site. The residue can be evacuated with care, avoiding the dispersion of seeds, or dried in the sun (making sure not to allow the roots to come back in contact with the ground). In sloping places, it is nonetheless recommended to roll up the pigface mat to form swaths, the weight of the whole left in the sun will promote the decomposition of the plant. However, this implies closer monitoring of new shoots during the first years.</p>

The transport of residue must be defined according to the accessibility of the site, its topography and the distance to be travelled. This can be done:

- ▶ with wheelbarrows, if practical for the terrain,
- ▶ with a grape picking basket,
- ▶ with stretchers that can easily be made for the occasion: the use of bamboo poles combines lightness with flexibility. Handles can be made at the extremities by wrapping the bamboo with successive layers of good quality masking tape that will not slip in the hand. For the fabric, prefer sail canvas or oilcloth; thick tarpaulins will be too heavy.

Procurement and selection of tenders

Uprooting operations on cliff faces require specific skills and equipment. Therefore, specifications were developed by Calanques National Park and the CBNMed concerning uprooting on five cliff sites (Jarre, Bec de l'Aigle, Sugiton, Pierres Tombées, Hôpital Caroline). The tender process was launched in January 2019. The proposals were assessed according to a price criterion (40%) and a criterion of technical value (60%).

The latter criterion was divided into a number of sub-criteria:

- › the environmental measures and methods implemented to prevent the degradation of natural environments and the risk of IAPS dissemination (25%);
- › the detailed provisional schedule by site, specifying the duration of the operation and the number of persons mobilised (25%);
- › the means deployed to carry out the operation, the equipment, the methodology for uprooting, removal and treatment, as well as staff safety (25%);
- › the specially qualified human resources for this operation (25%).

The works were entrusted to a group of companies consisting of Agir Écologique (a company specialising in environmental engineering) and La Compagnie des Forestiers (a company specialising in rope access work in natural environments). As required, they are supported by companies specialising in the installation of anchor points necessary for their intervention and for the helicopter transport of residue.

A second call for tenders was launched in March 2022 for uprooting and removal from the Sémaphore de Pomègues site (Frioul), as well as the removal of residue from an in-house uprooting operation in the autumn of 2022 (Fort Pomègues).

CONSERVATION MANAGEMENT

■ IAPS treatment

Flat uprooting operations

For flat sites, the operations are performed by in-house operators, with the support of the voluntary operations organised by Naturoscope. These operations were able to bring together up to thirty participants. The volunteers were mobilised through various channels depending on the sites and the public targeted. For operations requiring little labour, communication was simply an email invitation sent to the members of the various neighbourhood interest committees concerned and to neighbours whose awareness was raised via informational meetings. For operations requiring greater mobilisation, different channels of communication were used: Facebook publications relayed by the project partners, dissemination on the websites of Calanques National Park and Naturoscope, press releases, the mobilisation of volunteer networks (WWF, Marseille Autrement, J'agis pour la nature, company employee "team building"). The size of the public informed by this communication generated over 150 replies and requests (messages, phone calls, email), which required a significant amount of time for the registration process. To facilitate the organisation of the various operations, a preparatory technical sheet was developed and a prior visit to the site was made. For substantial operations, a prior in-house operation facilitated the intervention of volunteers.

These flat uprooting operations concerned five sites for an uprooted surface area estimated at 836 m² and an estimated total residue weight of 31.46 tonnes. The removal of residue was performed manually with classic equipment (improvised stretchers, wheelbarrows, sacks, grape picking baskets). The residue was essentially handled by tipper trucks belonging to the City of Marseille or by a specialised company for incineration.

SITE	DATE	UPROOTED AREA (M ²)	WEIGHT (TONNES)
Calanque de Ratonneau	March 2019	50	9
Mont Rose	February 2020	272	7.76
Pomègues fish farm	March 2020	239	8
Saména	March 2021	115	4
Cap Croisette	March 2021	160	2.7
TOTAL		836	31.46

Estimation of uprooted areas, weights and volumes for the main flat uprooting operations



Mont Rose uprooting operation – January 2020



Uprooting operations in Ratonneau in March 2019 with ground markings for the authorised path

These operations are both management actions and opportunities to raise public awareness. A photographic identification guide of the IAPS to uproot, but also of the local protected species to avoid trampling was distributed to participants. The volunteers were generally highly motivated despite the difficulty of the tasks. The uprooting of certain species, notably including the prickly pear, is a substantial operation with major risks of injury and irritation. The operation must also be sized to ensure that it can be completed once it has been launched.



NB : a cliff uprooting operation is scheduled for Pomègues Island in autumn 2022 for an estimated total surface area of 990 m².

It is important to remember that most of the sites treated are home to populations of several rare and threatened species. As the trampling caused by the repeated passage of operators and volunteers can have a significant impact on these species, the operators of the CBNMed and PNCAL previously identified and marked routes for the circulation of operators and the removal of residue according to the location of the most sensitive species. Storage areas must be previously identified and materialised. The sectors where the IAPS coexisted with these rare and threatened species were treated in-house without volunteer assistance.

After each operation, the areas that have just been uprooted can impact the landscape and negatively affect the users of the natural area. The removal of all residue and the clearing of rocks attenuates this effect. Nevertheless, this degraded landscape remains very temporary, as the wind and the first rains erase the traces of the operation.

Cliff uprooting operations

These cliff uprooting operations concerned five sites for an estimated uprooted surface area of 9346 m² and an estimated total weight of 114.47 tonnes of residue. These uprooting campaigns enabled the restoration of over 22 hectares of natural habitats. The removal of residue from uprooting sites was performed manually, via zipline or helicopter transport and then taken in charge by tipper trucks to be composted by Biotechna. Part of the residue was also able to be stored on site (Jarre, Sugiton-Pierres Tombées).

SITE	DATE	UPROOTED IAPS AREA (M ²)	AREA OF RESTORED NATURAL HABITATS (HA)	WEIGHT (TONNES)	VOLUME (M3)	NUMBER OF BIG-BAGS HANDLED
Jarre Island	January-March 2020	988	18.6	20.8	69.6	693 (100 L)
Bec de l'Aigle	June 2020	67	0.25	2.07	3.9	69 (100 L)
Frioul (hôpital Caroline)	September-November 2020	6 891	2	83.3	348	348 (100 L)
Pierres Tombées - Sugiton	January-March 2021	1 400	1.4	8.3	44	383 (100 L)
TOTAL		9 346	22.25	114.47	465.5	

Estimation of the uprooted surface areas and weight for the main cliff operations



NB : two cliff uprooting operations are scheduled for Pomègues Island (slopes of the Fort and the Sémaphore) for autumn 2022 for an estimated total surface area of 1220 m².

For intervention on the targeted sites, it was necessary to take into account a number of ecological, but also technical, constraints. For this purpose, the selected service providers proposed to Calanques National Park an adapted methodology that provided a response to the particularities of each site.

Ecological constraints

Located in the core area of the National Park, the intervention sites are concerned by specific regulations. The providers were thus obliged to give special attention to:

- › the non-introduction of potentially competitive plant species in the island environment;
- › the consideration of seabird nesting periods in the operations schedule;
- › the presence of protected plant species to be avoided at all stages of the operation (access to the site, temporary big-bag storage, sack handling, dangling ropes and friction on the cliff faces, etc).

Technical constraints

The experimental nature of this type of operation also entailed a certain number of constraints that had not necessarily been foreseen upstream. These situations required adaptation and a certain amount of flexibility on the part of the companies. The double speciality of the group retained for the first contract (interventions in natural environments and the consideration of environmental issues) provided real added value during the works phase.

CONSTRAINT	TECHNICAL SOLUTIONS AND ADAPTATION
No possibility of residue removal by land, lack of jetty facilities	<ul style="list-style-type: none"> - Onsite storage of all or part of the residue - Use of a semi-rigid boat
Unfavourable weather conditions (sea route)	<ul style="list-style-type: none"> - Adaptation of the operations schedule
No possibility of motorised machine circulation for residue removal	<ul style="list-style-type: none"> - Manual removal - Zipline installation - Helicopter transport
High level of tourist traffic	<ul style="list-style-type: none"> - Closure of visitor access during the period of works on unstable areas (signs, Rubalise® barricade tape)
Risk of falling rocks, residue thrown from the cliff	<ul style="list-style-type: none"> - Risk assessment (safety diagnosis) - Job phasing to avoid simultaneous operations on the cliff face and at its base
Difference between the project owner's and the service provider's estimation of the surface areas to be uprooted	<ul style="list-style-type: none"> - Prior update of map documents with the integration of the slope into the calculation of surface areas - Prior field visits
Strong appropriation by IAPS users	<ul style="list-style-type: none"> - Upstream awareness-raising and communication by the project owner - Measures for the reduction of the landscape impact of the operations



Rope access work and manual removal, Jarre Island operation



Slopes at Hôpital Caroline before/after the uprooting operation



Removal of residue by zipline, Sugiton/Pierres Tombées operation

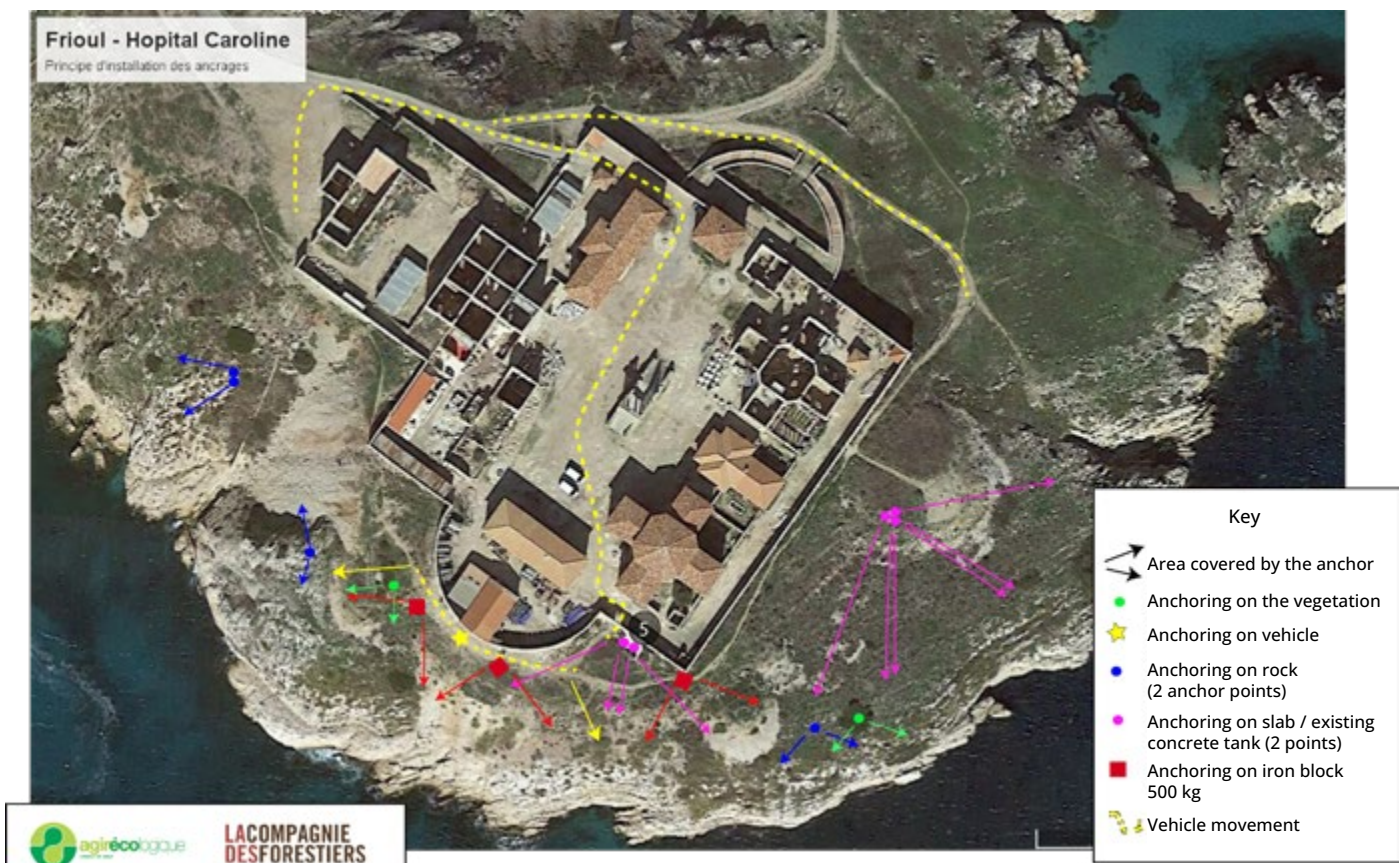


Diagram of the installation of anchor points at Hôpital Caroline © Agir Écologique

Managing residue

The handling of IAPS residue proved to be the most difficult challenge of these uprooting operations. Indeed, the prickly pear and moon trefoil have seeds almost year-round, which creates a major risk of recolonisation if the residue is abandoned on the sites of the operations.

Four lines of residue management were thus tested within the context of the project:

➤ **Onsite storage:** this is the first solution to envisage, especially if the configuration of the site allows it.

Removal from the Jarre site presented a difficult technical challenge due to the island location and the absence of jetty facilities. The identified storage area was a dip with very little plant cover by the sea. The residue was mostly transported there by air (zipline). This accumulated residue was cut up again in order to limit the capacity for the regeneration of individuals. It was concentrated on one part of the dip to limit the surface occupied and to increase the number of layers to favour natural decomposition. Storage in several layers, accentuated by the effect of the sea spray, caused the rapid degradation of the lower layers.

Storage under a tarpaulin was tested with smaller quantities of prickly pear and pigface on Frioul. An inspection after two years, without turning over the swaths during this period, revealed that the residue had revived on its own base.



State of decomposition of the lower layers in the Jarre Island storage area

Like the seed banks present in the soil, onsite storage areas can create a risk of recolonisation of the natural area by the IAPS. Storage must thus be regularly managed. The zones designated for storage must also meet a certain number of criteria:

- › be easily accessible to be able to receive the residue and enable long-term monitoring;
- › be relatively inaccessible to the general public;
- › be of sufficient size;
- › not be the subject of a mid-term recycling project;
- › have, as far as possible, limited contact with the natural area.

› **Incineration** : on several occasions, the City of Marseille provided tipper trucks to evacuate the IAPS from flat worksites. Considering that these were relatively small volumes, it was decided to incinerate them at the Cartonnerie waste treatment plant in the 11th arrondissement of Marseille.

› **Recycling** : with the study of several possibilities, including the transformation of the hearts of century plants into an alcoholic beverage by the REVEEAL association, and that of prickly pear and century plants for research for composite materials, textiles and glue by Fondation LUMA in Arles. However, these possibilities only concerned a marginal volume of residue.

› **Composting** : the Biotechna company implemented a composting methodology designed to prevent the germination of prickly pear seeds in the final compost. The residue is ground and then mixed with water treatment sludge. The mixture is then placed indoors in cells for 20 days of forced maturation, with a temperature increase up to 80 °C at the heart of the swath. Before leaving the building, the product is sifted and the fine part of the compost is matured on a slab for three months. This compost is then analysed in a COFRAC certified laboratory to verify its compliance with standard NFU 44-095 before commercialisation.

Although this is a good solution from the point of view of ecology and the risk of IAPS propagation, it may lead to significant costs, carbon emissions and the transportation of organic material away from sites that are already relatively lacking in it. For example, the removal of residue from Hôpital Caroline required the helicopter transport of residue from the uprooting site to a tipper truck loading site, road transport to the jetty, barge transport across the bay, and a second phase of tipper transport to Châteauneuf-les-Martigues.



Residue removal diagram for the Hôpital Caroline uprooting operation © Agir Écologique


■ Prevention of IAPS recolonisation

Repeat operations

In order to prevent IAPS recolonisation on the uprooting sites, regular repeat operations must be performed over a period of ten years after the initial intervention. Indeed, like century plant rhizomes or seeds, parts of the prickly pear root system may subsist in the soil. The operations should preferentially be performed outside the period of IAPS fructification, which is generally in winter. It is also necessary to coordinate these operations with the monitoring. It is also necessary to coordinate these operations with the monitoring.

The question of the time span between repeat operations was rapidly raised. The methodology tested provided for annual repeat operations during the first two years, followed by every two years. The efficacy of this methodology is nevertheless conditioned by the volume of IAPS regrowth. If the individuals are too small, the time spent searching for regrowth can be trying for the teams. If the individuals are too big, handling and residue management is more difficult.

Repeat operations are carried out in-house by the operators of each manager/owner under the supervision of the PNCAL and may benefit from volunteer operations.

 **NB :** a certain number of operators of the PNCAL, the Compagnie d'Intervention par Moyens Encordés (CIME) and the CBNMed have been trained for rope access work to carry out repeat operations on cliffs, notably using the permanent anchor points installed by the service providers for the initial uprooting.



Century plant regrowth after initial uprooting on the Frioul fish farm site



Rosemary plantation (Rosmarinus officinalis – Lamiaceae)

Cultivation of local plants

The initial proposal provided for the replantation of local plants after uprooting on certain sites. This planting aimed at boosting the recolonisation by local species on environments made bare and to limit erosion on slopes.

However, after more in-depth study, it was observed that uprooting sites generally have a sufficient capacity for natural recolonisation. Moreover, feedback from the field tends to show that to guarantee a satisfactory survival rate, planting requires very regular maintenance (watering), which is difficult to do in areas of difficult access. Lastly, it appears that planting can generate an obstacle to the expression of the local seed bank and thus to recolonisation by a cohort of species that is more diverse and better adapted to the environment than the one that could be replanted (Couturier, Geoffroy, Jailloux, Besnard, 2019).

Moreover, planting operations may give neighbours and users the impression that natural dynamics necessarily need to be assisted, that nature must be gardened to remain in good health, with the consequence that individual and even collective initiatives aim to contribute to these dynamics. Unplanned planting at Mont Rose after uprooting operations was thus the object of a reminder of the prohibition of gardening in the heart of the National Park.

Thus, a proposal was made to replant very frequented sites only, in order to accompany uprooting with a "positive" action, as these projects can be perceived as a violent act by part of the inhabitants or users. Indeed, although certain IAPS species are appreciated by the public for their ornamental value (especially pigface), others, due to their imposing size and the danger of injury, can be used as barriers and serve to mark the limits of a property. Surveys were thus conducted around each future uprooting site to determine the vegetal range to cultivate. Seeds and cuttings were then collected on the uprooting sites to be cultivated in City of Marseille nurseries, according to protocols drafted under the supervision of CBNMed. The seedlings were then transplanted at Mont Rose, Sugiton-Pierre Tombées and in pilot gardens. Certain seedlings were also distributed during awareness days (Calanques Mobile or Jardins d'Albertas open days). This action also aimed at improving the skills of City of Marseille operators concerning the identification and cultivation of local species, in order to develop similar practices for urban areas.

Pilot gardens

One of the problems of IAPS management lies in the fact that many inhabitants and users consider them as local species that are part of the landscape. Significant outreach work is thus essential to accompany uprooting and develop public awareness. After explanation, most people understand the value of uprooting (see "assessment"). For this purpose, several levers of communication were activated within the framework of the project, notably including pilot gardens.

Pilot gardens are private gardens around the National Park where owners cultivate IAPS. These latter were offered support for the replacement of IAPS by local species. Eight diagnoses were thus conducted with private individuals, groups and neighbourhood committees. The objective of these diagnoses was to identify the eligibility of applications with respect to a certain number of criteria: the ecological value, maintenance capacity, deployment scheduling, educational value and the swarming capacity of the approach with the neighbourhood.

After agreement with the LIFE partners gathered in a monitoring committee, the pilot garden contact persons were invited to sign an act specifying the nature of their commitment towards local flora. On its part, the LIFE project undertook to advise them on IAPS uprooting and residue removal, on selecting the species and quantities of local plants to replant, to provide seedlings, and to participate in the organisation and implementation of the operation.

In order to raise awareness and involve a maximum number of neighbours for this approach, uprooting and planting operations associating LIFE partners and volunteers were organised on the five sites retained. Signs were installed at each pilot garden, informing the public of the approach deployed on these plots and to promote the swarming of practices in favour of local biodiversity. Complementary awareness and communication actions were carried out: the distribution of local plants to the neighbours of the sites treated, public conference, press communications, awareness stands.



Pilot garden sign



Planter with a pigface colony, soon to be replaced by local species at Cap Croisette

MONITORING

■ Methodology recommendations

Like any monitoring protocol, it is a question of applying or designing a protocol that provides an answer to a single question. Thus, everything depends on the question asked: Is IAPS regrowth taken into account when sizing repeat campaigns? Are vegetal dynamics taken into account to measure the efficacy of the action? Does photographic monitoring provide an answer to this or must greater botanical expertise be mobilised? Once the guidelines are set, the variables to be measured, their frequency, the dimensions and locations of quadrats, etc., remain to be defined. Finally, it is also important to incorporate the specific characteristics of the site into the protocol design: the nature of the substrate in the case of the installation of permanent ground markers, the accessibility and frequentation of the site (trampling around the quadrats, marker vandalism, etc.), and the risks of the impact of the works on the environment (including disturbance to fauna).

The IAPS management operations undertaken within the framework of the LIFE programme aim to restore the natural coastal habitats to enable the local flora to develop in the place of IAPS. The parameters followed must therefore incorporate a notion of the evolution of the cohorts of flora over time.

■ Monitoring protocols

In order to simplify both the logistics in the field and future data analysis, it was decided to apply an identical monitoring protocol among the so-called "flat" worksites and those on cliffs. This protocol was applied to other IAPS management operation monitoring, especially that of Bagaud in the Port-Cros – Porquerolles archipelago (Braschi et al. 2018).

It consists of circular quadrats of 16 m² within which a phytosociological survey is carried out annually at the same date. The value of this system is that :

- › it involves installing only one permanent ground marker per quadrat, at the centre of the circle, to which can be attached a simple rope 2.25 m in length to visualise the physical footprint of 16 m² around this point. This is all the more relevant for terrain in listed sites and in the core area of the national park, thus limiting landscape issues and disturbing the fauna ;
- › the reference area is the best compromise between the representativity concerning the type of environment and technical feasibility. Indeed, on the cliffs, it is difficult or even dangerous to deviate by more than two metres from the axis of the rope access workstation ;
- › it is already routinely applied to other sites, enabling the results to be compared ;
- › the execution of phytosociological surveys on such surface areas and in such environments is relatively easy. The plant cover there is naturally scarce.



Illustration of a 16 m² monitoring quadrat with a rope attached to the plate in the ground © J.Ugo -CBNMed

■ Periods of execution

This monitoring must be carried out during an optimal period for the observation of flora and to objectively appreciate their cover, ideally in the middle of spring. Indeed, certain annual and bulb species may only be visible a few weeks a year. Moreover, as one of the key variables of this system is this relative cover of each species over a given area, it is essential that the measurements are taken at the same dates from year to year.



NB : repeat operations may falsify the reading of post-operation trajectories if they also cover monitoring quadrats. Good coordination between the partners responsible for repeat operations and those in charge of monitoring is therefore necessary.

■ Monitoring frequency

As this monitors plant dynamics after uprooting, annual monitoring is sufficient if it is performed rigorously (same dates, same weather and pressure during observation), ideally by the same observer from one year to the other.

LIFE PROJECT FEEDBACK

■ Action execution schedule

		2017		2018				2019				2020				2021				2022			
		III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Preliminary studies	Ranking intervention sites																						
	IAPS inventory																						
Conservation management	Flat uprooting operations																						
	Cliff uprooting operations																						
	Repeat operations																						
	Cultivation of local plants																						
Monitoring	Monitoring																						

■ Indicative costs

Costs related to IAPS management are the third most important expenditure item of the LIFE project, after trail development and awareness and communication actions. IAPS uprooting services on cliffs, and the removal and treatment of residue thus represented over 400,000 euros.

The following table details a certain number of costs that the manager must take into account during works scheduling.

NATURE OF THE COSTS	UNITS	PRICE INCL. TAX
75 anchor points with a 10-year guarantee	fixed price	€36,000
IAPS uprooting	m ²	€24 - €38 depending on the site and species
IAPS removal	m ²	€30 - €100 depending on the site and the method used
IAPS treatment	m ²	€5 - €8 depending on the method used
Cliff safety diagnosis	fixed price	€7800

Indicative costs of services related to IAPS management on cliffs



NB : the cost of residue removal and treatment were largely underestimated in the initial proposal. Thus, uprooting operations cost much more than planned. Residue management is a central question in budget assessment for this type of intervention.

■ Overall results

The uprooting operations of the LIFE project (flat works, cliff works, pilot gardens) enabled nearly 200 tonnes of IAPS to be uprooted to restore over 22 hectares of coastal environment favourable to remarkable plant species. Over 80% of the uprooted volume corresponds to prickly pear residue and 20% to century plant residue. The volumes of moon trefoil and pigface uprooted within the framework of the project remain marginal.

However, the exported residue does not represent the total amount treated, because part of the residue (century plants from Pierres Tombées, prickly pear from Jarre and moon trefoil from Ratonneau) was stored on site for desiccation or ground up. The estimation of uprooted volumes and areas remains approximate. However, the management actions enabled the co-construction of methods of estimation that were shared among managers and service providers.

The volumes of residue were monitored by the number of Big-bags removed, for which an average weight was estimated, for final transportation to a waste treatment centre. This enabled the estimation of area / species / weight / volume / cost ratios, which were useful to prepare works operations.

	AREA	WEIGHT	BIG-BAG
Prickly pear	1 m ²	35 kg	BB of 1000 L = 200 to 250 kg = 6.5 m ² treated
Century plant	1 m ²	50 kg	1BB of 1000 L = 100 kg = 2 m ² treated

Indicative area / weight / volume ratios for prickly pear and century plants

The importance of the definition of the methods of residue management when preparing the operation (method, place, guarantee of non-dissemination after the operation, cost) is to be noted.

Locally, the operations were sometimes met with a certain hostility. Several times on Frioul, the provider's teams had to employ pedagogical skills to explain the validity of these management operations. Thus, some of the island's inhabitants remain opposed to this type of operation, regardless of the method used. In Pierres Tombées, a regular user who had planted IAPS in the planters of the nudist beach launched an online petition¹ which received a certain amount of support (30,000 signatures). Awareness-raising and communication are thus fundamental and largely remain to be developed on the territory with a view to future uprooting operations, especially in the inhabited Calanques or on sites with significant visitor traffic. However, although the operations sometimes create agitation, this generally stops when they have finished, the former presence of the IAPS may be totally forgotten within a few weeks.

A new communication strategy implemented by the CBNMed was delivered at the end of the project and will reinforce the argument of PNCAL, City of Marseille and CD13 operators concerning these problems that are largely misunderstood by the general public.

■ Outlook

On the continent, certain sites with high environmental stakes were not able to be uprooted within the framework of the project. Discussions must be continued with the owners-managers to build plans of action and funding.

Under the impulse of the LIFE project, the outline of the strategy to combat IAPS on the scale of the National Park are starting to materialise. The major principles of this strategy propose the total eradication of IAPS on the islands in the mid-term, as the risk of recolonisation there is limited and easier to control.

Reflection on the permanent storage and composting of IAPS residue on Frioul is also in progress, as several areas present favourable characteristics. A study was launched to identify a treatment process that can be carried out in-house and which enables the substrate to return to the soil through the destruction of the germination power of residue.

¹ Petition: Stop au massacre, arrachage intempestif des Cactées dans les calanques de Marseille, absurdité économique et eugénisme écologique contre des plantes utiles et présentes depuis 50 ans (mesopinions.com)

REINFORCEMENT OF AWL-LEAVED PLANTAIN POPULATIONS

- General issues and objectives
- Preliminary studies
- Conservation management
- Monitoring and assessment
- LIFE project feedback

GENERAL ISSUES AND OBJECTIVES

Context

The awl-leaved plantain (*Plantago subulata* L., 1753) is a perennial plant of the Plantaginaceae family. In the strict sense, according to the conception of the genus by the French Mediterranean flora (Tison et al., 2014), it is only observed on the north-western shores of the Mediterranean Sea (France, Spain, Italy). In France, it is only observed in the departments of Pyrénées Orientales, Bouches-du-Rhône and Var; a single very ancient observation made in the Alpes-Maritimes (Ardoino, 1879) has never been repeated.

The awl-leaved plantain develops preferentially in haloresistant coastal garrigue; it is one of the characteristic structural species of the Astragalo tragacanthae-Plantaginetum subulatae Molin. 1934 (Noble & Baret, 2019). This habitat is well represented in the Calanques massif around Marseille. Its state of conservation is rather unequal in this territory: quite good on Frioul but rather clearly degraded on the continental coast west of the Calanques. Conversely, the awl-leaved plantain populations are in relatively good condition on the continent, but are in clear decline on the Frioul archipelago. Two main studies of the dynamics of its populations reveal worrying signs of its demographic regression (Amm et al. 2005; Born et al. 2008), which are demonstrated by:

- › increased necrosis associated with a strong individual mortality rate;
- › a low recruitment rate or even the absence of regeneration;
- › low reproductive success despite the absence of predators and a large number of flowers per inflorescence. This low reproduction rate may be linked to the quality or quantity of pollen, the low density of the population, or a problem of resources (water, substrate).

Of the 521 individuals counted in 2003 on Ratonneau Island, only 146 were to be found in 2015, and less than fifty in 2020 (Le Mire – Pecheux, comm. pers.). There appear to be several causes: trampling by very numerous visitors, soil eutrophication due to the large concentration of yellow-legged gulls, polluted sea spray from the bay of Marseille, "harsher" climate on this highly mineral archipelago, etc.

Overall objectives

In the light of these observations and considering the significant reduction of part of the causes of this insular decline (trail development, improvement of water quality in the bay of Marseille), it was decided to reinforce the populations on the Frioul archipelago in order to compensate the natural deficit of seed germination and to reconstitute a viable island population.



Awl-leaved plantain

PRELIMINARY STUDIES

■ Objectives

Given the speed and extent of the decline of the awl-leaved plantain on the Frioul archipelago, the action provided for under the LIFE project had to take on the form of an emergency rescue, with all the necessary methodological and technical precautions.

Considering:

- › the very small number of individuals and viable seeds on Frioul, as well as the very low in-situ germination rates;
- › the need to be able to closely monitor the efficacy of this operation, which is easier with plants that are already well individualised;
- › the experience of the CBNMed with the production of plants under controlled conditions.

It was decided to produce a little over 500 awl-leaved plantain seedlings in the ex-situ conservation facilities of the CBNMed and to replant them on Frioul after a maximum of six months of cultivation. Planting was carried out in two phases, the first half in 2018, the other half the following year. The seeds required for these operations were all derived from the island populations of awl-leaved plantain to be reinforced, the source populations, around which the produced seedlings were then planted.

■ Methodology recommendations

The very first methodological recommendations concern the strategic choices of the protocol design, notably including those that imply cultivation under controlled conditions rather than direct sowing. Given the speed of the decline of the species on the island, it was not possible to undertake extensive studies on the genetic structure of the populations. These studies may have enabled the validation of the hypothesis of a mix of seeds from the continent, thus compensating the seed deficits of the archipelago. In the absence of such a study, this hypothesis was eventually discarded through the precaution principle: the risk of allogamous depression could not be eliminated. Moreover, even though direct sowing is much more economical in time and energy, it implies more complete monitoring and above all a greater quantity of seeds, which was not conceivable with the source populations of Frioul alone.

The historical data concerning the awl-leaved plantain on the Frioul archipelago being rather well localised, reinforcement sites other than those of current occurrence were not sought. Its long-term absence from other sites, despite a priori favourable conditions (relatively well represented phrygana throughout the archipelago) was a major argument for the restriction of the operation to its historic sites. The value of a two-phase reinforcement campaign such as this is to be able to adjust the second campaign according to the feedback from the first. The adjustments made during the second planting campaign are given in the following chapters

■ Authorisation

As it is a protected species, and because the populations concerned are located in the core area of the National Park, two authorisations are necessary to carry out this operation: the waiver of article L411-1 of the French Environmental Code ("protected species" waiver via CERFA form 13617*1) and the authorisation of the Director of the National Park for the sampling of plant species in the core area of the park. These two applications were accompanied by a letter explaining the details of the operation (nature, number, dates and places of sampling, identity of the operators, etc.).

CONSERVATION MANAGEMENT

■ Seed sampling

Methodology recommendations

Once the administrative authorisations have been obtained, the usual technical precautions for seed harvest were taken:

- › uniformly distributed sampling over the entire population;
- › the harvest of entire infructescences for sorting in the laboratory (counting, weighing, etc) and to avoid losses in the field;
- › the harvest of a maximum of 20% of the infructescences per individual to avoid significant impact on the natural reproduction of the species;
- › temporary storage of infructescences in paper bags (greengrocer type bags) using one bag per population and bag labelling for the traceability of future operations;
- › bags placed in a dryer for at least two months to limit losses through rotting.

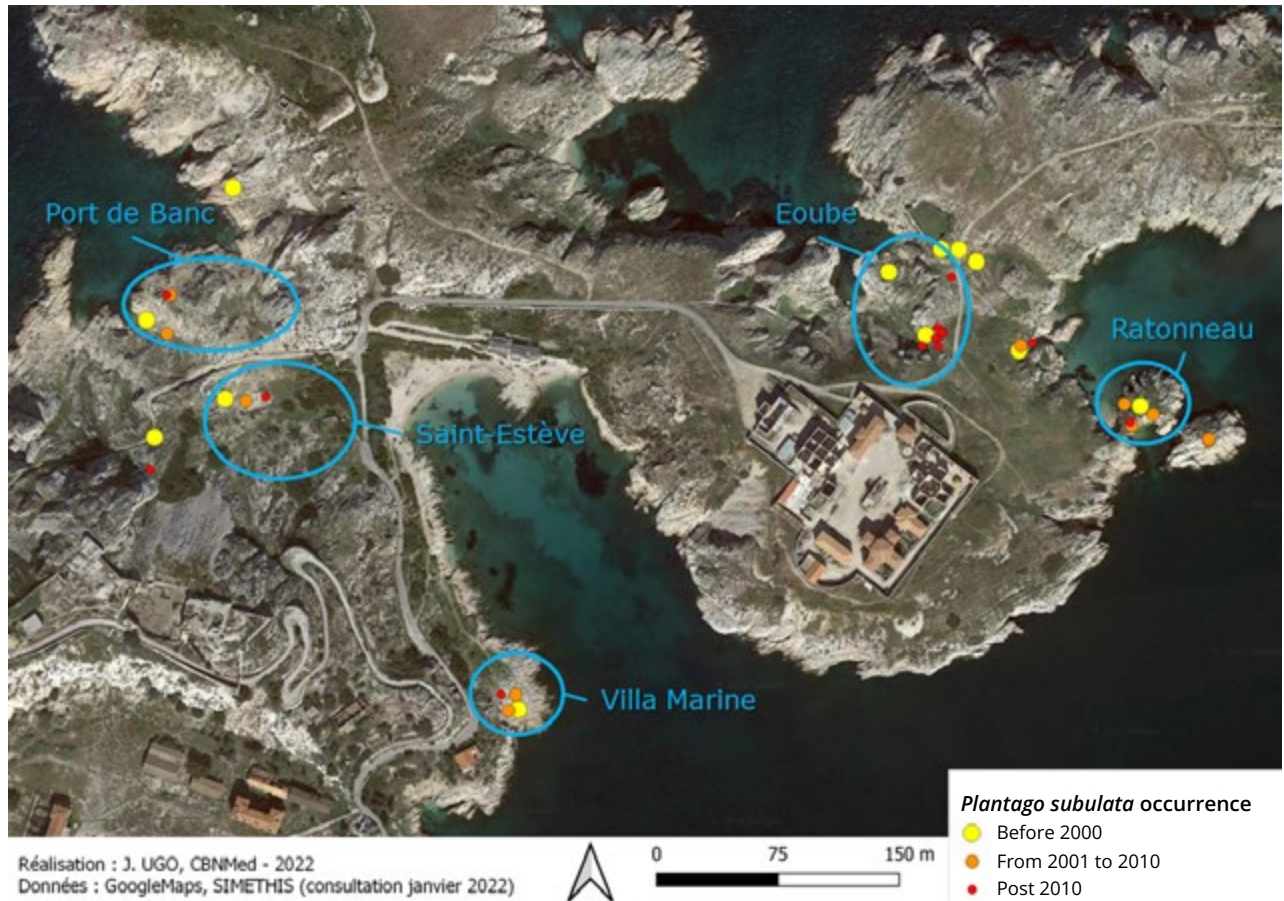
For this particular species, manual infructescence sorting was particularly time-consuming and tedious. In the absence of automated sorting equipment, it is important not to neglect this time when calculating the operation, especially for an operation such as this. Indeed, the timing between harvests (July 2017) and planting (September 2018) should take into account the time for desiccation, seed sorting, germination tests for the selection of the most effective method, and cultivation (6 months). Everything must flow in a smooth progression to avoid delaying planting, which itself must be programmed just prior to the first autumn rain.

Procedure

The summer period decided for the seed harvest naturally depends on the phenology of the plant, which is variable from one year to another according to weather conditions. The period was carefully assessed thanks to the field observation of the PNCAL rangers, who directly inform CBNMed agents of the state of the plant.

Like planting operations, seed harvests are carried out in two phases. Two CBNMed agents accompanied by a PNCAL ranger went to Frioul in late June 2017 for the first harvest. This same configuration was reproduced in early July 2018 for the harvest required for the second planting in 2019. Each harvest session lasted a half day, including boat transport from the continent and the approach to the various sites on foot. These sites are represented by the blue envelopes in the figure below.

LOCATION OF AWL-LEAVED PLANTAIN SITES
ON RATONNEAU ISLAND IN FRIOUL



During the harvests of the summer of 2017, only the Saint-Estève, Eoube and Ratonneau sites were sampled. The Port de Banc site was considered to be lacking in terms of seed production, while the Villa Marine site was considered too "mineral" and too frequented by tourists to be the site of this type of planting operation. During the summer 2018 harvest, the Port de Banc site was sampled along with the three other previously targeted sites.

■ Cultivation

Methodology recommendations

The CBNMed possessed the results of previous awl-leaved plantain germination tests, which enabled the selection of methods considered favourable from the first campaign, without wasting precious seeds on less appropriate methods. This was particularly useful at this stage considering the small number of seeds harvested during the first campaign.

As it is a species that is subservient to coastal rocks for which the almost total absence of soil is one of the main characteristics, the choice of the soil mixture to place in the seeding pots was essential. The objective was to find a suitable substrate, while respecting the "frugal" nature of the plant. One part of the seedlings was thus placed in pots filled with soil brought directly from Frioul, mixed with stones that also came from the site, and completed with organic potting compost. This operation required a new special request for authorisation to remove soil from the core area of the park, which was quickly granted due to the stakes. In the light of the rather inconclusive results of this experiment (no growth, no better survival of plants than for a standard substrate), it was not repeated for the second campaign. The standard mixture used for the other part of the 2018 plantings was used for all plants in 2019, i.e. a third of potting soil (Citepro TP01 UAB), a third of topsoil (Richeterre brand) and a third of golf substrate (4SPRO). This decision to homogenise cultivation conditions enabled non-negligible time savings during the weekly monitoring of plants in the nursery.

Procedure

The seedlings derived from germination tests, begun in mid-November 2017 and recorded daily, were immediately placed in anti-bunching pots (7x7x14 cm) with the previously detailed substrate mixture and, at first, placed in a greenhouse in Porquerolles with light watering every two or three days. The plants thus gradually arrived in the greenhouse according to their germination and remained there until mid-March 2018, when the temperatures are more clement, before placing them under a shade structure. Watering was then performed when considered necessary, depending on the state of the seedlings and weather conditions, throughout the spring and summer of 2018. The same procedure was followed for the cultivation of the second campaign (from November 2018 to summer 2019).

■ Planting

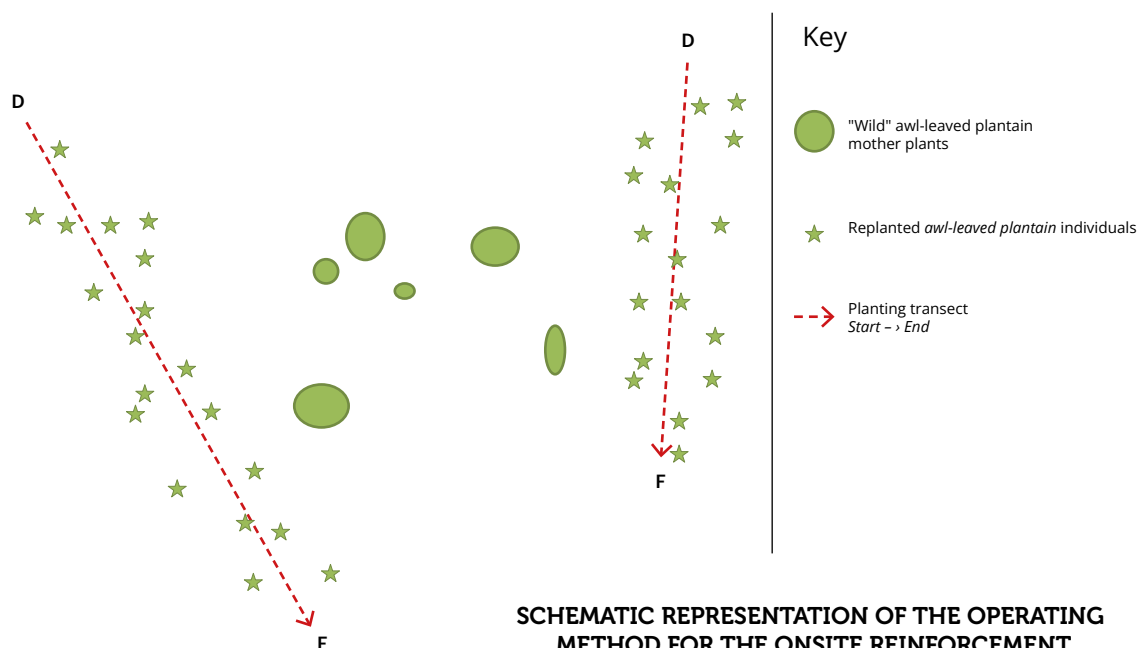
Methodology recommendations

As mentioned above, the decision was made to respect the origin of the seedlings as far as possible and to replant them near their mother plants, or within the same mother populations. This constraint conditioned planting due to the very limited availability of "diggable" surface in these sectors; indeed, the awl-leaved plantain favours rocks and bare coastal garrigue where the vegetation can only express itself in small pockets wedged between rare cracks in the rock. This, associated with the presence in the soil of numerous other rare and threatened plant species, some of which are protected, made a day of field reconnaissance prior to the operation essential. The objective was to estimate the number of plants per site that could reasonably be planted, the accommodation capacity of the environment, considering both the favourable nature of the habitat as well as the potential risks of degradation.

Regarding this, it was decided not to mark these plantations on the ground: no conspicuous markers, no signage or no-go zones. Indeed, these installations generally attract visitors, who are curious to see what is going on, thus generating significant trampling as well as occasional acts of vandalism. This choice was motivated by the trail network development on the archipelago several years ago and which today appears to be quite well respected. It is not rare to observe off-trail wandering, but this remains marginal and the planting sites were for the most part located at a distance from these paths potentially used by visitors. This also had consequences on the planting layout as well as on the monitoring methods detailed in the dedicated chapters.

Planting layout

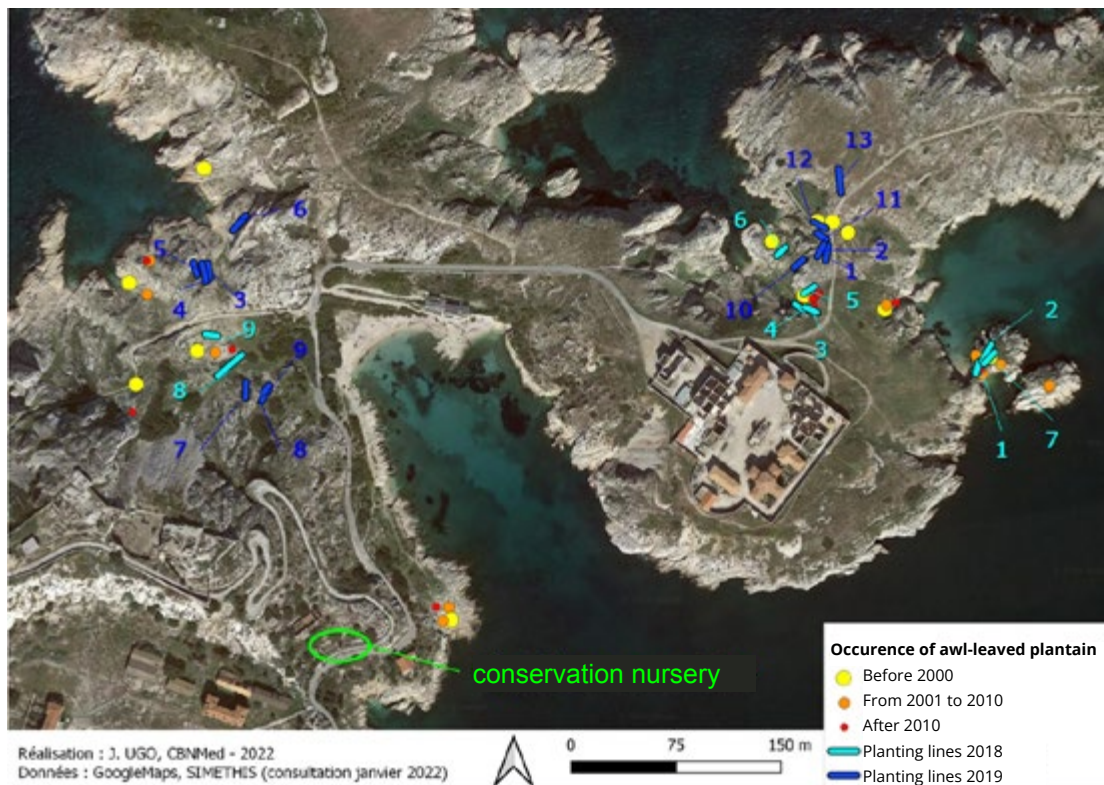
The choice of the planting sites was conditioned, as mentioned above, by respect for the origin of the seeds: each seedling produced would have to be replanted in its original site. To facilitate reconnaissance during later monitoring, the seedlings were organised, depending on the availability of soft soil, along lines that were materialised by a decametre as shown in the figure below. This system enabled the notation of the "coordinates" of each seedling according to its position along the decametre and its distance from it:



The 2018 plantings concerned the Saint-Estève, Eoube and Ratonneau sites; 204 pots of awl-leaved plantain were distributed in nine planting rows. A batch of 95 seedlings mixing all island sites was also made for installation in a conservation nursery located near the natural sites. This nursery, developed with the assistance of students of the Natural Environments and Fauna Management Professional Bacalaureate at Calanques agricultural high school two weeks before the 2018 plantings, was the first part of a project for a botanical garden organised by the PNCAL and the City of Marseille. In 2019, considering the feedback from previous plantings (see the "feedback" section), the Ratonneau site was not retained and the Port de Banc site was finally chosen: 291 pots of awl-leaved plantain were planted there in thirteen rows.

These rows and the location of the conservation nursery are shown in the figure below.

LOCATION OF THE CONSERVATION NURSERY AND THE 2018 AND 2019 PLANTING ROWS WITHIN THE AWL-LEAVED PLANTAIN POPULATIONS ON RATONNEAU ISLAND IN FRIOUL



Procedure

The first planting campaign on the Frioul archipelago took place on 25 and 26 September 2018 and mobilised the equivalent of 18 person-days. The 295 individuals planted were distributed as follows:

- › 48 seedlings at the Eoube site;
- › 72 seedlings at the Ratonneau site;
- › 84 seedlings at the Saint-Estève site;
- › 91 seedlings at the conservation nursery (mix of the 3 sites).

The second planting campaign took place on 30 September and 1 October 2019 and mobilised the equivalent of 13 person-days. The 291 individuals planted were distributed as follows:

- › 122 around Eoube Calanques;
- › 111 seedlings at the Port-de-Banc Calanques;
- › 58 inland from Saint-Estève beach.

The numbers of seedlings per site were determined by the availability of substrate in habitats considered as favourable. In both cases, the plants were watered once a week during three weeks by PNCAL agents, with an average of five 20-litre jerrycans used per session.

MONITORING AND ASSESSMENT

■ Methodology recommendations

The choices adopted in terms of monitoring protocol design must be suitable for the characteristics of the species and, above all, of the planting site, while providing a response to this simple question: what is the seedling survival rate after planting?

It is, in fact, these principles of simplicity and sobriety that governed the choices:

- › to note only the "living/dead" status of the seedlings. Variables concerning their vigour, such as the number of leaves per seedling or the diameter of the rosettes, are too tributary to edaphic and microclimatic conditions that are not normalised here. Moreover, the size of the seedlings does not correlate with their survival;
- › to make these plantations as discreet as possible (no conspicuous markers, no information signs). This meets several obligations related to the nature of the site. The landscapes on the Frioul archipelago are highly mineral, with low-lying vegetation, thus it was not conceivable to disrupt this identity with additional installations, even more so in the core area of the National Park.

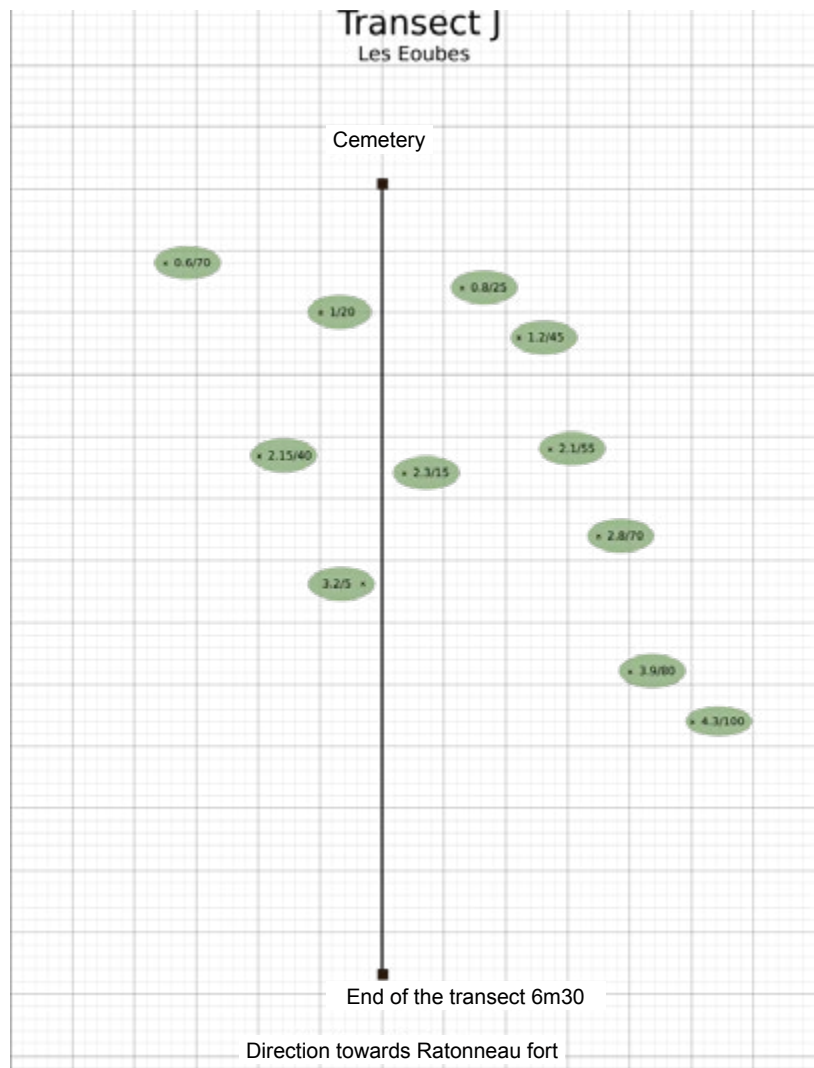
As for the choice of the periodicity of monitoring sessions, it must be carefully studied taking into account all the parameters of the site in question. In this case, the springtime sessions were significantly constrained by the territorial behaviour of the yellow-legged gull, which is then in the midst of its mating season. Certain couples had in fact built their nests in the middle of a planting row in Calanque d'Eoube. Being a bird that does not abandon its nest at the slightest perturbation, the impact of this disturbance on the species is minimal but should not be neglected for other species.

■ Monitoring protocols

The objective of the monitoring implemented on these plantations is to be able to measure the survival rate of plants after planting. The planting procedure was therefore designed with this in mind: the extremities of the rows were materialised by semi-permanent markers fixed into the rock (anchor plates used for climbing), enabling a decameter to be fixed there to easily find the seedlings, whose coordinates had been previously noted during planting (distances in centimetres along the axis and perpendicular to it) as shown in the figure opposite.

The status of the seedlings (living or dead) was noted at each session, as well as any flowering / fructification. On their part, PNCAL agents performed the annual monitoring of wild awl-leaved plantain individuals on Frioul; this information is necessary to inform them of any new germination near the plantation rows.

EXAMPLE OF A TRANSECT PLANTING MONITORING PLAN



■ Periods of execution

The first monitoring session of each campaign was carried out one month after planting, and then every three months during one year, followed by every six months in the second year, and finally once a year from the third year.

LIFE PROJECT FEEDBACK

■ Action execution schedule

		2017		2018				2019				2020				2021				2022				
		III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	
Preliminary studies	Diagnosis and definition of the strategy	■	■																					
	Application for authorisations	■	■																					
	Germination test			■	■			■	■															
Conservation management	First campaign	Seed harvest	■																					
		Cultivation			■	■																		
		Planting					■																	
		Watering					■																	
	Second campaign	Seed harvest				■																		
		Cultivation							■	■														
		Planting								■														
		Watering								■	■		■	■										
Monitoring and assessment	First campaign monitoring					■	■	■	■	■	■		■	■					■				■	
	Second campaign monitoring										■	■	■	■	■		■		■				■	

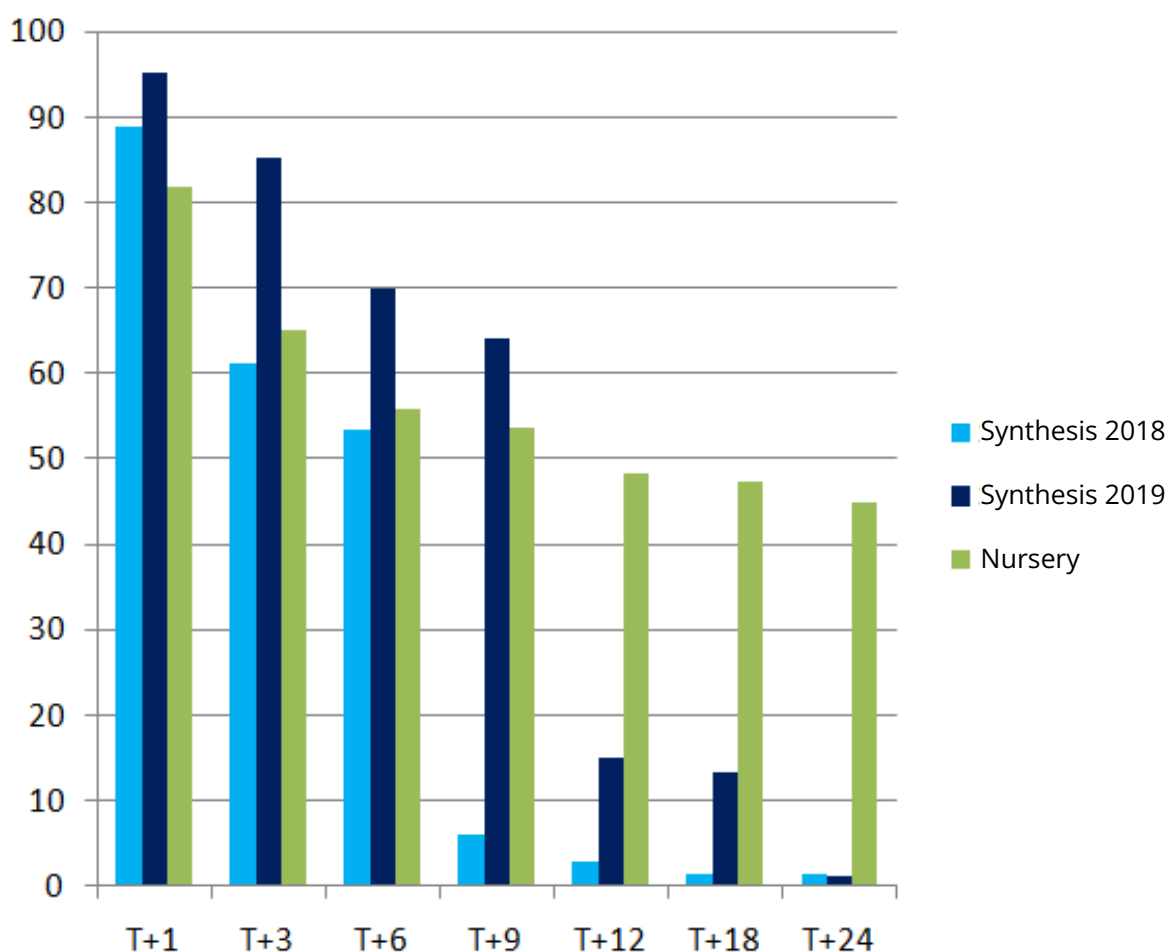
■ Material and equipment used

The choice of 7 x 7 x 14 cm anti-bunching pots was appropriate with respect to the root systems of the produced seedlings because some of them were indeed very vigorous after six months of cultivation and their roots had started to grow out of their pots. However, their depth of 14 cm was sometimes a problem during planting: the very mineral nature of the reinforcement sites did not always allow digging to such a depth. This reveals the difficulty in finding the best compromise between the vigour of seedlings, cultivation methods and maintenance costs.

■ Results

The figure below presents the average survival rate by year of planting and by monitoring session (T + X months after planting)

AVERAGE SURVIVAL RATE OF AWL-LEAVED PLANTAIN SEEDLINGS IN ALL SITES BY YEAR OF PLANTING (2018 / 2019) AND BY MONITORING SESSION (T+X)



Even though it is too early to make an assessment after only two years of post-planting monitoring, some information can nonetheless be drawn from this initial data:

- › the cumulative survival rates decrease by 10% to 15% from the first month for the 2018 planting, probably revealing some mishandling while planting. Certain seedlings were indeed very vigorous and their roots had developed outside of their pots. Unpotting these individuals probably damaged their root system, thus fragilising their replanting. The seedlings produced in 2019 were much more homogeneous and a similar decrease was not observed during the first monitoring sessions of the second campaign over the same time span;
- › cumulative survival rates fell by 30% to 45% in mid-spring for the 2018 plantings. These losses could be due to a serious deficit in precipitation during the winter of 2018-2019. Indeed, between January and March 2019, there was only 15.9 mm of rainfall instead of the 149 mm (i.e. 10% of the precipitation) that on average falls during this same period (source: www.meteofrance.com – reference station Marignane);
- › the catastrophic survival rates found during the monitoring sessions of August 2019 and February 2020 confirmed this trend. No surviving individuals were found on the Saint-Estève and Ratonneau sites, and the rare survivors in Calanque d'Eoub were well developed but in clearly insufficient numbers. The heatwave of 2019 was very certainly fatal for them. This occurred not only during the summer (+15% temperature and -60% precipitation compared with normal conditions during the 3 summer months), but especially during the winter and spring, with a nearly 90% decrease in precipitation between January and March 2019. This phenomenon was probably attenuated for the 2019 plantings by weekly watering during the months of April, July and August 2020. The decrease in the survival rate for the second planting campaign only occurred after the summer of 2020, and in a less pronounced way than in 2018 (15% survival rate for the 2019 plantings one year after planting, compared with less than 3% for those of 2018 over the same time period);
- › over the same one-year time span, the survival rate of the seedlings installed in the conservation nursery, more sheltered from the wind and with a little more available soil, was around 50% and seemed to stabilise after the second year of monitoring. The seedlings were not watered there, and only light weeding was regularly carried out by PNCAL agents;
- › it was only after the second year after planting that the 2019 seedlings reached the same survival rate of around 3% as those of 2018, very likely due to the absence of watering during the summer of 2021.



Awl-leaved plantain individual found among tufts of Allium commutatum

The most significant and quickly detected effect was the explosion of a population of *Allium commutatum* at the Ratonneau site. Bulbs of this garlic had been removed from plantation holes during the operation, most of which were fragmented by digging, which contributed to its multiplication around the planting site, to the point of exerting strong competitive pressure from the following spring.

■ Discussion and prospective

Even though the monitoring sequence is very short and the fact that it is difficult to draw a firm and definitive conclusion concerning this operation, the available elements lead to a negative assessment. Negative for both the awl-leaved plantain itself, the decline of which on the archipelago seems to continue despite our combined efforts, but also for the manager and the CBNMed, which invested human and technical resources to carry out this operation.

Occasional trampling was observed (A. ROBIN – PNCAL, pers. comm.), but that alone cannot explain such a decline in survival rates. As mentioned earlier, the summers of 2018 and 2019 were particularly hot and dry. It is quite possible to imagine that seedlings raised under a shade structure during 6 months, even originating from mother plants from Frioul (thus genetically adapted to the harsh local conditions), suffered some difficulty to adapt on site after being pampered for several months.

Another hypothesis can be made: the fact that all the seeds from which the seedlings were grown came from Frioul, from a population on the decline estimated at a few dozen individuals. A probably genetically depleted founding sample, bearing the causes of its own decline, lacking sufficient potential for adaptation. Although it seemed urgent to intervene, and the means deployed for this operation can be judged as adapted to the location of the species and the constraints of the site, this operation was evidently too late to contain this decline on the Frioul archipelago.

REINFORCEMENT AND (RE)INTRODUCTION OF GOAT'S THORN MILKVETCH POPULATIONS

- General issues and objectives
- Preliminary studies
- Conservation management
- Monitoring
- LIFE project feedback

ISSUES AND OBJECTIVES GLOBAL

■ Context

In the south of France (Provence), the distribution of the goat's thorn milkvetch population is very sporadic along a peri-urban coastal strip at the gates of the Marseille metropolitan area in the Bouches-du-Rhône (Marseille, La Ciotat) as well as in the Var (Saint-Cyr-sur-Mer, Six-Fours-les-Plages and La Seyne-sur-Mer) for a total of 4919 individuals (Baumberger et al. 2021). It is a remarkable fact that 88% of the individuals are located in Calanques National Park (Bouches-du-Rhône department) and 12% in the Var department. In addition, around 70% of the individuals develop in areas near Marseille, with 45% of these in the coastal Calanques sector and 25% on the Frioul (Pomègues and Ratonneau) and Riou archipelagos.

Goat's thorn milkvetch can develop on polluted soils with metal and metalloid trace elements (MMTE) originating from past industrial activities on the peri-Marseille coast at sometimes very high concentrations (Laffont-Schwob et al., 2011; Salducci et al., 2019). This tolerance could be explained by the capacity of goat's thorn milkvetch to establish two types of root symbiosis that may facilitate MMTE sequestration in the root system and its rhizosphere, limit their transfer to the aerial parts of the plant and thus give it a selective advantage to develop in soils lacking water and nutrients (Laffont-Schwob et al. 2011).

Various *in natura* studies of its population dynamics since 2005 have revealed worrying signs of its demographic regression (Affre et al. 2015), which are manifested by (i) moderate reproductive success, (ii) a low recruitment rate (seedlings and young plants) or even the absence of regeneration, and (iii) an increase in individual necroses associated with (iv) high adult mortality. Indeed, most individuals (66.3%) show signs of necrosis above 10%, and 22% of individuals have a foliar necrosis above 50% (Baumberger et al. 2021). Thus, population dynamics decrease sharply and regularly (population growth rate less than 1).

The causes of the decline of goat's thorn milkvetch are multi-factorial and it is difficult to distinguish a predominant factor. On one hand, urban infrastructures (habitations, roads, paths) on the peri-Marseille coast have led to a dramatic loss and degradation of its favourable habitats, with the disappearance of at least four previously observed populations (Baumberger et al. 2021). On the other hand, abiotic stress (violent wind, strong levels of salinity and drought), the dramatic organic and inorganic pollution by water and sea spray due to maritime traffic and the discharge of treated wastewater have led to a certain individual mortality (Robert-Peillard et al. 2015). Similarly, intense visitor and recreational traffic combined with the natural competition generated by plant species characteristic of coastal garrigue and invasive alien plant species (pigface, century plants, prickly pear) have increased the regression of its populations (Affre et al. 2015).



Necrosed branches of an Astragalus tragacantha

In this context, although the restoration of the habitats is a good approach to preserve threatened plant species, certain factors like the limited dispersion of diaspores and transitory ground seed banks render the spontaneous renewal of plant populations in restored habitats difficult or even impossible (Godefroid et al. 2011). A more effective restoration measure to conserve threatened plants consists of the translocation of individuals, i.e. the voluntary removal of individuals from natural populations with the aim to establish a new population (introduction), re-establish a population that has disappeared (reintroduction), or to increase an established population (reinforcement) (Menges 2008). Indeed, the translocation of individuals in the form of seeds compared with seedlings yields an extremely low success rate (Menges 2008).

■ Objectives

In the light of these observations and within the framework of the LIFE Habitats Calanques project, it was decided to perform a demographic rescue of the goat's thorn milkvech by transplanting seedlings *in natura* in 8 pre-existing sites (reinforcement of the Mont Rose, Saména, Calanque des Trous, Escalette, Goudes, Maronaise, Cap Croisette and Marseilleveyre sites) and in 4 favourable new sites (introduction/reintroduction in the Sémaphore, Mounine, Batterie Marseilleveyre and Queyrans sites) in order to increase the potential of connectivity between existing habitats.

LOCATION OF THE TRANSPLANTATIONS OF ASTRAGALUS TRAGACANTHA SEEDLINGS IN THE REINFORCEMENT SITES



Code R in orange, Mont Rose, Saména, Calanque des Trous, Escalette, Goudes, Maronaise, Cap Croisette and Marseilleveyre and the introduction / reintroduction code I in blue, Sémaphore, Mounine, Batterie Marseilleveyre and Queyrans © PNCAL

PRELIMINARY SCIENTIFIC STUDIES

The rescue of a plant species with a demographic deficit requires prior studies of demographics, genetics and the biology of reproduction in order to be effective (Bottin et al., 2007; Heywood et al. 2018). A group of scientific studies of ecological, reproductive and genetic parameters was performed upstream by Aix-Marseille Université (Institut Méditerranéen de Biodiversité et d'Écologie Marine et Continentale and Laboratoire Population Environnement Développement) in order to unify the knowledge required for the restoration of goat's thorn milkvetch populations.

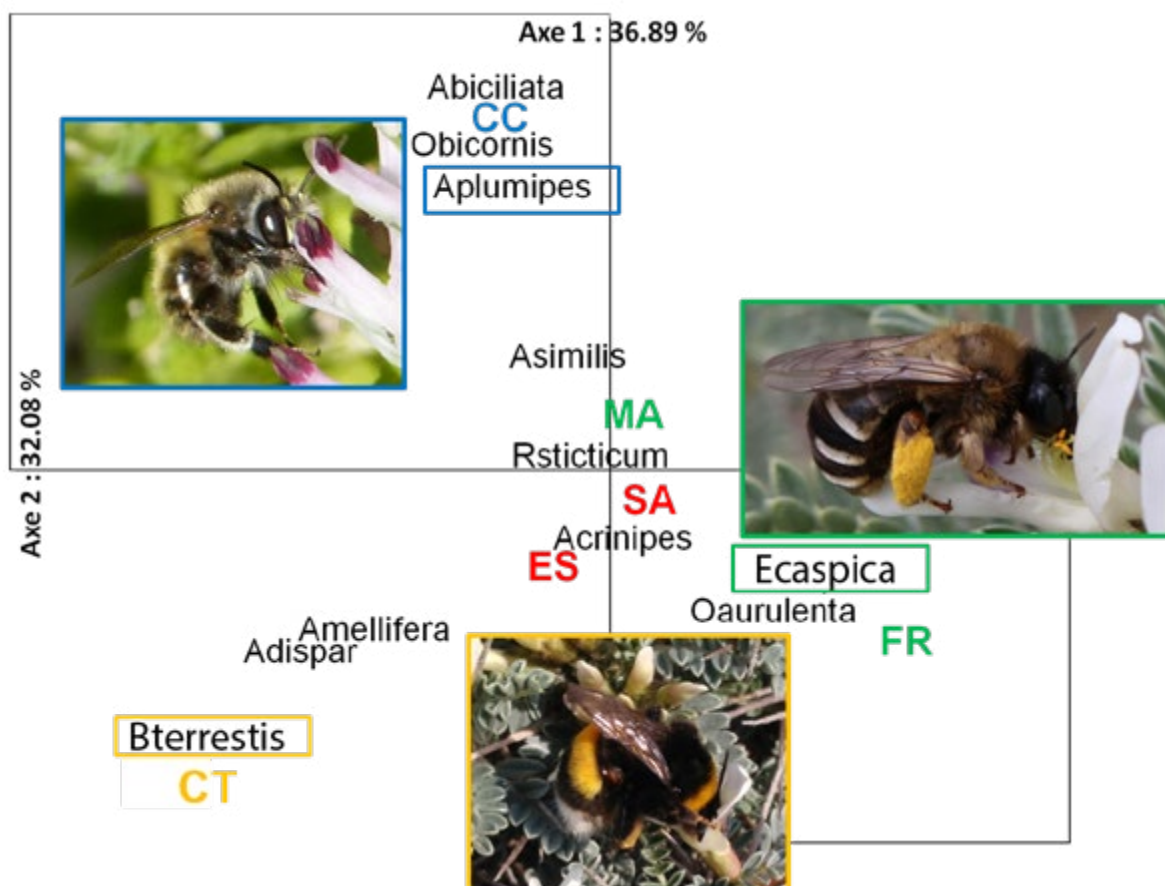
The restoration of plant populations aims to (i) maintain self-supporting genetic populations capable of undergoing adaptive evolutionary change (Guerrant & Kaye, 2007) and (ii) prevent inbreeding depression within the populations and, at the same time, prevent allogamous depression among the populations (McKay et al., 2005). Inbreeding depression is a reduction of the vigour of the progeny resulting from inbreeding, and allogamous depression is a reduction of the vigour of the progeny resulting from allogamous breeding. Moreover, the reproductive success of entomophilous plants can decrease if the pollinators are ineffective or absent. On the other hand, the existence of genetic structuration among the populations also poses the problem of genetic manipulation during population restoration experiments, i.e. the origin of the seeds (Falk et al., 1993; Krauss and Hua He, 2006). For example, weak genetic differentiation among populations allows the use of inter-population seeds of multiple origin to favour genetic variability and improve the long-term persistence of a population, while strong genetic differentiation among the populations requires the exclusive use of intra-population seeds to avoid translocations of individuals with poorly adapted genotypes and to preserve the genetic integrity of each population (Krauss and Hua He, 2006; McKay et al., 2005; Wilkinson, 2001; Sackville Hamilton, 2001; Godefroid et al., 2011).

Thus, the objective of this study consists in characterising the reproductive and genetic particularities of the goat's thorn milkvetch in terms of advantages or handicaps in order to optimise later choices of population management.

■ Reproduction and the activity of pollinators

On one hand, manual controlled pollination and the observation of the activity of pollinators (Schurr et al. 2019) has shown that the goat's thorn milkvetch cannot reproduce by spontaneous autogamy but is auto-compatible. The reproductive success of the flowers thus depends on the visit of pollinating insects. Different guilds of pollinating insects have thus been observed according to the sites, with the predominance of a single pollinating species in most populations, in particular, at Cap Croisette, on Frioul and at Calanque des Trous with the respective predominance of solitary bees *Anthophora plumipes*, *Eucera caspica* and *Bombus terrestris*. In addition, a significative inbreeding depression has been demonstrated only for the Calanque des Trous site and an allogamous depression during breeding between the Cap Croisette site and those of Marseilleveyre and Calanque des Trous. The perennity of goat's thorn milkvetch populations is thus characterised by ecological interdependencies that cannot be neglected for the preservation of this plant.

ANALYSIS BY CORRESPONDENCE OF THE DISTRIBUTION OF THE CAPTURES OF SPECIES ACCORDING TO A. TRAGACANTHA POPULATIONS IN CALANQUES NATIONAL PARK



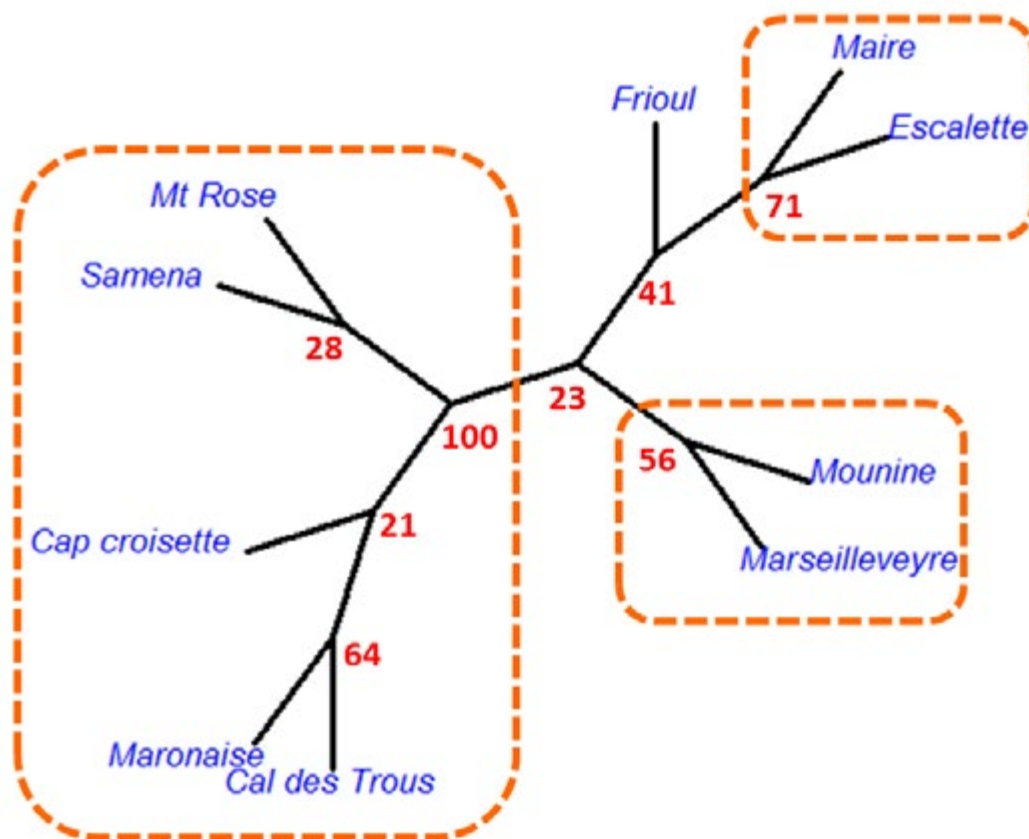
The different colours distinguish the different groups by hierarchical grouping. Sites with the same colour have a similar pollinating guild according to the hierarchical grouping (MA and FR, and ES and SA sites). CC: Cap Croisette, ES: Escalette, FR: Frioul, CT: Calanque des Trous, MA: Marseilleveyre, SA: Saména

ABICILIATA: *Anthophora biciliata*, APLUMIPES: *Anthophora plumipes*, ASIMILIS: *Anthophora similis*, ACRINIPES: *Anthophora crinipes*, ADISPAR: *Anthophora dispar*, OBICORNIS: *Osmia bicornis*, OAUROLENTA: *Osmia aurulenta*, ECASPICA: *Eucera caspica*, BTERRESTRIS: *Bombus terrestris*, RSTICTICUM: *Rhodanthidium sticticum*, AMELLIFERA: *Apis mellifera*.

■ Genetic structuration of populations

On the other hand, molecular analysis of the polymorphism of microsatellite markers (ISSR, Inter Simple Sequence Repeat) on 224 goat's thorn milkvetch seedlings enabled the assessment of the existence of genetic mixing due to sexual reproduction and to assess the genetic differentiation between the sites to help the selection of seed sources. The sampled sites were Marseilleveyre, Mounine, Cap Croisette, Maronaise, Calanque des Trous, Escalette, Saména, Mont Rose as well as the Frioul and Maïre sites to facilitate the comparison of the genetic structure. Thus, a slight deficit of intra-site genetic mixing was observed, which may be caused by inbreeding and/or an aggregate spatial structure of individuals. Moreover, as 89% of the genetic diversity is distributed within the sites and 11% between the sites, the level of genetic differentiation between the sites is weak to moderate with, however, the appearance of three distinct evolutionary groups (i) the Mont Rose, Saména, Cap Croisette, Maronaise and Calanques des Trous group, (ii) the Mounine and Marseilleveyre group, and (iii) the Escalette and Maïre group.

CLOSEST NEIGHBOUR NETWORK OF NEI GENETIC DISTANCES REVEALED BY 37 ISSR MARKERS



The numbers at the level of each branch indicate the bootstrap values varying between 0 and 100% (random selection statistical method with replacement for which a high level indicates a strong signal and significant validity of the branches between the sites)

■ Management choices

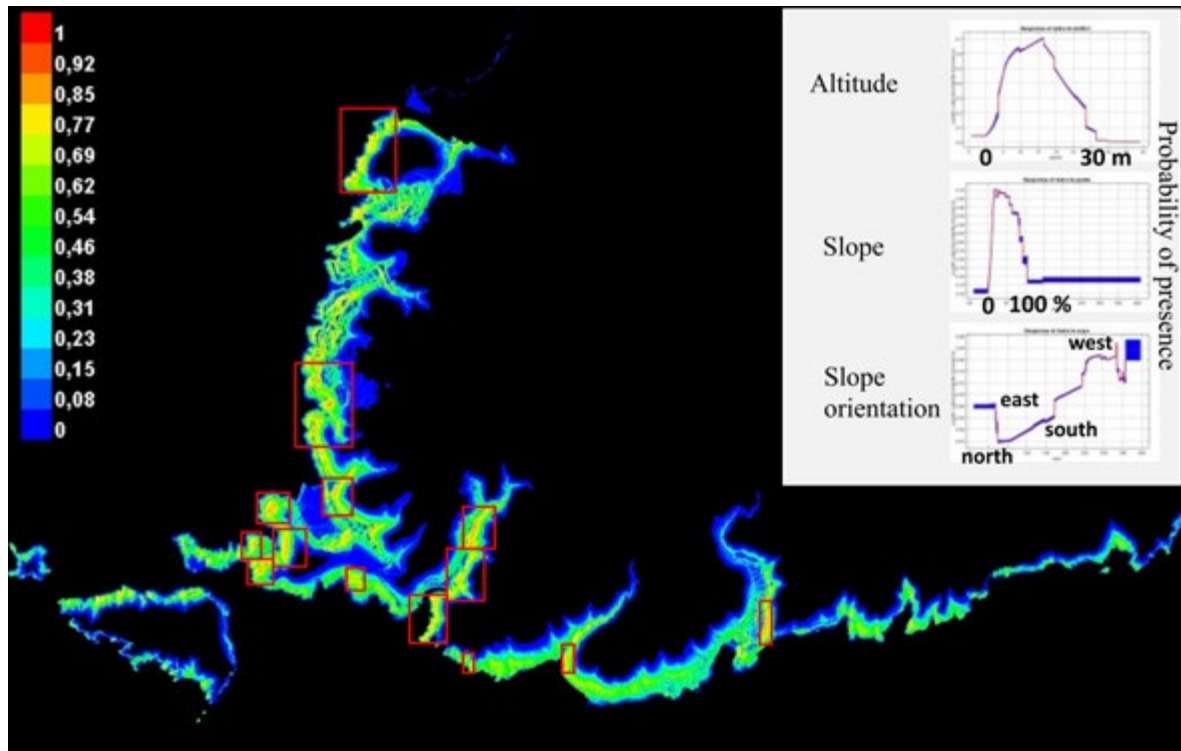
Given these results, it was possible to define how to take into account the origin of the seeds for the restoration of goat's thorn milkvetch populations. Thus, the existence of a genetic mix offers the possibility to collect seeds from different individuals on the same site as long as they are separated by a few metres and to mix all the seeds within each site. However, the seeds could not be mixed between the sites due to the existence of an allogamous depression between the Cap Croisette site and the Marseilleveyre and Calanque des Trous sites. Thus, the reinforcement of the sites was performed only with the seeds of each site without mixing them between sites. Nevertheless, faced with the inbreeding existing only in the Calanque des Trous reinforcement site, the seeds of the nearby Saména and Mont Rose sites (from the same evolutionary group), were mixed with the seeds of the Calanque des Trous site in order to increase the potential of genetic mixing and to reduce inbreeding on the Calanque des Trous site. Finally, concerning the 4 new introduction or reintroduction sites, the weak genetic differentiation between goat's thorn milkvetch populations justified the mixing of seeds from the various existing sites.

■ Model of the physical environment favourable to the goat's thorn milkvetch as an aid to site selection

The objective of this study is to define the quality of the habitats in order to choose the introduction / reintroduction sites. The originality of the method is to combine an empirical approach with a modelling approach. Therefore, the quality of the habitats was modelled using the method implemented by Maxent software on the basis of three topographical variables: altitude, slope and slope exposure, derived from a digital terrain model (DTM) with precision of 0.5 metres (source: IGN source).

Before this modelling, surveys of the flora and the study of habitat variables in existing goat's thorn milkvetch populations demonstrated that: (i) the occurrences of goat's thorn milkvetch are limited by woody plants and altitude, (ii) goat's thorn milkvetch is excluded from coastal garrigue formations, and (iii) altitude correlates with woody vegetation. Thus, most of the occurrences of goat's thorn milkvetch are located at less than 20 metres above sea level. Altitude is the principal substitute for the favourability of the habitat between the sea and woody vegetation, the slope is a substitute for the availability of soil and water, and the orientation of the slope is a substitute for the physical constraints such as wind and sunshine. Then, 2241 points of occurrence of goat's thorn milkvetch (including the occurrence of 104 seedlings) were taken into account. The Maxent method uses combinations of "characteristics" to shape response curves between occurrences and variables. Once adjusted, the response curves are extrapolated to produce a map of potential goat's thorn milkvetch occurrence (favourability map).

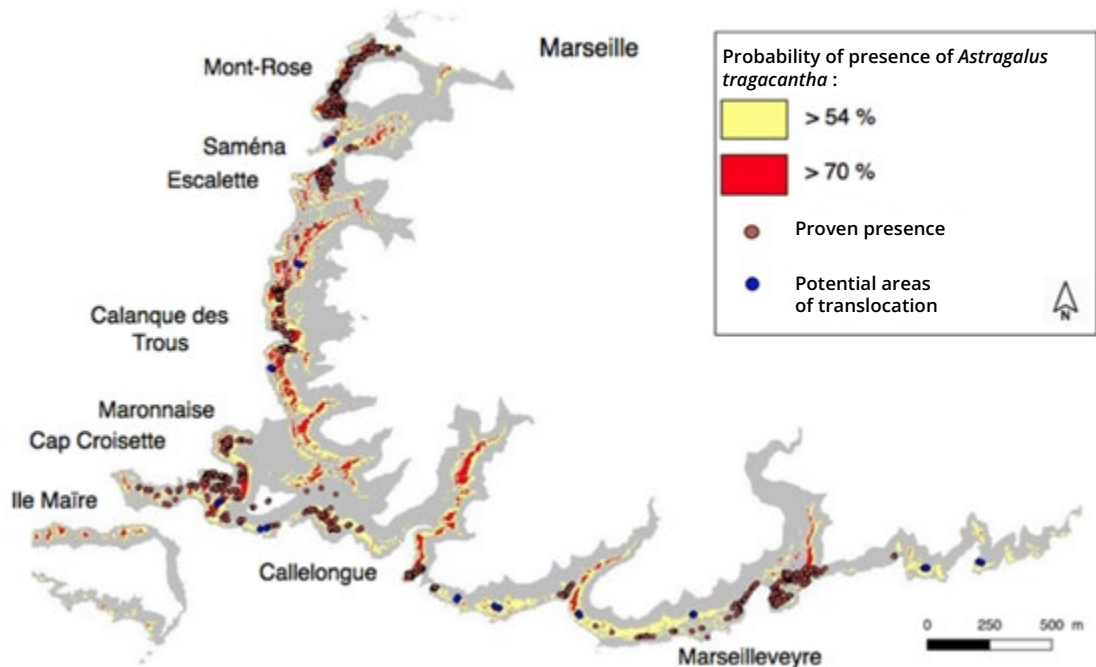
FAVOURABILITY MAP PRODUCED BY THE MAXENT METHOD BASED ON ALTITUDE, SLOPE AND SLOPE ORIENTATION OF 2241 OCCURRENCES OF ASTRAGALUS TRAGACANTHA



All black areas were excluded from modelling. The red boxes on the map indicate favourable areas. The insert shows response curves between habitat occurrences and variables.

The favourability map situated the most adapted sites (favourability scores above 70%) for goat's thorn milkvetch between 5 et 20 m of altitude, on slopes under 100% (45°) and most often oriented to the west, avoiding artificial surfaces (roads, buildings) and the woody plant zones that are unsuitable for the development of awl-leaved plantain. In all, 11 favourable zones were identified manually on a computer.

LOCATIONS OF POTENTIAL SITES (BLUE DOTS) FOR THE REINFORCEMENT OR THE INTRODUCTION / REINTRODUCTION OF *ASTRAGALUS TRAGACANTHA* AFTER FAVOURABLE HABITAT MODELLING BY THE MAXENT METHOD



Red and yellow colours indicate a superior aptitude of 54% and 70% respectively

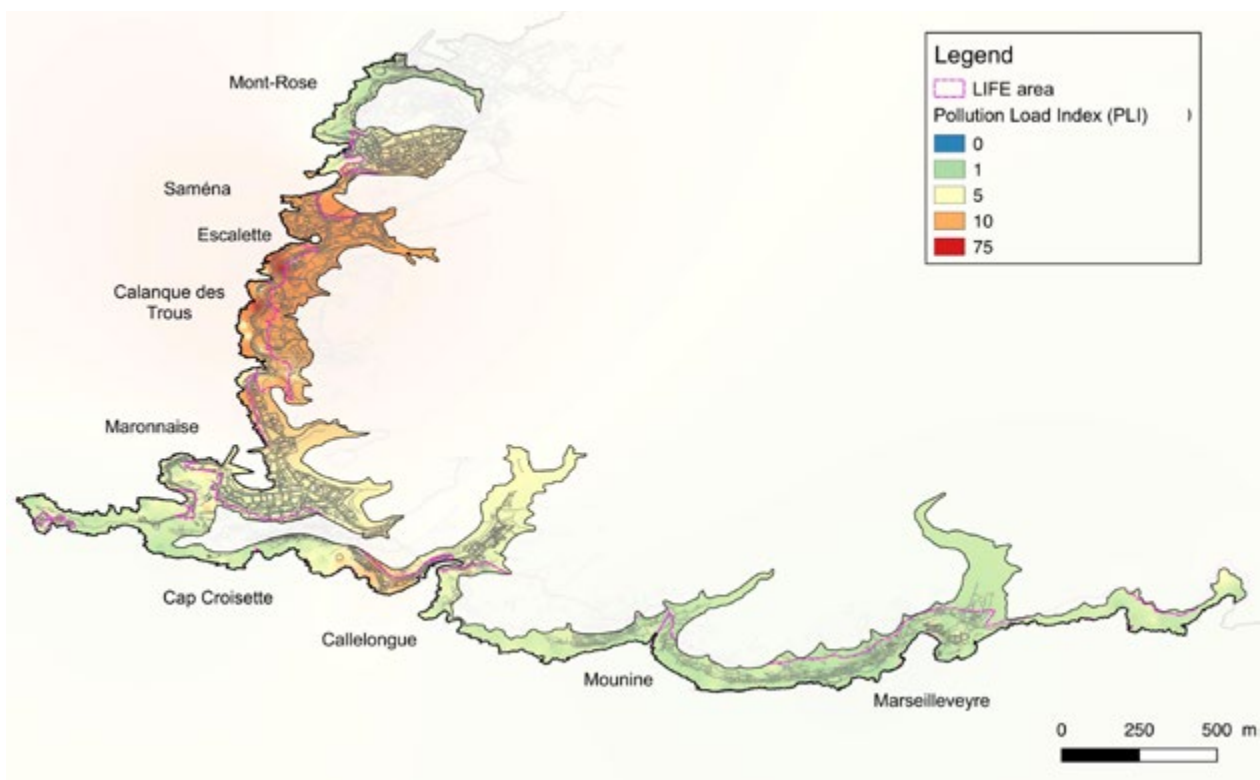
Among the 11 potential zones, five sites are very close to current occurrences of goat's thorn milkvetch and have already been taken into account on the 8 reinforcement sites. The six other sites can be considered as introduction / reintroduction sites in order to increase connectivity between goat's thorn milkvetch habitats. Among these six introduction / reintroduction sites, four are located in the south-western part, where the frequency of goat's thorn milkvetch is reduced, and the two others are located at the eastern limit and can be considered as a possibility to extend the distribution of goat's thorn milkvetch. AMU, CBNMed and PNCAL agents made a joint visit to the six latter sites. Certain sites were thus eliminated from the outset due to difficult access, because planting and watering would be too complicated to perform. Others were abandoned due to their visitor traffic or the composition of plant formations, estimated as being too different from coastal phrygana. Finally, the Sémaphore, Mounine and Batterie Marseilleveyre sites were retained to increase the connectivity between goat's thorn milkvetch populations, and the Queyrans site to extend its local distribution area.

The Batterie de Marseilleveyre site was the subject of discussions due to its rather distant location from the coast, behind a pine wood and with low-lying garrigue (heather) which could lead to a closure of the environment. It was nevertheless maintained in order to test whether the protection offered by the pines, especially from polluted sea spray, could be of interest to increase the connectivity between goat's thorn milkvetch populations. Finally, the Maire Island population was initially to be reinforced. However, following a field visit, the presence of 5-6 individuals did not allow sufficient fruit harvests, the naturality of which is always questionable. Moreover, the recurrent watering of seedlings would have required field logistics that were considered to be too complex.

■ Map of metal and metalloid trace elements

At the same time, based on the previous results of the modelling of favourable areas, a map of concentrations of metal and metalloid trace elements (MMTE) in surface soils on a 50 m grid (Heckenroth et al. 2022) was made. This study determined whether the MMTE levels were not so high as to thwart the success of transplanting, even if the goat's thorn milkvetch can develop *in natura* on soils presenting this type of pollution. The surface soil levels of arsenic (As), copper (Cu), lead (Pb), antimony (Sb) and zinc (Zn) were analysed *in situ* using a mobile X-ray element analyser by energy dispersion (Niton XL3T Gold+). Thus, there is diffuse contamination by As, Pb and Sb elements compared with Cu and Zn. A multi-contamination pollutant load index, for which any value over 1 indicates a confirmed contamination of the soil, revealed significant contamination at the Escalette site and the adjacent area of massive slag deposits as well as at the Callelongue site due to the backfill used for road foundations (Heckenroth et al. 2022), including in locations at a distance from the industrial waste dumps.

MAP OF THE MULTI-CONTAMINATION POLLUTANT LOAD INDEX (PLI) BASED ON FACTORS OF ARSENIC, COPPER, LEAD, ANTIMONY AND ZINC CONCENTRATION



Given that the majority of goat's thorn milkvetch populations develop on soils that have been contaminated with MMTE and to the extent that the *in situ* concentrations of MMTE do not exceed those that permit the development of seedlings under laboratory conditions, the restoration of goat's thorn milkvetch populations on contaminated soils was validated and will also promote the biological fixation of soil MMTE in the goat's thorn milkvetch rhizosphere and limit their transfer into the soil, air and water.

■ Improving the growth of seedlings via the inoculation of a microbial consortium

Goat's thorn milkvetch naturally presents two symbiotic root associations with, respectively, mycorrhizal fungi and bacteria that fix atmospheric nitrogen in the soil. Thus, the selection of an effective symbiotic treatment is crucial in order to optimise *ex situ* seed germination and the *in situ* survival of individuals and therefore the efficacy of the restoration of goat's thorn milkvetch populations. Indeed, the inoculation of symbiotic micro-organisms was necessary in numerous cases of *in natura* planting in order to diminish the stress of transplanting and to promote plant nutrition (Martin-Laurent et al., 1999).

To define the optimal microbial consortium to provide, an experiment consisting of the inoculation of 7 strains of bacteria representing the diversity of the rhizobia (*Mesorhizobium*, *Rhizobium*) was conducted under controlled conditions in order to test their effect on the growth in pots of goat's thorn milkvetch seedlings originating from the Saména, Calanque des Troues, Escalette and Cap Croisette sites (Blot and Mariedit-Asse, 2018). After 6 months of growth, only the strains of *Mesorhizobium* stimulated the growth of the seedlings; the most effective was strain 4 of *Mesorhizobium temperatum*. To determine whether the most effective bacteria to stimulate the growth of seedlings were also good competitors (thus ensuring their survival after inoculation), genetic analyses (*metabarcoding*) were carried out to identify which bacterial symbionts really colonised the roots of plants compared with the initially inoculated mixtures and in what proportions. The strains most frequently found in the roots 6 months after the inoculation of the bacterial mixture were strains 2 and 4 of *Mesorhizobium temperatum* and strain 1 of *Mesorhizobium muleiense*. To maximise the potential to establish a bacterial symbiosis in the roots, the consortium of these 3 strains, which are both good growth stimulators and good competitors, was inoculated during the cultivation of the goat's thorn milkvetch seedlings.

■ Administrative authorisations

As it is a protected species, and because the populations concerned are located in the core area of the National Park, two authorisations were necessary to carry out this operation: a waiver of article L411-1 of the French Environmental Code ("protected species" waiver via CERFA form 13617*1) and the authorisation of the Director of the National Park for the sampling of plant species in the core area of the park. These two applications were accompanied by a letter explaining the details of the operation (nature, number, dates and places of sampling, identity of the operators, etc.).

CONSERVATION MANAGEMENT

Preliminary work shed light on the choices of conservation management for the ecological restoration of goat's thorn milkvetch populations and revealed the relationship and reciprocal interest between research and management.

■ Fruit sampling and seed sorting

Once the administrative authorisations had been obtained, the fruits (pods) were harvested on the goat's thorn milkvetch mother plants taking the following precautions:

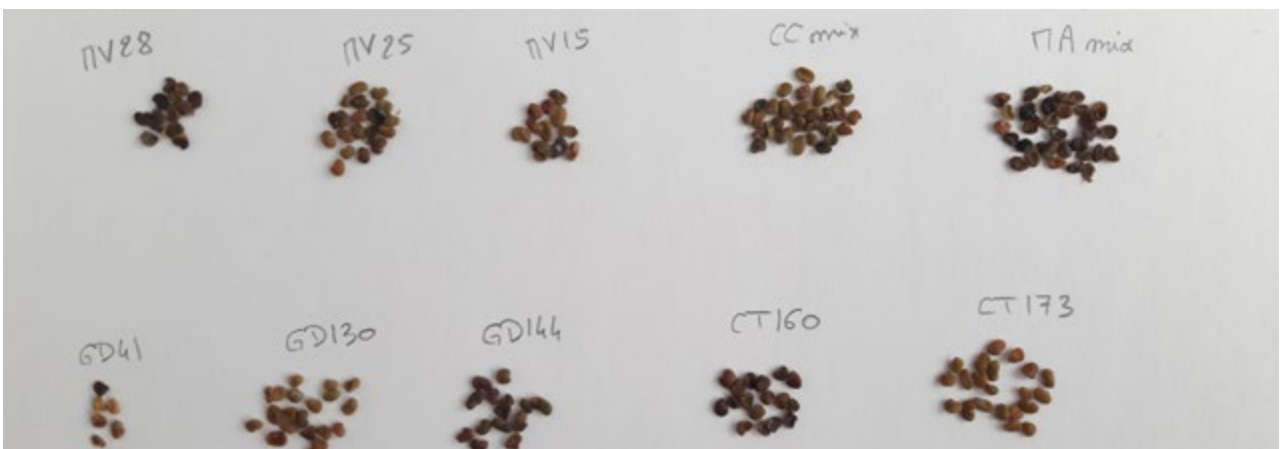
SEED SAMPLING AND SORTING PROTOCOL

- › sampling uniformly distributed among the plants of each site;
- › sampling of 40 ripe fruits per plant on plants at a distance of at least 5 m for a total of 20 plants on each site;
- › sampling of ripe fruits (completely dry pods and slightly open at the top) one by one using long tweezers or wearing gloves to avoid the pain caused by the thorns;
- › the 40 ripe fruits per plant are arranged on a coffee pot filter on which is noted the name of the agent who harvested the seeds, the name of the site, the number of the individual and the date of harvest, thus each coffee pot filter corresponds to one individual;
- › 20 coffee pot filters are placed in a paper bag (greengrocer type bag) or in a small box labelled with the name of each site;
- › the geolocation of the harvested individuals;
- › the bags of each site are temporarily stored at ambient temperature in a dry place to avoid the rotting of the fruit;
- › the number of fruit for each site and each plant is counted and recorded on a spreadsheet;
- › all the fruit of each plant are placed on an A3 sheet of white paper in a dry place at ambient temperature;
- › manual husking of each fruit and manual sorting of the seeds taking into account that the seeds resemble small beans of about 1 mm in length and using tweezers to remove non-viable smaller and black seeds which are not to be kept;



NB : *to count the total number of seeds sampled per goat's thorn milkvetch plant, it is possible to use an automatic seed counter which will save time even though each pod only contains from 1 to 12 seeds maximum.*

- › all of the viable seeds from each plant are placed in a tube (glass or plastic) progressively counting the number of seeds placed in the tube in order to record the number on the spreadsheet;
- › an abbreviation of the site name and plant number is marked on the tube using a black indelible marker;
- › the tube is closed and stored in a dry place at ambient temperature.



Seed harvesting and sorting

In order to reach the initial objective of 300 seedlings to transplant in each of the 12 reinforcement and introduction/reintroduction sites, two fruit sampling sessions had to be planned because the germination rates after 6 months and the survival rate of seedlings was highly variable and lower than expected among the different sites. Within the framework of an *in natura* transplantation of plant species, it is thus important to provide for several periods of fruit harvest, cultivation and seedling transplantations in order to mitigate unforeseen biological and technical problems. Thus, the sampling of ripe fruit, which is naturally a function of the phenology of the plant and which is variable from one year to the next according to weather conditions, was performed by four PNCAL agents under the supervision of the AMU in two phases, in June 2018 and June 2019, for the sites at Mont Rose, Saména, Escalette, Calanque des Trous, Goudes, Maronaise, Cap Croisette and Marseilleveyre. Each annual session to harvest ripe fruit lasted 3 full days and 2 full days respectively. Manual seed sorting was performed, in 2019 and 2020, during 4 full days and 3 full days respectively by 3 agents of the City of Marseille.

Of the 2260 individuals of goat's thorn milkvetch identified on the continental coast (Baumberger et al. 2021), 160 individuals were concerned by seed sampling (20 individuals per site for 8 sites), i.e. approximately 7%. The annual individual reproductive success (total production of fruit and seeds per plant) is 1697 ripe fruit per individual and 3684 seeds produced per individual. Thus, the average sampling of 40 ripe fruits per plant represents around 2.5% of the total annual individual production of ripe fruit. Furthermore, *in natura*, goat's thorn milkvetch seeds germinate very rarely and the rare seedlings grown from seeds have an extremely low survival rate on the PNCAL territory. Thus, the cumulative impact of the two ripe fruit harvests in 2018 and 2019 did not significantly disturb the dynamics of the goat's thorn milkvetch populations.

■ Cultivation under controlled conditions

Preparing the seeds and the bacterial inoculum

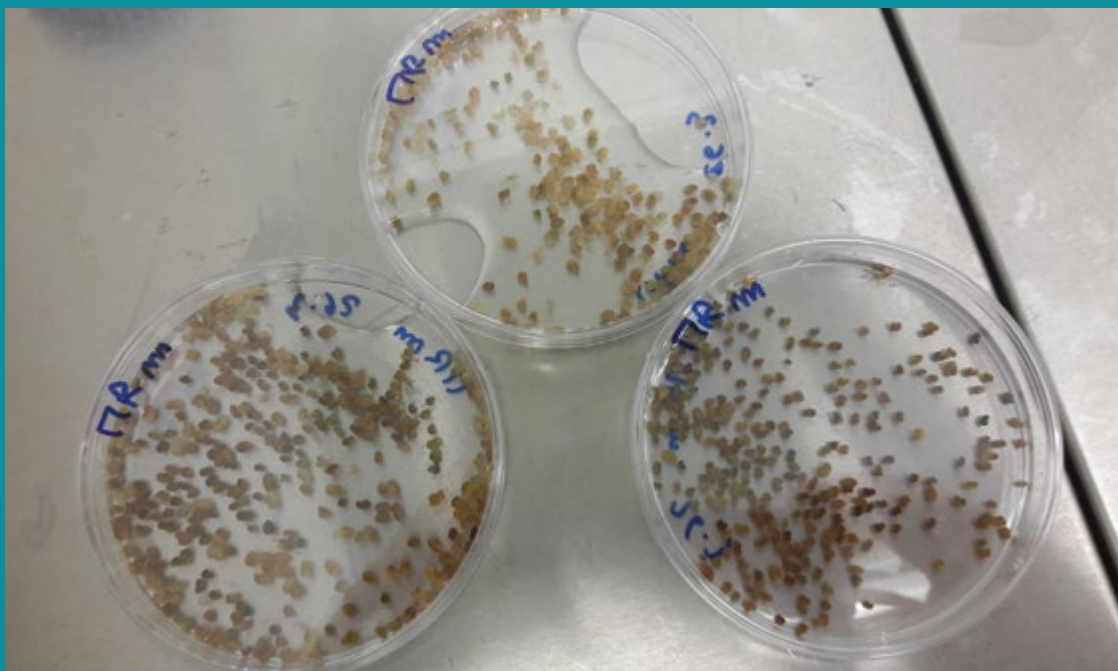
First, in March of the year following each ripe fruit harvest, the seeds were subjected to scarification and then cold stratification to improve their germination capacity. The seeds necessary for each site were counted. Preparation consisted of practically doubling the number of viable seeds required to plant. The remaining viable seeds were transferred to the CBNMed seed bank facility.

Then, the seeds corresponding to each goat's thorn milkvetch were poured and mixed for each site in a sterile 100 ml bottle (total of 8 bottles) according to the protocol shown in the box. Seed scarification and stratification was performed by two AMU agents in March of each year and took place over 1 full day.

SEED SCARIFICATION AND STRATIFICATION PROTOCOL

Under a fume hood, for each bottle (100 ml):

- › add 20 ml of 96% sulphuric acid (H₂SO₄) during 15 min;
- › pipette the sulphuric acid;
- › rinse the seeds 3 times during 5 min with 80 ml of sterile distilled water;
- › add 80 ml of 50% bleach during 5 min;
- › pipette the bleach;
- › rinse the seeds 3 times during 5 min with 80 ml of sterile distilled water;
- › seed stratification by placing the seeds of each bottle in a Petri dish in a refrigerator at 4 °C for 48 h.



Seed stratification in a Petri dish

At the same time, three strains of *Mesorhizobium* (2 strains of *M. temperatum* and 1 strain of *M. muleiense*). Indeed, these strains were selected as the best goat's thorn milkvetch root symbionts; the growth medium was prepared 7 days before each of the two inoculations of the microbial consortium according to the following protocol.

GROWTH MEDIUM PREPARATION PROTOCOL

- › prepare the "Yeast Extract Mannitol" (YEM) Agar growth medium with 20 Petri dishes per strain (20 x 3 strains = 60 dishes);
- › prepare the "YEM Broth" growth medium for 6 L;
- › cultivate the three bacterial strains on YEM dishes and incubate for one week in an incubator at 25 °C;
- › sterilise 8 empty 1L bottles for inoculum preparation;
- › sterilise 800 ml of distilled water in three different 1 L bottles in order to adjust the optical density (OD) of each bacterial strain.

On the day of inoculation, the optical density is adjusted and the preparation of the inoculum is finalized in a biosafety cabinet (BSC) according to the following protocol.

INOCULATION OF BACTERIAL SUSPENSIONS IN THE GROWTH MEDIUM PROTOCOL

- › dilute and agitate the YEM medium to 1/9 in each of the three previously prepared bottles containing 800 ml of sterile distilled water;
- › replace each bacterial strain under suspension in the diluted YEM medium;
- › perform absorbance measurements at 600 nm and adjust to 1.2 for each of the strains in each of the three bottles;
- › in a sterile 1 L bottle place 100 ml of each of the three bacterial suspensions and add 600 ml of YEM medium. Use the same procedure to prepare 8 bottles for a total volume of 900 ml inoculum/bottle x 8 bottles = 7200 ml of inoculum

Two inoculations of the microbial consortium were performed the following day and one month after sowing the seeds by two AMU operators during an entire day.

Sowing the seeds

Secondly, the seeds were sown in the greenhouse of the City of Marseille (Fresnaie nursery, Aubagne). To ensure 300 individuals per site for the 12 reinforcement and introduction/reintroduction sites (3600 seedlings in all), the number of seeds was practically doubled (approximately 6600 seeds) in order to take into account the reduced germination rates and the possible mortality of seedlings during growth under controlled conditions. Thus, around 6600 pots (10.5 x 8 cm, 350 mL) were placed on labelled trays with the name of the site and the following protocol was implemented.

SOWING PROTOCOL

- › add 200 ml of non-sterile coco perlite potting soil (coconut fibre + 10% perlite Coco-Mix Platinum Soil – Culture Indoor) per pot;
- › add 150 ml of previously autoclaved (120 °C, 1 bar, 20 min x 2 cycles) coco perlite potting soil;
- › water the pots 24 h before sowing one seed per pot.



NB : do not use potting soil with fertilizer (including planting soil) nor an automatic topsoil mixer in order to avoid cancelling the specific effect of the bacterial consortium inoculation.

- › sow the seeds 48 h maximum after scarification;
- › place one seed per pot with tweezers;
- › water immediately after sowing the seeds and 2-3 times a week after sowing.

It is preferable to water by automatic misting in order to avoid the lodging of the seedlings due to watering with a hose or watering can. Watering was verified by an operator from the Services of the City of Marseille (Fresnaie nursery, Aubagne). If necessary, it is possible to add a ferric solution during the growth of the seedlings. Protecting the pots with transparent plastic film minimises the risk of contaminating the sterilised potting soil with aerial micro-organisms in the greenhouse. The preparation of the pots and seed sowing was conducted in the greenhouse of the Services of the City of Marseille (Fresnaie nursery, Aubagne) by four operators and three operators from Aix-Marseille Université during three entire days. Day/night temperatures in the greenhouse were controlled during the entire growth of the seedlings because a series of germination tests on scarified seeds, based on temperature variations (5, 10, 15, 20 and 25 °C as well as alternating day/night temperatures of 20-10 °C) and carried out by an CBNMed operator, had revealed the best conditions for the germination of goat's thorn milkvetch seeds with alternating day/night temperatures of 12 h at 20 °C / 12 h at 10 °C.



Cultivating goat's thorn milkvetch at the Fresnaie nursery

The inoculation of the three bacterial strains was performed by placing, wearing gloves, 1 ml of inoculum around the seed / seedling in each of the 6600 pots with a sterile 10 ml pipette or a 1000 μ l micropipette. All pots were watered the day following each inoculation. Two months after sowing, 50 to 100 mL of potting soil consisting of white peat, ericaceous compost and perlite was added to the pots to provide the necessary nutrients for seedling growth.



Bacterial strain inoculation

Seed germination rates were very unequal among the sites with, on average, 53% of germinated seeds on all 8 sites where the fruit had been harvested. This low seed germination rate may be due to poor-quality seeds (non-viable). Cultivation lasted 7 months, from March to November of the same year. The quantification of germination rates and seedling survival was regularly performed by two operators from Aix-Marseille Université (IMBE). The growth conditions of the seedlings in the greenhouse were good because only 3% seedling mortality was observed after the seeds had germinated.

To acclimatise the 7-month seedlings before in natura transplantation, all the trays of 6600 pots were placed outdoors in vegetable garden planters lined with cloth and protected by removable shade structures. Hemp mulch was occasionally placed around the pots to act as an anti-slug solution and to maintain the humidity around the pots. The most developed seedlings (at least 5 or 6 leaves) were selected for in natura transplantation.



Acclimatising seedlings to the outdoors

Transplantations *in natura*

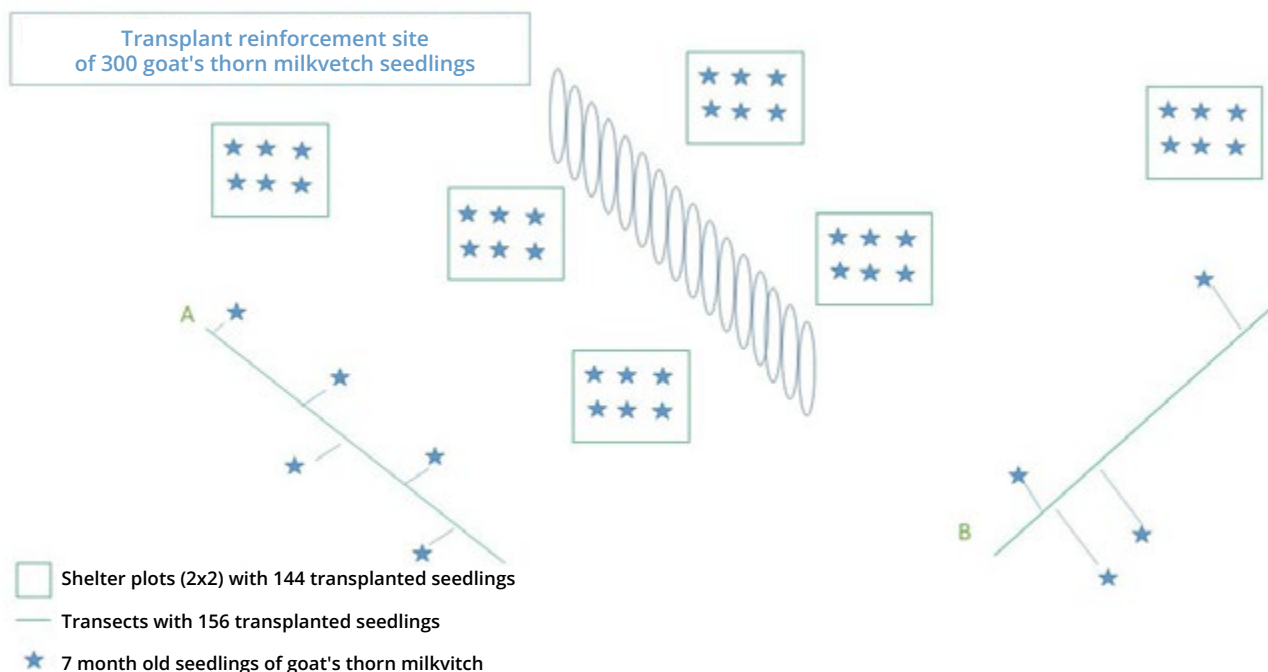
In November 2019 and 2020, agents from the Calanques National Park, the Ville de Marseille, the Bouches du Rhone Departmental Council, the Porquerolles National Mediterranean Botanical Conservatory, the ARBE and the University of Aix-Marseille transplanted 3,600 goat's thorn milkvetch seedlings (at 7 months of growth) to each of the 8 population reinforcement sites (Mont Rose, Saména, Escalette, Calanque des Troues, Goudes, Maronaise, Cap Croisette and Marseilleveyre), and 4 introduction/reintroduction sites (Sémaphore, Mounine, Batterie Marseilleveyre, and Queyrans). 300 seedlings were transplanted into each site as follows:

➤ **at the 8 population reinforcement sites:**

- 144 randomised seedlings within 6 geo-referenced quadrats (3 m x 2 m), divided into 24 seedlings per quadrat; these seedlings were grown from a mixture of intra-site seeds, except for the Calanque des Troues site, for which the 144 seedlings were grown from a mixture of intra-site seeds and seeds from Mont Rose and Saména;
- 156 seedlings grown from a mixture of intra-site seeds spread along the various geo-referenced transects along the outer edges and outside of each site, in order to enhance connectivity between the sites.

➤ **4 introduction/re-introduction sites:**

- 144 randomised seedlings within 6 geo-referenced quadrats (3 m x 2 m) divided into 24 seedlings per quadrat grown from a mixture of inter-site seeds from the 8 population reinforcement sites;
- 156 seedlings grown from a mixture of inter-site seeds, spread along the various geo-referenced transects around the outer edges and outside each site, in order to enhance connectivity between the sites.



At each of the 12 sites, the 144 seedlings placed within the 6 quadrats were protected by enclosures positioned directly around each quadrat, or with wooden stake-and-wire fencing laid out to channel human movement; this was not the case for the 156 seedlings transplanted along the various transects between the sites. Surrounding quadrats with enclosures makes it easier to access all the seedlings in order to monitor their progress on a regular basis, and to measure other factors such as the physico-chemical properties of the soil.

Protective measures were implemented from January-June 2020 by the National Forestry Office (ONF), by way of a general framework agreement between PNCAL and the ONF. Small signs were installed on the quadrat fencing, explaining to passers-by that they should not step over the fences in order to avoid trampling the plants.

Overflow plants from certain sites (Mont Rose, Saména, Escalette, Calanque des Trous, Goudes, Maronaise, Cap Croisette, Marseilleveyre) were transplanted into ground on either side of the sites, in order to further increase connectivity between these goat's thorn milkvetch populations. Over the course of 2019 and 2020 a total of 4,532 seedlings were transplanted, almost doubling the population of these plants in the Calanques National Park (+92%).

Around 22 individuals from the PNCAL, CBNMed, VDM, CD13, ARBE, AMU, CNRS, and IRD were involved in each goat's thorn milkvetch transplanting session over a 10-day period. Given that this is a protected species that must be handled with particular care, the involvement of volunteers was not a viable option.



Milkvetch planting at Cap Croisette



Milkvetch seedling with its identifier tag



Milkvetch planting at Sémaphore de Callelongue



Unloading and planting milkvetch at the Queyrans introduction site.

In terms of the practical reality of transplanting goat's thorn milkvetch seedlings, each person involved was allocated a specific role for the quadrat or transect, based on precise usage recommendations.

JOB DESCRIPTIONS PER QUADRAT OR TRANSECT (1 GROUP OF 3 PEOPLE A/B/C)

- › depositing 2 trays containing 24 pots each at the side of each quadrat or transect, demarcated using a spray can
- › marking out the 3x2 m quadrat using two decametre tape measures, or the transect by unrolling a double decametre.

ROLE A: THE DIGGER

- › uses a spade and a pickaxe to make holes roughly 10cm across and 10cm deep
- › piles the soil just beside the hole
- › forms a rectangular pattern of holes (6 holes up and 4 holes across) for a total of 24 holes per quadrat, or as many holes as required on either side of the transect
- › ideally, spaces the holes around 20cm apart

ROLE B: THE PLANTER

- › removes seedlings from their pots by hand, taking care not to break the roots
- › gently loosens up the soil around the roots if it is tightly packed
- › places the seedling into the hole and packs it with soil from both the hole and the pot
- › ensures that the collet (the top of the root ball) is not left sitting above ground level
- › slightly packs in the soil
- › places some mulch around the base of the seedling (optional), then some gravel from the site around the seedling
- › labels the planted seedling with the tag from the pot it came from

ROLE C: THE RECORDER

- › gives role B the code for the seedling in question
- › systematically notes down (on paper) the spatial layout of the seedlings *in situ* once they have been planted
- › uses a spray can to mark out the four corners of the final quadrat or the start/end of the transect

Watering of the seedlings at each site was carried out by the Bouches-du-Rhône Departmental Council just after transplantation, then once a month during the summer period (June, July, August) following each transplantation session in 2019 and 2020; after this, watering no longer took place. For each watering, it has been estimated that 500L of water was required per site for 300 seedlings, or 6000L (6m³) of water for the 3,600 seedlings across all twelve sites (excluding overflow seedlings).

Throughout the entire duration of the transplanting operations in 2019 and 2020, specific user recommendations were formulated by agents from the Calanques National Park, under supervision from agents of Aix-Marseille Université (IMBE/LPED) for all individuals performing transplants in the field, vis-a-vis the potential presence of diffuse trace metal pollution in soils.

REMINDER: soil pollution from trace metals and metalloids is invisible to the naked eye, and soil that appears to be relatively untouched by human activity can still contain potentially toxic concentrations of contaminants such as lead, arsenic and antimony. Occasional exposure to these contaminants does not carry serious risk, provided certain precautions are taken:

- › not working the soil with bare hands, but instead using thick gloves such as gardening gloves (not latex lab gloves), as there is a risk of collecting contaminated soil under the fingernails and exposing oneself to toxic components when the fingers come into contact with the mouth;
- › wearing a protective mask, as there is a risk of inhaling contaminated soil particles on a daily basis;
- › on windy days, facing away from the wind or wearing a protective mask; brushing off your work clothes before leaving the site, as they can become contaminated with particles;
- › washing clothes separately when you return home;
- › washing your hair and exposed body parts that could potentially retain these particles (ear cavities);
- › washing your eyes with a saline solution or similar product if you suffer from irritation.

MONITORING

Monitoring survival rates

The survival rate of transplanted seedlings was quantified following the transplantations carried out in November 2019 and 2020. Growth parameters such as height, volume of seedlings or number of leaves could not be accounted for, since the slightest variation in climate conditions, notably a rapid temperature variation, can cause leaflets to fall from the leaves, thereby precluding regular measurement of seedling growth. As such, for each population reinforcement and (re)introduction site, monitoring of the survival rates for the 144 seedlings in each of the 6 quadrats per site was carried four times (one checkup in winter, spring, summer and autumn) in the year following each transplantation session, then twice (once each in spring and in autumn) in the following years. Monitoring of the survival rates of the 156 seedlings planted along the transects was carried out once after each transplantation session in 2019/2020 and once in 2022. The goal of the transplantations along the transects at the edge of each site was to reduce site fragmentation and increase connectivity between them. These transect plantings were not taken into account when researching the correlation between survival rates and abiotic factors.

Monitoring of physico-chemical soil characteristics

The physico-chemical makeup of the soil found in the quadrats was analysed just once, following the transplantations carried out in November 2019 and 2020. A composite soil sample was taken from inside each of the 6 quadrats at each site (max 1.5L per quadrat) in order to analyse its granulometry, cation-exchange capacity (CEC), available phosphorus (P), concentrations of organic carbon (C) and nitrogen (N), and concentrations of trace metals and metalloids. In addition, a semi-quantitative measurement of metal and metalloid levels present in the soils was taken using a portable spectrometer (the X Niton® XLt 792W fluorescence analyser from Thermo Scientific©)

LIFE PROJECT FEEDBACK

Calendar of operations

The complete range of actions associated with this objective were carried out between 2017 and 2022, over the course of several key project phases: preliminary scientific studies (2017-2018), transplantations (2019-2020), and finally assessment studies (2019-2022).

		2017		2018				2019				2020				2021				2022			
		III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Preliminary scientific studies	Methods of sexual reproduction and genetic structure																						
	Modelling the physical environment conducive to milkvetch growth																						
	Map of trace metal presence (09/2018)																						
	Identification of bacterial symbiotes and Experimenting with inoculation from microbial consortium																						
Conservation management	Removal of fruits and sorting seeds																						
	Cultivation																						
	Transplantation																						
	Setting up exclosures																						
	Watering <i>in natura</i>																						
Monitoring	Monitoring seedling survival rates																						
	Analysis of physico-chemical soil characteristics																						

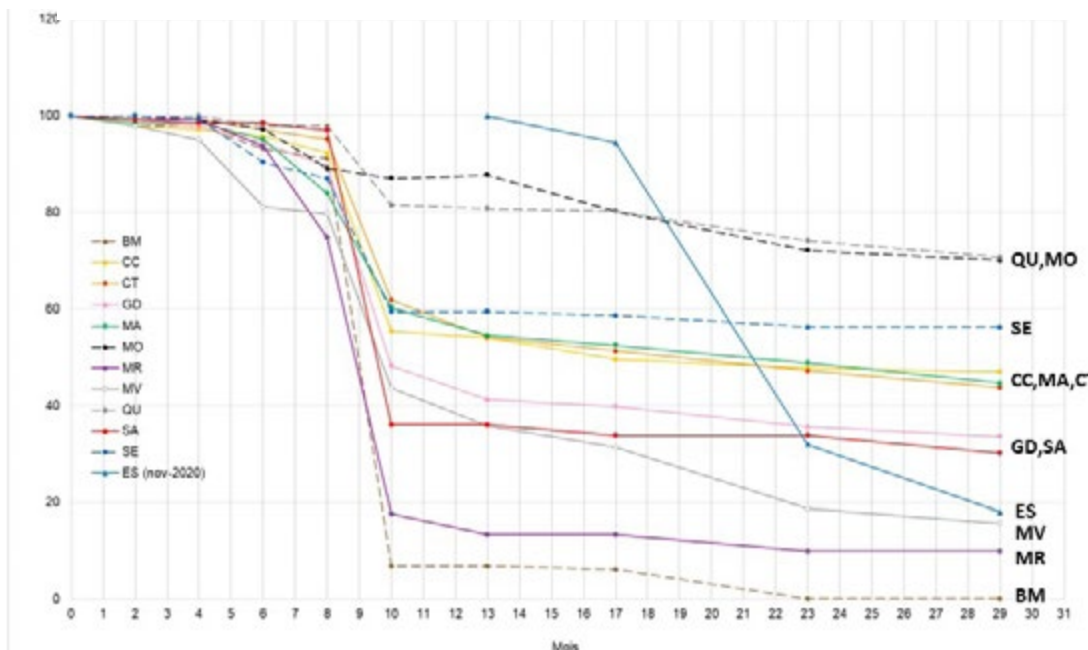
Overall results

Across all the 12 population reinforcement sites and 4 (re)introduction sites, the average survival rate for seedlings transplanted into quadrats was 38.8%, as observed 29 months after transplantation across a total of 1,728 seedlings.

It should be noted that 36 seedlings transplanted into the quadrats were manually uprooted by members of the public during a 17-month period post-transplantation across the 12 sites; this in spite of the use of tags to identify the transplanted seedlings, which underlines the importance of increasing the use of explanatory signage and raising awareness of efforts to restore coastal habitats along Marseille's Calanques.

The (re)introduction sites showed a higher level of seedling survival than their population reinforcement counterparts, in particular the sites at Queyrans (70%) and La Mounine (70%), and to a lesser extent the Sémaphore site (55%). These higher survival rates validate the results of the scientific modelling of favourable habitats and the choice of (re)introduction sites. However, a choice (or more honestly, a gamble) was made to attempt (re)introduction at a more inland site within an area of bare scrubland in deep soil, at the Batterie de Marseilleveyre site. This attempt proved unsuccessful, as the survival rate for seedlings at this site had already dropped to 0% by the autumn of 2021. Elsewhere, sites closer to the sea displayed higher seedling survival rates.

ASTRAGALUS TRAGACANTHA SEEDLING SURVIVAL RATE (%) AT 8 POPULATION REINFORCEMENT SITES AND 4 (RE)INTRODUCTION SITES



BM : Batterie de Marseilleveyre, CC : Cap Croisette, CT : Calanque des Trous, GD : Goudes, MA : Maronaise, MO : Mounine, MR : Mont Rose, MV : Marseilleveyre, QU : Queyrans, SA : Saména, SE : Sémaphore

Analyses of the physico-chemical characteristics of the soils showed broad diversity between the 12 sites, rendering any potential correlations between seedling survival rates and soil conditions largely non-indicative. However, the initial results showed higher survival rates in soils characterised by higher levels of fine and coarse silt, such as the Queyrans, Mounine and Sémaphore sites, and vice versa in soils characterised by higher levels of fine sand and clay such as the Mont Rose and Batterie de Marseilleveyre sites. Other results showed lower seedling survival rates in enriched soils (nitrogen, phosphorus) and at sites with a cover crop and greater amounts of organic matter on the soil surface, such as the sites at Mont Rose and Les Goudes, which indicates that the population dynamic of goat's thorn milkvetch plants declines when faced with increased competition from co-occurring plants, in particular the invasive plant species that thrive in deteriorated coastal areas.

It should be noted that the manual watering of seedlings just after each transplantation session, and once per month in June, July and August 2020 and 2021, enabled an improvement in seedling survival rates, but was completely unable to alleviate the negative effects of the summer drought that followed each transplantation session on the reduction of seedling survival rates across all sites.

Looking beyond seedling survival rates, the success of this broad-scale effort to restore the goat's thorn milkvetch population also depends on the number of individuals that will reproduce (flowering and fructification) in the coming years. For this perennial plant, it was pleasantly surprising to observe fructification in around half a dozen individuals across all sites during the April 2022 monitoring campaign (month 29). Moreover, given the significant variability in germination patterns between seeds from different sites, a number of additional seedlings were recovered after the two cultivations carried out under controlled conditions, and were then transplanted along the so-called "bonus" transects between the 12 sites. As such, between the quadrats, transects and "bonus" transects, a total of 4,532 goat's thorn milkvetch seedlings were transplanted into sites along the Calanques around Marseilles (from Mont Rose to Queyrans). This conservation management operation for these populations thereby enabled, between the dates of the two transplantation sessions, an almost twofold increase in the naturally occurring population of 4,919 individual goat's thorn milkvetch plants counted in the departments of Bouches-du-Rhône and the Var.



Seedling of Astragalus tragacantha transplanted in November 2019 at the Calanque des Trous site, having flowered and produced fruit (presence of mature pods) in spring 2022.

COMMUNICATION AND AWARENESS

- Issues and objectives
- Preliminary studies: development of the communications strategy
- Communications actions
- LIFE project feedback

ISSUES AND OBJECTIVES

■ Context

Created in 2012, the Calanques National Park is Europe's largest peri-urban national park. This biodiversity hotspot is a highly attractive location and receives many visitors throughout the year, resulting in an increased risk of rare and protected species being trampled, and more broadly the deterioration and fragmentation of natural environments. The majority of the public are unaware of the ecological issues at play in these areas, which is problematic. The main goal of the communication campaign was to alter the behaviour of visitors to the Calanques, who constitute the primary target of this project.

■ Objectives

In addition to making users more aware of the vulnerability and value of the natural heritage at stake, the goal is to modify their habits and reinforce best practices. A joint decision was therefore taken to foster:

- › greater availability of information on the value of the coastline, the damage it has incurred, and measures and best practices to be applied;
- › targeted public awareness campaigns;
- › a process to encourage the active engagement of the target audience.

PRELIMINARY STUDIES :

DEVELOPMENT OF THE COMMUNICATIONS STRATEGY

In an area characterised by highly distinct interests, joint consultation was essential in order to define the orientations driving the project and the messages to be communicated. In order to achieve this, the project was supported by a communications agency in order to develop the communications strategy in close collaboration with the partners. An annual review of communications challenges and objectives was established in order to optimally adjust the actions and tools used during each step. Indeed, it was essential to properly define the communications strategy and communication plan for the duration of the project by identifying its priorities.

The communication strategy was finalised after a full year of consultation and discussions. Detailed over the five-and-a-half-year duration of the project and updated each year during partner meetings, its key pillars are as follows:

- › **Concept and messaging:** an engaging communications campaign has been deployed, in order to incite behavioural changes by carrying across values that enable audiences to get behind and identify with the project. The goal of this positioning is to structure the messaging around an evolving and value-rich concept: "Calanques LIFE: a natural way to live."
- › **The messaging** needed to make the multiple facets of the Calanques' terrestrial coastline accessible, clear and meaningful to all audiences.
- › **Tone :** in order to unite people around a concept that is both motivating and in the public interest, the tonality was centred around positive, inspiring and clear messages. The main lever selected was the emotional angle.
- › **Engaging communication principles:** the goal was to incite change without explicitly requesting it. Each message, medium and project initiative sought to develop one or several of the levels of engagement illustrated in this timeline diagram:

Definition of target audiences

Raising awareness among various audiences represented a major objective for the LIFE Habitats Calanques project. These audiences were broken down into 3 groups by order of priority:

- › primary target: firstly the general public, but also local residents living in these locations who can act as local representatives. The general public includes visitors in search of leisure and the great outdoors, and may include regular visitors or first-time arrivals: tourists, Marseille residents, people from the wider urban area, etc.
- › secondary target: formative influencers, as they have an impact on behaviours. This refers to economic and social entities, such as educational establishments.
- › other targets: other targets are partners and institutions contributing to the project's image. This refers to managers, scientists, local governments and, by extension, local officials.

COMMUNICATIONS ACTIONS

■ Creation of adapted tools

Numerous tools and methods have been implemented in order to meet the specific communications needs of the local area and European Commission requirements.

Consideration of which tools to employ was guided by a benchmark study carried out on other LIFE projects, and a communications workshop was held in February 2019 for all the partners. A plan for communication and the distribution of each tool was established. This was substantiated by the development of a consolidated agenda for the design of all tools, and by drawing up a technical specifications sheet for each tool. The latter detailed the objective for each tool, the audience being targeted, initial content elements, the budget allocated, and the schedule for its use. All communication formats used were the subject of collaboration with the project partners (usually technical specialists) overseen by the ARBE, which commissioned most of the communications campaigns. They were then reviewed and validated by all beneficiaries associated with the project (particularly communication specialists). Certain tools were deployed during events in order to promote faster dissemination; the date of the event in question thereby dictated the schedule for the creation of certain tools. The majority of these tools are detailed below.

SUMMARY OF TOOLS AND TYPES OF COMMUNICATION ACTIONS

TARGET AUDIENCES	TOOLS	ACTIONS
All audiences	Roll-up banners	<ul style="list-style-type: none"> ▶ Public information meetings ▶ Conferences and debates ▶ Presentation stands at local events: <ul style="list-style-type: none"> « La Voie est Belle » , « La Fête des plantes » , « Delta Festival » , « World Cup Series Final MSL 2019 » , « CMN UICN » , « Fête de la mer et des littoraux » , « Le Hublot » , « Jardins d'Albertas » , « Embruns » ... ▶ Calanques National Park open-door day ▶ Community volunteering projects
	Documentary and animation films	
General public	Public brochures in two formats	
	Mini-guide to recognising species and best practices for dealing with invasive exotic plants	
	Poster on coastal flora in Provence	
	Layman's report	
	Website	
	"Calanques LIFE" Facebook page	
	Goodies (T-shirt, packets of local plant seeds, reusable cups, LIFE stickers, badges)	
	Educational kit and exhibition materials for schools	
Transit advertising campaign on Marseille public buses		
Smartphone app game		
Influencers and institutional bodies	Institutional Brochure	<ul style="list-style-type: none"> ▶ Educational programme in schools ▶ Pilot garden ▶ Training courses for partners in coastal issues, hosting and travelling to workshops in partner countries, international conference ▶ A Provence coastline version of the "Jardiner, ça coule de source" ("Gardening comes naturally") programme, aimed at gardening professionals ▶ Consultation and knowledge-sharing workshops ▶ Closing seminar
	"Plant Local" guide	
	Coastal Habitats management guide	
	Record of the closing seminar	
Supporting tools	Communication Strategy	
	Graphic charter	
	Photo reports	
	Illustrations	
	Press campaigns and media coverage	

■ Tools and materials

External services were procured in order to provide the tools used to compile the communications materials:



COLORFUL LOGOS

EXTRACT FROM THE GRAPHIC CHARTER:
PROJECT LOGOTYPE COLOUR VARIATIONS

► **Photographic reports** : the goal was to compile a catalogue of photos for each audience type, adapted to suit each communications tool (various formats). The project themes were defined:

- habitats of community interest
- the project's flagship plant species: goat's thorn milkvetch and awl-leaved plantain
- threats observed and addressed by the project (invasive alien species, urbanisation, user habits, climate conditions, etc.)
- installations to channel foot traffic (before / after)
- actions undertaken during the project: seed collection, greenhouse cultivation, replanting, uprooting invasive alien species, cooperation and communication events, etc.

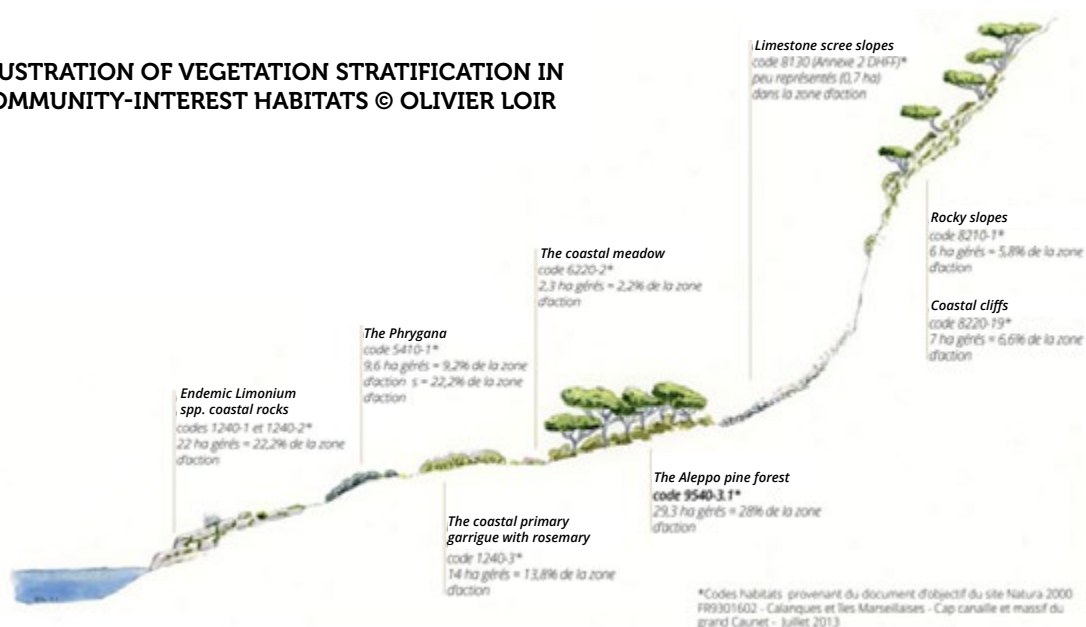
Illustrative and decorative images were also requested for use as cover photos for communications materials.



NB : the partners were major suppliers of photographs. A charter for the use of photographic images should be drawn up for the duration of LIFE and post-LIFE.

► **Illustrations** : the goal was to compile a catalogue of drawings representing the project in order to enhance the communications tools. Elsewhere, the use of illustrations proved extremely useful in the creation of tools for use by students (c.f. wall chart for schools) as well as those for teaching purposes, such as the banner illustration below representing community-interest habitats, which was notably used in brochures, on the website, in training courses and also when presenting the project to institutional partners.

ILLUSTRATION OF VEGETATION STRATIFICATION IN COMMUNITY-INTEREST HABITATS © OLIVIER LOIR



The graphic charter, photography and illustrations therefore served to define the project's visual identity, enhance the value of communication products and illustrate management actions within them.

Tools aimed at the general public

Objectives and Methodology

Materials aimed at the general public were designed to:

- › improve knowledge (ability to recognise local flora and natural habitats, information on the impact and risks posed by visitor traffic, etc.) and bring about greater recognition of the heritage value of community-interest habitats in the Calanques;
- › spreading the project's overall message and issues, and developing the public's perception.

This communication needed to give users a sense of appropriation vis-a-vis the project's messages.

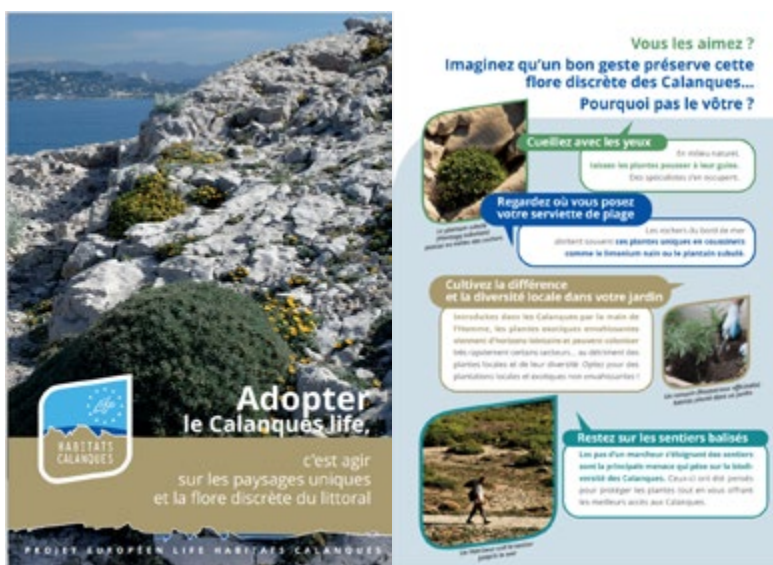
The objective of creating such a wide variety of materials was to connect with the entire public, regardless of age, socio-professional status, leisure preferences or user habits in or near the Calanques (swimming, outdoor pursuits, gardening, etc.), level of familiarity with new technologies (paper materials vs. website, social media and smartphone games), mode of travel used to visit the Calanques (awareness campaign via advertising on buses in Marseille), or potential expectations in terms of the way in which information is provided (conference debates, or more accessible and fun educational methods).

Materials created

Public brochures

Two types of brochure were compiled:

- › A brochure with a detachable final page indicating the correct habits to adopt in order to protect habitats and species in the Calanques;
- › a quiz, which is an example of practical application of engaging communications using the "helping hand" principle: its content is designed in the form of fun questions, and its shape in the form of a fan enables visitors to use the brochure to cool themselves off in hot weather. The fact that it is extremely portable means people can keep it for longer, thereby increasing the chances they will pass it on. Its smaller size also makes it easy for park agents to carry when on the go.



EXTRACT FROM THE PUBLIC BROCHURE

FAN DECK BROCHURES FOR THE PUBLIC



➤ **Poster for public display**

The poster features a picture display of flora found on the coast of Provence, identifying certain local protected and non-protected species, as well as certain IAPS. The poster was handed out at our event stands, in garden centres and as a goodie to various participants, and was very popular.



➤ **Guide to recognising invasive alien species on the Provence coastline, and best practices to observe.** As its title suggests, this guide presents the most problematic IAPS found in and around the Calanques. It provides visual and informative content for recognising IAPS, explains their impacts and encourages users to plant local plant species in their gardens.



> 5 roll-ups banners were set up on site : 2 promoting the project's slogan, and 3 addressing (respectively) the issue of invasive alien plant species, the introduction and population reinforcement of goat's thorn milkvetch, and the redevelopment of walking trails. They were particular useful during the Embruns festival and the Jardins d'Albertas "Plant Days" events (cf. below).



THE THREE TOPIC-SPECIFIC ROLL BANNERS

> Website and Facebook page

The project's website <https://www.habitats-calanques.fr/> was designed to spread awareness of the project (previously published guides are available for download from the site), to share the results achieved and to present more fun, interactive content, notably including a game challenging users to identify various plant species. A contact form for getting in touch with the project is available. The Facebook page also served as the venue for a live stream on Invasive Alien Species during the pandemic, in late 2020.



WEBSITE HOME PAGE

The Facebook page was created in 2019, enabling the general public to receive regular updates about upcoming and past actions and events, notably including the community volunteering projects for removing IAPS.



PROJECT FACEBOOK PAGE

› **Goodies** were produced to help the public quickly identify the project's image and messages. This enabled the project to reach a wide number of people using a simple, universally accessible tool. These goodies could be handed out after meetings and discussions, acting as a gesture in the moment but also creating a tangible memory of the event and thereby creating a link with the recipient.



**STICKER HIGHLIGHTING THE PROJECT'S SLOGAN,
ALONG WITH A 4G PACKET OF LOCAL GOAT'S THORN
MILKVETCH SEEDS**



In addition to these communications materials, which are fairly standard for a LIFE project, more innovative tools were also implemented with a view to reaching a wider audience.

› **Documentary and animations**

These were outsourced to a service provider who was sent the desired storylines, which had been developed ahead of time in a working group made up of the project's technical specialists.

› a film lasting 10-15 minutes, whose goal is to review the major conservation issues in the Mediterranean coastal habitats of the Calanques, and to explain how the LIFE project addresses these issues via the various actions undertaken. Interviews were held with the project partners in order to discuss the following subjects: natural habitats and local flora, invasive exotic plant species, planting schemes and scientific monitoring, development of walking trails and channelling foot traffic, campaigns to raise public awareness;

› there were also 10 animations (short animated films lasting 1-2 minutes): 6 aimed at the general public covering positive habits to adopt, and 4 aimed at institutional bodies covering the technical implementation aspects of the actions undertaken.

VARIOUS ANIMATED FILMS AIMED AT THE GENERAL PUBLIC AND INSTITUTIONAL BODIES

POSITIVE HABITS FOR THE GENERAL PUBLIC	ACTIONS TAKEN FOR INSTITUTIONAL BODIES
Staying on the trails to avoid trampling plants	Redevelopment of walking trails
Avoid planting IAPS in gardens	Management of IAPS removals in flat and cliffside areas by wardens
What are IAPS and their impacts?	
What is the goat's thorn milkvetch?	Population reinforcement and introduction of goat's thorn milkvetch and awl-leaved plantain
Overview of positive habits	LIFE project management
The Calanques ecosystem and the threats it faces	



EXTRACT OF A STORYBOARD FROM A FILM AIMED AT THE GENERAL PUBLIC ON POSITIVE GARDENING HABITS WITH REGARD TO IAPS

Screenwriting and directorial credits: Le Gobie / Illustrations and animation: Duodaki

› **The bus advertising campaign on Marseille public transport vehicles** was aimed at the city's residents and Calanques users, as well as tourists, and its aim was to encourage audiences to adopt more eco-friendly and respectful behaviours when entering an environment as exceptional yet also as fragile as the Calanques. It was displayed on the Marseille city bus network in the summer of 2022, from early June until the end of August. The choice was made to communicate an engaging message to encourage each user to stick to the existing trails; a message centred around the need to curb rambling and trampling, as these contribute to the fragmentation of natural habitats.

As such, the visual chosen shows the goat's thorn milkvetch, a symbolic plant for the LIFE project and an umbrella species: by conserving this plant, we also protect the various other local plant species typical of the unique local ecosystem they constitute, known as the "phrygane."

From early June to the end of August, the wide back of a line 19 bus carried the LIFE message. This campaign was also visible on one of the BHNS 1-line buses from late June onwards, and on half of the Capelette network from mid-July, as all these lines might be used by passengers travelling toward the Calanques.



**AWARENESS CAMPAIGN ON A HIGH-FREQUENCY BUS ROUTE
AT PLACE CASTELLANE**

› **The smartphone game** (*still under development when this guide was being compiled*) as the ability to reach a specific younger audience that does not feel "spoken to" by other types of awareness campaign; the game can also serve to supplement these formats. The video game is simple, quirky and fun, and addresses several of the issues at stake: management of invasive alien plant species, conservation of species and their habitats, and rambling/trampling by visitors. The goal is to create an "infinite runner"-style game in which the avatar runs along a course featuring various missions, reflecting the positive habits the project seeks to promote:

- › staying on the marked trails
- › avoiding trampling the plants
- › not planting or encouraging the expansion and propagation of invasive exotic plants
- › improving and supporting the development of local plants
- › understanding the issues and recognising plants that need to be protected
- › spreading the word and becoming an ambassador.

The game will be developed in project mode, along with a video game studio that works in partnership with a video game design school. A team made up of students in application design, graphic design and marketing will work on the promotion of the finished application, under the supervision of a professor. The project will use agile development, favouring an incremental and iterative approach that will enable viewing of the application's various stages of progress, and the functionalities that have already been delivered and are operational, during regularly scheduled meetings.

Examples of public events

There have been several opportunities to interact with the public since 2017: the Delta Festival (2019), the Fête du Vent (Sept 2019 and Sept 2021), the World Cup Series Final Marseille (2019), the IUCN World Conservation Congress from 3 - 11 September 2019, the Fête de la Mer et des Littoraux 2021, etc.

The two final events in the first half of 2022 were:

› The "Embruns "festival"

Held at Cap Croisette on 15 May 2022, to mark the 10th anniversary of the foundation of the Calanques National Park, this festival was an opportunity to promote the project and interact with people of all ages (around 150 attendees) on the subject of flora found on the coastline of Provence, taking advantage of the location to help festival-goers explore locally growing species. The exhibition boards on display, bearing the message "Ensemble pour protéger un littoral exceptionnel" ("Working together to protect an exceptional coastline", cf. below), helped attract walkers over to the stands. .



EMBRUNS FESTIVAL, 15 MAI 2022
AT CAP CROISSETTE

› The "Journées des Plantes" at the Albertas Gardens at Bouc-Bel-Air

This annual gathering was held on the 20 and 21 of May in 2022, bringing together garden centre owners, horticulturalists and garden lovers. The event gave the teams an opportunity to promote the project and inform some 440 people about the flora of the Provence coastline. For this event, the Naturoscope lent its expertise to the project team by providing presentation and outreach materials for the general public. In particular, gardeners were invited to explore alternatives to invasive exotic plants, as the spread of these plants outside people's gardens constitutes one of the major threats to the development of local flora. Through various workshops (including a quiz on identifying coastal flora, a board game on "biodiverse gardens," an interactive display on coastal vegetation, etc.) and communications materials (posters, mini-guide, garden guides, roll banners, etc.), the team helped the public to rediscover the ecological and ornamental wealth of local flora, and the means of preserving biodiversity in our gardens.



"JOURNÉES DES PLANTES" EVENT AT THE ALBERTAS GARDENS, FROM 20 - 22 MAY 2022

■ Tools for school students: the education pack

Objectives and Methodology

The objectives were:

- › to raise awareness among children (starting in late primary education) and the general public of the value and fragility of the biodiversity of coastal habitats in the Calanques;
- › to encourage the public to adopt habits that respect the coastal habitats of the Calanques;
- › to inform the public about actions implemented as part of the LIFE Habitats Calanques project.

Several steps were followed :

- › organisation of brainstorming workshops with the beneficiaries involved, in order to define the major themes for the content of the educational tools: goals, scientific principles to be shared, pitfalls to avoid, typology of tools used, choice of species, definition of illustrative and photographic requirements;
- › consultation for the "supply of illustrations" service;
- › composition, revision and layout design of the various materials;
- › publication and testing of a prototype, produced in both an event and classroom format;
- › delivery of the "Restore your nature," education kit and the "Working together to protect an exceptional coastline" exhibition materials;
- › publication of tools, available online on the www.naturoscope.fr website;
- › deployment of the educational programme and display of exhibition materials in establishments.

An education kit and a set of exhibition materials were designed and produced. An educational presentation programme to teach students about coastal habitats was deployed in primary, secondary and high schools. The audiences targeted encompassed primary, secondary and high schools near the Calanques, from La Ciotat to Marseille.

Educational materials produced

› The "Restore your nature" education kit

"Restore your nature" is an educational tool designed for a broad audience, and can be used starting from late primary through to secondary and high school students, as well as the general public. It offers materials to initiate educational projects for children aged 8 and up. These resources get audiences thinking about the interactions between the various components of the region's environment: ecological conditions, habitats and species, and how humans use and impact these areas. It is made up of various materials:

› User guide and learning resources

This tool helps provide users, teachers, presenters and educators with a base of information, thereby enabling them to use the tools provided independently, and to develop their own pedagogical approaches around this topic. The user guide is an 8-page booklet designed to facilitate classroom use of the educational pack and its 33 resource sheets, providing scientific and technical details on habitats, species, area uses, threats and the actions being taken by the LIFE project.

20 copies of the tool were published in A4 format, and distributed to local schools.

› The "Restore your nature" game

Using an interactive wall art image presenting the main habitats threatened along the Calanques coastline, players help bring the environment back to life by placing moveable magnetic pictures in the right places, in the form of a game.

It comprises:

- › wall art images of coastal habitats: three panels (50 x 75 cm) made from dibond aluminium
- › illustrated magnet stickers: species, users, LIFE actions. 33 stickers, 8 x 8 cm
- › dice and player cards

THE "RESTORE YOUR NATURE"
EDUCATION KIT



› **The educational booklet entitled "Nature kids' corner"**

This resource features games to help children learn about the value and fragility of the Calanques coastal habitats, while also having fun. 12 pages, A5 format.

› **The Mont Rose coastal habitat exploration guide**

This on-site guide is designed to present an exploration outing at the Mont Rose site for secondary and high school students. 8 pages in A5 format, printed by the classes.



› **The PowerVote Quiz**

Used as an activity during presentations, conferences and meetings, getting the audience to participate using electronic pads. Can also be used in paper format.

PowerVote is an interactive voting system that can be used for in-person training courses, meetings, conferences, questionnaires, etc. It functions using the Microsoft suite (with PowerPoint). Highly intuitive and easy to install and use, it is made up of 3 elements:

- › the free software is available online, and once installed enables access to a PowerVote window directly in PowerPoint;
- › wireless individual handsets enabling the participants to vote;
- › a presenter handset for controlling the tool, allowing the user to present the questions, surveys and results remotely;
- › a USB key plugged into the computer creates the link between the handsets and the PowerPoint presentation in question, where the results of the vote are displayed instantaneously in graphic format.

The tool offers clear yet detailed settings that the user can adjust to their preference (timing, response format, display of results, etc.). The entire kit (USB key, 1 presenter handset and 40 participant handsets) costs around €2,000.



Left: presenter handset
Right: participant handset

› The "Working together to protect an exceptional coastline" exhibition materials

These exhibition materials aimed to help audiences understand what makes the Calanques coastline a unique environment and how LIFE Habitats Calanques helps protect it, using engaging photos, headlines and summary texts. They offer various reading levels for different audiences, allowing every viewer to walk away having learned something new or with a fresh perspective on this environment, regardless of how long they spent reading. It can be used in a passive or active manner, and can be incorporated into class or school projects. It is made up of 16 educational posters (60 x 80cm), of which 20 copies were produced.



EXTRACT FROM EXHIBITION MATERIALS

It was distributed to schools taking part in the educational programme. Displayed in the common areas of twenty schools, it helped spread awareness among the entire student body.

■ Presentation method

The educational activity cycles included a day-long class outing and a half-day of additional activities in the classroom. Various approaches were implemented in partnership with teaching staff, depending on the learning level of the classes participating. A choice of various locations was offered for class outings: Mont Rose, the Sugiton Calanque, the Frioul archipelago, or the Calanques at Port-Miou/PortPin or Sormiou.

Shown below is an example of a "standard" program for a high school class visiting Mont Rose.

Day 1: site outing

- › getting to know the landscape: exploring coastal habitats, the biotope and biocenoses;
- › identifying flora: using an investigative game, the students learn to recognise 12 plants from around the Calanques coastline;
- › observing, along the route, the various actions and developments implemented as part of the LIFE Habitats Calanques project;
- › presentations of the "LIFE roles." Via the tangible examples encountered on the walk, the students can explore the variety of jobs and workflows involved in a LIFE project.

The various sequences are broken up by activities from the information booklet on the Mont Rose coastal habitat.

Half-day 2: classroom visit

- › slideshow on coastal habitats, presented in the form of a quiz using interactive handsets;
- › the "Restore your nature" game;
- › assessment using the "Nature kids' corner" game book.

■ Mobilizing teachers

Once the tools were finalised, two events were organised to present the "Restore your nature" education pack and the "Working together to protect an exceptional coastline" display materials. Due to the health crisis, the two sessions were held remotely: one via Facebook Live, and the other via videoconference. An online questionnaire allowed teachers to express their interest in having their classes participate.

Three email communications campaigns were sent out to inform schools about this educational program. The various materials created were made freely available online via the www.naturoscope.fr website.

Once the activities and presentations had been scheduled, the exhibition materials were supplied to each school during classroom visits. The schools themselves were responsible for displaying them. Each teacher submitted an evaluation sheet providing their assessment of the various items: quality of educational tools used, approaches taken, presenter performance, etc.

■ Tools for local authorities: a closer look at the "Plant local in Provence-Alpes-Côte d'Azur" guide.

Objectives

Faced with the issue of invasive alien plant species in their towns and surrounding areas, the local authorities from the Provence-Alpes-Côte d'Azur region expressed the need for information and guidance with regard to the use of vegetation landscaping in their development projects. Given this growing demand for awareness and guidance, it appeared necessary to offer a broad-scale pedagogical tool that would address the expectations of these local areas and take into account the ecological specifications of the region.

The goal is to encourage the planting of local and wild species, in order to preserve and promote biodiversity in public and semi-public spaces in the Provence-Alpes-Côte d'Azur Region, while also encouraging gardeners to consult local experts for the advice and guidance necessary for their development.

This guide is aimed at local government departments in charge of green spaces, as well as urban planners, architects, administrators, public and private developers, and landscapers working in either design or maintenance. It covers all operations involved in development, construction or renewal projects undertaken by local authorities. It devotes equal attention to the approaches used to integrate "urban nature," and increase the proportion of plant-covered surfaces in a given area, as well as approaches for the restoration of hedgerows, riparian forests and the renaturing of spaces damaged by human activity (dumps, former industrial sites, etc.).

Methodology

► Benchmark

A benchmark study was carried out so that this production could be compiled based on feedback from approaches already used in other regions (Île de France, Nord-Pas-de-Calais, Nouvelle Aquitaine or Centre-Val de Loire, etc.) as well as those currently underway (Occitanie). The documents produced served as a reference for all the stakeholders involved.

► Governance

This production, which sought to address the needs of the local area, was co-developed in close collaboration with the region's Botanical Conservatories (the Mediterranean and Alpine National Botanical Conservatories), using expanded governance to optimally integrate all stakeholders and the various professions/sectors involved: the French Office of Biodiversity, developers, landscapers, local authorities, and plant producers. The lead time for the project was set at 18 months. It was essential to take the necessary time to consult with the various experts involved, notably in order to identify both user needs and the needs and limitations faced by producers. Project governance was provided via a steering committee, a project group and working/revision groups.

► Content and format

The guide features an initial section entitled "General information and recommendations," and a second section providing a non-exhaustive gallery of vegetation suitable for growth in the various areas that make up the region. The working group users voted to organise the vegetation image gallery by type of plant formation (woods, wetlands and open areas), then by biogeographical zone (alpine and Mediterranean). These lists included local vegetation from coastal habitats. The guide will be available in digital format, accessible from the ARBE website home page (arbe-regionsud.org). It will run to around a hundred pages.

Initial feedback

The production of "Plant local in Provence-Alpes-Côte d'Azur," a guide to integrating local and wild vegetation in the development of public and semi-public spaces at the Provence-Alpes-Côte d'Azur regional level, forged and reinforced solid links between various professionals, notably between developers and producers. The collaboration with the botanical conservatories and the use of the "Local plant" mark (an existing national campaign) also facilitated and strengthened interactions and links between participating professionals. This project demonstrated developers' keen interest in the subject of local vegetation. It also raised new questions about the use of certain species with regard to their ecological specificities and the phenomenon of climate change, as well as their practical use in the field and the way in which some were showcased more than others within the guide.

■ Training agents

Objectives

Awareness campaigns were carried out by agents from the Calanques National Park, forestry workers from the Bouches-du-Rhône Departmental Council and the Ville de Marseille's sea patrol division, as part of their monitoring and awareness mission. Their role was to inform visitors about the fragility and rareness of coastal habitats, to explain the usefulness of the actions undertaken by the LIFE project, and to induce a change of perspective and attitudes in terms of their relation to nature. In order to ensure consistent and coherent communication on the project throughout the region, training courses were provided for these agents.

Methodology

The training modules differed in their content and frequency depending on the staff partaking in them, given that not all partners share the same level of knowledge of local conservation issues. The project's coordination and management teams jointly created and delivered the training modules. This decision enabled the project to offer flexible and adaptable training modules each year, depending on the project's progress.

Target Audiences

The in-person training sessions were designed for three types of audiences:

› Permanent staff at the Calanques National Park

Given their existing awareness of the issues and threats affecting the coastline, training for these staff consisted of detailed familiarisation with the initial actions being applied by the project. Opportunities for discussion and feedback were held within this institution throughout the duration of the project, with the agents being directly involved in deploying the project's initiatives across the area.



**TRAINING ECO-WARDENS AT THE CALANQUES NATIONAL PARK
ON 14 APRIL 2022**

› **Seasonal staff at the Calanques National Park**

This annual training course was delivered in two parts, timed to match the arrivals of seasonal staff. Updated each year, it was divided into several phases in order to get the participants involved and enable them to understand and get behind the project, notably via:

- › a pre/post-training questionnaire based on DÉFI Calanques (using the PowerVote tool);
- › a presentation on the coastal habitats of the Calanques and LIFE project actions currently underway;
- › a discussion and Q&A segment at each stage of the presentation;
- › the use of roleplay to highlight the issues faced in terms of language elements and messages to be used with visitors;
- › a site visit;
- › distribution of the project presentation to each participant.

In order to enhance the visibility of the project and Europe across the region, velcro LIFE badges were produced, designed for the uniforms worn by Calanques National Park rangers. Each agent involved in the project wore a LIFE badge when on site.

› **Permanent agents in other partner structures**

After identifying knowledge levels and requirements, training was provided to agents at each partner structure involved in the early phases of the project. They involved a detailed presentation of the issues and actions to be implemented, delivered using resource documents. The training was capped off with a discussion forum. At the request of partner structures, other light training modules were also delivered during the project. A "final update" training module was provided toward the end of the project for each partner, in order to conclude efforts by presenting its positive outcome, and to establish the long-term messaging on the project.

■ Showcasing the project and international cooperation

The objective of cooperative efforts is to enable the exchange of practices and methods, and sharing feedback. The creation of a synergy between European players was also expected for these Mediterranean coastal habitats, whose conservation status is a concern for the majority of southern European countries.

This cooperation has taken the form of practical exchanges, as well as sharing of methods and practices for development and governance, via 21 international cooperation agreements and an international conference.

Instances of international cooperation involved:

- ▶ hosting 3 experts in September 2019. This cooperation was associated with the international conference to enhance knowledge sharing and practices on a broad scale;
- ▶ a 4-day visit to Valencia, Spain in October 2019, in which 4 beneficiaries associated with the project took part. 5 locations were visited and a number of issues discussed (protocols for removal of IAPS, plant cultivation, etc.), while new contacts were also established.



TRIP TO VALENCIA IN OCTOBER 2019

LIFE PROJECT FEEDBACK

▀ Action execution schedule

It was necessary to plan illustration and photography services right from the outset of the project, despite the difficulty in accurately defining the project needs at this stage. Service providers should be mobilised for the entire duration of the project.

The calendar shown below provides an idea of the schedule for the production of communications tools, in the knowledge that various steps must be taken into account:

- prior consideration and definition of needs with the project partners;
- consultation;
- delivery of the service, including consultation phases;
- delivery/printing (or posting and updating for the website and Facebook).

		2017		2018				2019				2020				2021				2022			
		III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Preliminary studies	Communication Strategy																						
	Graphic charter																						
Design of communications materials	Photography																						
	Illustrations																						
	Public brochure																						
	Fan deck brochure																						
	Institutional brochure																						
	Guide to recognising and dealing with IAPS																						
	Botanical poster																						
	Education pack and exhibition materials + activities																						
	Stickers																						
	Facebook page																						
	Website																						
	Production of 5 roll banners																						
	Bus wrapping campaign																						
	Plant Local Guide																						
	Management guide																						
	Doc. and presentation activities																						
	Smartphone App																						
	Closing seminar																						
Layman's report																							
Events	Public events																						
	Regional, national and international cooperations																						

■ Indicative costs

NATURE OF THE COSTS	BUDGET / FINAL COST	PRICE INCL. TAX DETAILS	DETAILS
Support in defining the communications strategy	Final cost	€9,000	
Graphic charter	Final cost	€6,000	
Photo reports	Budget	€3,200	15 days
Illustrations	Estimated	€3,700	
Project website, maintenance and hosting over 5 years	Final cost	€11,000	
Documentary and animation films	Estimated	€30,000	
Bus network campaign (posters and ad spaces)	Final cost	€40,000	
Smartphone application	Budget	€2,000	

Guide and brochure production – templates*			No. of pages
Project presentation brochure for the general public	Budget	€1,000	4
Presentation brochure for institutions	Budget	€2,000	16
Layman's report	Budget	€2,100	10
"Plant Local in ProvenceAlpes-Côtes d'Azur" guide	Budget	€5,000	120
Management guide	Budget	€8,000	200
Record of the closing seminar	Budget	€4,000	180

*not including printing and translation

In addition to the cost of graphic design and page layout, the cost of printing and translation must not be overlooked.

■ Results

The Facebook page had gained 758 followers as of mid-June 2022, and 641 Likes. The statistics available from June 2020 onwards indicate that around 19,000 people viewed an item of content on the page. The website, meanwhile, totalled around 15,000 visitors over the course of a year (25 June 2021 to 25 June 2022).

■ General Public and Influencers

Participation in various events and the organisation of public meetings with residents, local interest groups and socio-economic players provided an opportunity to raise awareness and inform many people about the project. As such, from the outset of the project until May 2022, the following notable events were organised:

- › 14 public meetings (residents and local interest groups) and 1 public webinar;
- › 8 meetings with socio-economic stakeholders;
- › 19 participations in local, national or international events;
- › and other meetings with public stakeholders, politicians, scientists, etc.

The meetings held for the public and socio-economic stakeholders had reached around 1,900 attendees by the end of May 2022.

The international conference was held over 3 days in September 2019 in Marseille, and welcomed 108 guests who participated in conferences (on scientific, management and communication topics) as well as site visits, and over 200 people were made aware of the project during the public open-door day.

■ Schools

On 30 June 2022, 15 classes participated in the educational programme, resulting in a total of 376 students receiving in-person exposure to the project. 17 classes have already been signed up for the 2022/2023 school year, representing around 425 students.

The photography exhibition has been displayed in 8 schools; a copy is on permanent display in the Maison de la Nature, while another was displayed temporarily during the "Embruns" festival. The 10 remaining copies will be displayed in participating schools during the 2022/23 school year.

To date, the exhibition has reached around 2,000 people indirectly.

In addition, the tools created have been used by Naturoscope representatives delivering LIFE presentations in over 15 classes, i.e. a further 400 students.

■ Training agents

216 agents have been trained, and 23,336 visitors to the Calanques were made aware of LIFE project issues between 2018 and 2021.

YEARS	NUMBER OF INDIVIDUALS MADE AWARE OF THE LIFE PROJECT
2018	988
2019	4,566
2020	7,193
2021	10,589

Monitoring of awareness efforts made by eco-wardens during summer seasons

■ Conclusions

A number of lessons have been learned as a result of the completion of this LIFE project, with the following points being particularly worthy of attention:

- › the possibility of carrying out a separate LIFE project ahead of time, dedicated to communication and awareness, should be considered. During the visit to Valencia as part of the project's international cooperation angle, we were given a presentation of an Information and Communication project entitled LIFE Seducción Ambiental, commissioned by the Albufera Nature Park, whose goal was to raise awareness of the Park's natural heritage among local stakeholders, inhabitants and authorities, and to provide information on the Natura 2000 network via an intensive campaign. The observation made regarding this area, which is an important migration stopover for many bird species, was that the tourists who flock to Valencia for its beaches and nightlife were by and large unaware of the site's ecological value, nor were they particularly familiar with the environmental regulations in place there. Communication is one of the key aspects of the LIFE Habitats Calanques project, and the ongoing pursuit of regular awareness campaigns is one of the key factors in its success, all the more so given that certain actions extend beyond the scope of LIFE, such as the maintenance of walking trails and removal of invasive alien species;
- › the resources (time, man-hours) provided by each beneficiary associated with the project must be optimally appraised and allocated to workloads that can vary widely over time, based on their participation in certain events, and on certain time periods being more conducive to presentations and activities.
- › the constraints associated with collaborative projects must be properly taken into account:
 - establishing a set process for the validation of materials produced is necessary in any multi-partner project, and was the case from the outset of this project; a 15-day period of revision and validation was applied prior to the release of any communications tools, although the timeframes often had to be shortened in order to ensure tools were available for upcoming events. A certain level of flexibility must therefore be accepted as standard:
 - assessment of the timeframes required for the completion of group work, taking into account the need for back-and-forth and the validation process. In particular, the timeframes required for the use of external graphic design and page setting services must be properly anticipated (time needed for consultation, corrections, etc.);
 - tools need to be put in place for sharing and co-development between the beneficiaries associated with the project, notably with regard to the guides (which are compiled using multiple contributions),

but also for the sharing and storage of photographs.

- › a communications tool kit exists, and it is necessary not to spread human resources too thinly by adjusting these tools if needed to the priority targets, and to take into account the need to forge regular links with some of these targets. A newsletter, for example, is a useful tool for providing regular information updates. The option was considered of using a newsletter to inform the local residents around the Calanques National Park, but this would mean allocating the time necessary to publish several issues. The Facebook page is also a more interactive tool, but requires regular posts and diversified content: information about past events, announcement of upcoming events, livestreams, etc.
- › clear indicators must be defined, and it is necessary to monitor these throughout the entire duration of the project. In particular, it should be noted that public Facebook pages offer only a limited statistical history. Although an excellent idea, the Défi Calanques was not applied in tandem with ongoing events;
- › communications campaigns by partners outside LIFE must be taken into account. As such, the project had to avoid the pitfall of issuing communications that would serve to enhance the appeal of the Calanques area, and to work in a more joint fashion with the PNCAL communication teams. For example, an ad campaign on bus shelters organised by the PNCAL (which applies a visitor quota for the Sugiton calanque) and the LIFE awareness campaigns displayed on buses took place over the same summer period. The LIFE campaign needed to have its own visual identity, and its messages needed to be fully distinct from those of the National Park, while remaining coherent with them.

■ Outlook

The full range of communications materials will continue to be disseminated by the ARBE and the project partners, with print orders having already been planned in sufficient quantities. The "Plant Local" Guide will be distributed in late 2022, and an event may be planned to accompany its release – in the form of an hour-long ARBE Webinar episode, for example. An update of the digital version is currently under review, and this could occur on an annual basis.

The smartphone application is intended to remain in use based on user rates. Application maintenance and upgrading operations have been offered by the supplier (the École des métiers du jeu vidéo), and this offer will be examined. This would have the advantage of patching any bugs encountered, and of relaunching the game by offering players new features. The website is set to be handed over to the Calanques National Park. In addition, each of the project partners' social media outlets may issue communications regarding the next phases of the project.

As regards training operations on the issues of coastline conservation, these will be routinely integrated into more global training provided to PNCAL eco-wardens, and agents of the project's partner structures.

More globally, user feedback could be gathered by the various partner projects via their respective social networks.

Finally, the ARBE will remain at the disposal of LIFE project partners to provide ongoing support and guidance.

ASSESSMENT

- Context and goals
- Assessment of the socio-economic impact of the actions undertaken
- Assessment of ecosystem services

CONTEXT AND GOALS

The assessment process is a means for the LIFE project partners to list and "rank" certain actions, to help give them meaning outside the groups who actually carried them out. By showcasing the importance of the actions applied, the assessment process is a means of arguing for their continuation.

ASSESSMENT OF THE SOCIO-ECONOMIC IMPACT OF THE ACTIONS UNDERTAKEN

■ Objectives

The assessment of the project's socio-economic impact aims to understand the impact of eco-management actions on the local economy and population.

This assessment is based around three key elements:

- › a comparative study of user perceptions of eco-management actions, before and after site development and plant removal work was undertaken;
- › a study of the project's socio-economic impact on the local area;
- › an analysis of the project's contribution to the Sustainable Development Goals (SDGs).

The first two studies were outsourced to RESSOURCES, a sociological and ethnological research unit specialising in support services for managers of protected spaces. The third study was carried out internally by the PNCAL and the ARBE.

■ Methodology

User perception study

This action followed on from research into users' impressions of the natural heritage of the coastline and surrounding landscapes, as well as the regulation of natural spaces (FHUVEL) undertaken between 2010 and 2013.

The methodology applied involved going directly to users of sites covered by the LIFE project, and asking them to fill out a survey. This survey was jointly developed by the service provider and the Calanques National Park. The first survey was carried out from July to October 2020 at the following sites: Calalongue/Marseillevyre, Cap Canaille, Mont Rose, Morgiou, Sugiton and Port Pin. This questionnaire included 56 questions, with an average response time of 25 minutes.

464 questionnaires were gathered, of which 400 were retained for random selection in order to improve the reliability of the sample. As far as possible, the handing out of surveys was performed at random times and locations. The sample was then adjusted as per quotas, taking as a reference the Altimax study from 2017.

A second phase of the enquiry will be carried out in summer 2022, and a final report will enable an assessment of user perceptions both before and after eco-management actions were performed.

Socio-economic impact study

The goal of the study is to identify indicators of socio-economic value associated with the protection and management of coastal environments.

The main difficulty with this type of assessment lies in the fact that there are no commercial activities directly related to the creation or improvement of "natural assets" by the LIFE project's development actions that might be taken to counterbalance the expenses generated by the project.

These commercial values can, however, be made commensurable with an estimate of the value that site users might attribute to the habitats restored and/or the environmental amenities they feel have been gained or lost. This involves evaluating the level of approval felt for positive amenities, such as the improvement of walking trail conditions, or the consent required for negative developments, such as access restrictions, for example. In this sense, the goal is to assess the non-commercial value of the preservation and creation of coastal habitats.

The pre-identified methodology used involves the identification of socio-ecological indicators via bibliographical research, amassing "commercial value" data, and finally gathering responses to questions pertaining to this assessment during the second phase of the user perception study, which can later be extended to a wider panel such as a specific user group.

Contribution of the project to Sustainable Development Goals

In 2015, the UN launched its Agenda 2030, which gives the world's nations, along with all civil society stakeholders (local governments, companies, associations, and citizens) 15 years to achieve its 17 Sustainable Development Goals (SDGs). These 17 SDGs are broken down into 169 targets to be achieved. This new international framework, which in France was transposed into the "French Roadmap for the Agenda 2020," encourages project commissioners to retain a pro-actively transverse vision of their actions, examining their contribution to the SDGs and also their means of improving them. This global vision enables them to take into account the impacts, both positive and negative, that their actions will have on sustainable development issues, something they may not previously have considered.

THE SEVENTEEN SUSTAINABLE DEVELOPMENT GOALS

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OBJECTIFS DE DÉVELOPPEMENT DURABLE



Two presentation tools were used conjointly to collectively assess the project's contribution to SDGs:

› **The "action reviews" from the SDG toolkit**

Implemented by the Ministry for the Ecological Transition, the tool kit includes an "action review" resource, which uses a specific in-person Q&A session to collectively self-assess an action's impact on the 17 SDGs (negative/neutral/positive) and to identify improvement pathways suggested by the working group.

› **The SDG Mandala tool**

Implemented by the departmental government of Gironde, the Mandala is another tool enabling collective, in-person self-assessment of the impact an action will have on the SDGs (negative/neutral/positive), to identify methods of improvement (using the following formulation: "Impact of the action could be improved by..."), but also to prioritise the enhancements of the action's contribution to the various SDGs. The SDG review documents offered by the Mandala provide a comprehensive summary of each SDG, along with its targets and associated keywords, as well as the question the working group must address; in this way, they enable users to quickly appropriate the targets in order to complete the assessment as smoothly as possible.

A working session was held between the ARBE and the Calanques National Park in order to consider the contributions made to SDGs in the recent years of the project, so as to enhance the post-LIFE period using the results highlighted by the assessment.

Four action reviews were drawn up, reflecting the 4 key objectives and action groups for the project:

- › development of walking trails;
- › introduction and population reinforcement of goat's thorn milkvetch and awl-leaved plantain;
- › the removal of Invasive Alien Plant Species;
- › engaging communications in order to modify behaviours and boost cooperation.

The Mandala was applied across the board, taking the 4 action groups into consideration.

■ Preliminary Results

The preliminary results pertain to the initial inquiry phase carried out in summer 2020, and should be supplemented with a comparative analysis of the results of the study carried out in 2022. The results of the socio-economic impact study, which was launched in summer 2022, were not available at the time of writing.

User perception study

In a general sense, over 80% of visitors shared a positive vision of the eco-management actions, and expected them to have positive results. The highest levels of support were found among respondents from upper socioeconomic grades (AB+), with advanced qualifications and tending to fall within the 45-54 age range. The lowest levels of support were associated with an over-representation of respondents aged 65 and over, as well as an underrepresentation of higher social grades, and remain largely associated with visitors from Marseille itself. However, this represents a trend that is not determinative, and should not be automatically be interpreted as such. Indeed, no significant social divisions, nor any substantial minority of radical opposition (i.e. a minority of people who felt systematically opposed to any and all actions) were detected.

The study revealed a number of pertinent points:

- › with regard to erosion, few of the users questioned were capable of identifying **instances of erosion** in the photos presented by the questionnaire, this despite the fact that users also expressed a highly

positive appreciation of newly restored landscapes, and that respondents ranked trampling and walking off-trail as the primary source of damage to the Calanques. Moreover, almost 70% of people surveyed felt that taking a path and leaving the marked trail would damage vegetation, whereas 46.1% saw this as a source of soil erosion. As such, it appears that a communications strategy oriented toward awareness and understanding of this issue would benefit from including a depiction of landscape erosion, which would make this issue more continuously present in the minds of visitors. Rather than convincing users of the effects of trampling (though without abandoning this point), the goal would be for them to learn to recognise these effects within the landscape.

- actions designed to support and **manage flora** are by some margin the most popular. Over two thirds of visitors surveyed were in favour of removal operations (67.1%), while 92.1% of individuals surveyed said they were in favour of planting schemes. Knowledge of local Calanques flora, particularly endemic flora, is not as widespread, demonstrating that being in favour of actions supporting flora does not require any specific knowledge thereof. Indeed, goat's thorn milkvetch remains largely unknown: 63% of people surveyed had never heard of it, and only 11.6% of respondents knew that it was a plant that grew along the coast. Invasive alien plant species were the most widely recognised types of plants – twice as many respondents were able to identify them, yet were unaware of their status as IAPS. The most widespread observation was the difficulty certain respondents had in recognising which plants were naturally present in the region. 40% of those surveyed thought that agave grew naturally in the Calanques, and that this had more or less always been the case.

It was also observed that, unless presented with awareness resources on the issue, the individuals surveyed might be aware that a given plant species was invasive, yet still not be willing to see it disappear from the Calanques coastline. It would seem, therefore, that this segment of the public are aware of the competition that occurs between these plants and local flora, but do not appreciate the scale of its consequences. This suggests that communication and awareness measures would benefit from highlighting the significance and spatial extent of environmental changes caused by IAPS.

The Barbary fig was the species least identified as endemic and the most frequently identified as exotic, while the invasive and highly competitive properties of IAPS were most commonly associated with the pigface plant (*Carpobrotus*). In terms of illustrating the non-endemic aspect of these plants, communications could therefore be made more efficient by using the Barbary fig as an example. By the same token, greater emphasis could be placed on the invasive/competitive nature of certain species by taking pigface as an example, although this is widely cited as one of the more popular plant species. An awareness campaign would therefore benefit from focusing on the Barbary fig and using this as a springboard to look at other IAPS, rather than presenting the Barbary fig and pigface "on the same level."

Les six plantes suivantes poussent sur le littoral des Calanques :



Y en a-t-il que vous connaissez ?

	oui	non
Figier de Barbarie		
Luzerne arborescente		
Agave		
Griffes de sorcière		
Plantain subulé		
Saladelle		

Dans quelle(s) catégorie(s) classeriez-vous ces plantes ? Vous pouvez cocher plusieurs cases

	Figier de barbarie	Agave	Luzerne arborescente	Plantain subulé	Griffes de sorcière	Saladelle
Une plante propre aux Calanques, qui y pousse naturellement						
Une plante exotique						

› **walking trail developments** were well-received: three in four people surveyed were in favour of this. Across all responses received, 56% of visitors correctly identified the main purpose of these developments before it had been presented to them. Respondents often attributed another purpose to them (safety, visitor guidance, ease of access), which may help explain the public's enthusiastic appreciation of these trails, despite the fact that just under half of those surveyed were unaware of their ecological purpose. A certain proportion of visitors supported the developments despite certain misgivings, feeling that they detracted from the site's aesthetic appeal but considering this to be a lesser evil. The survey suggests that communication has a strong capacity to shape opinions on the actions taken. The individuals who were less in favour of developments tended to shift their opinion after being presented with communications content, eventually expressing support for the walking trails. Less than 15% of people who were fully opposed to the developments remained so. Communication also tends to soften the most hardline positions; this is equally true of both the most positive and negative stances.



Reportez vous à la page précédente. Quel(s) passage(s) associez vous le plus spontanément aux termes suivants :
entourez le numéro de la photo du ou des passages que vous voulez retenir

Confort pour se balader							
1	2	3	4	5	6	aucun	
Plaisir de se balader							
1	2	3	4	5	6	aucun	
Authenticité							
1	2	3	4	5	6	aucun	
Nature							
1	2	3	4	5	6	aucun	

EXTRACT FROM THE USER SURVEY ON TRAIL DEVELOPMENT

© RESSOURCE

Contribution of the project to SDGs

LIFE project actions contribute to certain SDGs, specifically:

› **ODD 15 - Life on land:** the essence of the project is to contribute to the conservation of terrestrial ecosystems, biodiversity and endangered species, to combat invasive alien species and to integrate these issues into policies for the management of natural spaces.

› **ODD 8 - Decent work and economic growth:** in effect, the project has enabled collaboration between local players, has promoted the creation and retention of employment through outsourcing a portion of its services, notably including the project management and delivery of trail development work (€1.4M), the completion of IAPS removal, evacuation and processing (€480K) and services pertaining to public awareness and communication (€250K). To these direct effects should also be added the indirect impact of economic activity linked to the diversity of the supplier chain involved in these management actions: services for project management (experts in nature, security and health and safety, construction management), materials and services connected to trail development (cables, posts, stone blocks), and the removal, evacuation and processing of IAPS (transport by helicopter, composting, upcycling).

Moreover, the LIFE project also contributed to sustainable tourism.

› **SDG 11 - Sustainable cities and communities:** the project has helped promote the sharing of management and support tools used by local governments to address issues linked to local flora and IAPS. Elsewhere, the engaging environmental education actions address the goal of developing a society that uses knowledge as a driver of action in favour of sustainable development (SDG 12 - Sustainable consumption and production), in order to stimulate changes in behaviour and to equip citizens with the skills they need in order to achieve the objectives set by the strategy.

■ Outlook and Limitations

Regarding the first two studies, the methods of inquiry via questionnaires can have certain limitations. The "permeability", as identified during the user perception study, of support for the project's actions (i.e. the ability to modify opinions on the actions taken via communication *in situ*), can be interpreted in different ways:

- › it may be attributed to support or trust being placed not in the actions themselves, but in the authorities undertaking them. This scenario would posit that the individuals surveyed felt the actions ran contrary to their own perceptions, but consider that if they are being undertaken by the management authority, this must be for a good reason;
- › it could be a case of agreement bias, i.e. the desire or tendency to lean in the perceived direction taken by the institution issuing the questionnaire (or in simpler terms, saying what we think others want to hear). This bias is well-documented in social sciences, and remains an inevitable factor.

This agreement (or acquiescence) bias could also be present in the responses to questions used in the socio-economic impact study. Indeed, certain ecosystem services could potentially be the subject "tutelary" values, i.e. values for which the users are not capable of expressing a personal preference or of gauging their level of significance due to a lack of ecological knowledge, meaning they defer to the opinion of a "superior," which in this case is the park management's scientific authority. If such is indeed the case, this aspect should be taken into account in communications efforts. Indeed, the user perception survey raises the question of park users' ability to form preferences on the complex natural assets to be considered, for which the level of information available to the general public remains generally low.

While the Sustainable Development Goals to be achieved are fairly clear, the methods used to assess their achievement vary considerably. Indeed, since 2015, numerous tools/methodologies have been created at the initiative of the Regional Executives for the Environment, Development and Housing, as well as local governments, notably including tools that involve assessing the contribution of a particular project to the SDGs. Consideration must therefore be given to the choice of methodology used. The assessment is highly dependent on a declarative and subjective analysis made by project stakeholders. This can have several objectives, the choice of which will influence the methodology adopted:

- › evaluating the contribution of a pre-operational action in order to identify all orientations pertaining to possible SDGs, and ensuring that the action does everything it can to address and improve the SDGs;
- › evaluating the contribution of an action over time, by monitoring the contribution of each key step in the completion of the action;
- › evaluating the contribution of an action to the SDGs once the action has been completed, in order to gauge its level of contribution to SDGs and to suggest ways to modify and upgrade the action as a result.

For the LIFE Habitats Calanques project, the latter option was selected, with the analysis being carried out as part of the planning for post-LIFE, i.e. the maintenance and improvement of the project's actions over the long term.

ASSESSMENT OF ECOSYSTEM SERVICES

■ Objectives

Human societies draw a number of goods and benefits from natural environments. These are referred to as ecosystem services (ES). This recently defined concept highlights the importance of nature for humankind, and our dependence on functioning ecosystems. Three types of ecosystem services are defined:

- › provisioning services (PS) are those which create finished products which can then be extracted from natural environments, such as foodstuffs, wood, water, etc.;
- › regulating services (RS) are non-material services which contribute directly to human well-being through the regulation of natural processes (climate and flood regulation, presence of pollinators, etc.);
- › cultural services (SC) represent the intangible benefits attributed to ecosystems, including recreational and tourism-related uses, mental interactions with aesthetic and spiritual values, etc.

An assessment of the impact of actions on ecosystem functions is a required action in all LIFE projects. The concept of an ecosystem service is often used to create awareness and encourage local governments and officials to take action in favour of biodiversity. It allows for the measurement of benefits and/or losses that eco-management actions will have on ecosystem functions. The objective of this study is to estimate the impact of the LIFE Habitat Calanques project's actions on the landscapes of the Calanques National Park, in terms of ecosystem services (ES) provided by the N2000 habitats involved.

■ Methodology

A participative approach was selected, based on the protocol established in the thesis by L. Tschanz (Tschanz, 2021) and validated by the European Commission, and the thesis by S. Campagne (Campagne, 2018). This approach is replicable, succinct (lasting 6 months) and adaptable all types of environments. The assessment principle relies on the establishment of an assessment matrix based on expert estimations, referred to as a "capacity matrix," adapted to the area being studied. The list of ES is sourced from the Common International Classification of Ecosystem Services (CICES). The assessment is carried out via three key steps:

Step 1: assessment via matrix of ES potential across the entire area covered by the Calanques National Park. This provides a global vision of the hypothetical maximum ES yield, and forms a basis for the assessment of ES produced (step 2).

Step 2: matrix assessment of ES produced within the central areas of the Calanques National Park at T+0 (prior to the LIFE project). A territorial analysis of ES is established per habitat within the Calanques National Park's central inland areas.

Step 3: prospective theoretical impact of the project's actions, refocused on the targeted habitats of community interest as of T+5 (end of the project). This step enables us to visualise perceptions of the impact of the project's actions on the ES produced by the ecosystems.

■ Mode of operation

A group of experts with various areas of expertise, profiles and geographic backgrounds was put together. These experts reviewed the list of ES in order to adapt it to the specific characteristics of the area, as well as the list of habitats of priority interest in the sectors being studied. The final matrix is obtained by way of the individual matrices drawn up by each expert.

The assessment matrix is a table showing ecosystem services (ES) on its x axis and the habitats or ecosystems targeted on its y axis. A score between 0 and 5 is given to grade the potential capacity (Step 1), actual capacity (Step 2) and prospective capacity (Step 3) of habitats to provide a given service. A confidence score (CS) is given per column and per line for each ES and each habitat.

Analysis and interpretation of the results must take into account:

- › the standard error, which illustrates the variability of scores between different scorers;
- › the confidence score, which represents the range of uncertainty associated with an estimation;
- › the consensus score, which denotes the similarity of responses between scorers.

Results

In the case of this study:

- › a total of 12 structures and 24 individuals were involved;
- › 27 ES (8PS, 10RS and 9CS) were identified and assessed;
- › 25 habitats in central areas of the Calanques National Park were studied in step 2, and 16 habitats in step 3, so as to focus on sites of community interest targeted by the LIFE Habitats Calanques project.

For each habitat, it is possible to determine a bundle of services that provides average scores for regulating services (RS), provisioning services (SA) and cultural services (CS). It is also possible to perform the analysis per site studied. These results highlight the heterogeneity of services provided at T+0 according to habitat type.

BUNDLE OF ES PROVIDED AT T+0, PROVIDED BY 6 COMMUNITY-INTEREST HABITATS



In the **final capacity matrix**, Cultural Services (CS) are seen as having the strongest potential, notably with regard to phrygane habitats, which incidentally have the highest average ES score, while provisioning services (PS) had the lowest potential, particularly in terms of rocky habitats.

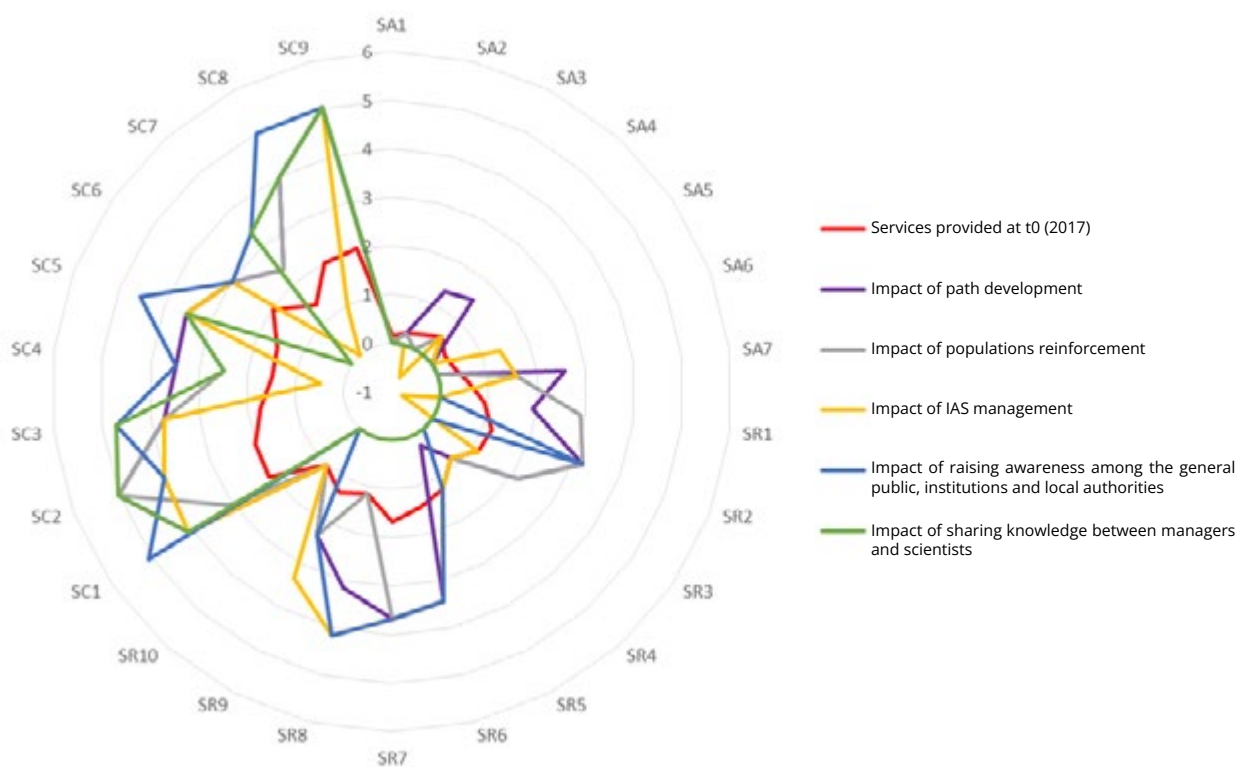
FINAL CAPACITY MATRIX AT T+0

Scoring scale from lowest to highest, represented by colour scale ranging from blue (0) to red (5). The confidence score (CS) appears in pink when positive (>1.5).

	SA1	SA2	SA3	SA4	SA5	SA6	SA7	SA8	SR1	SR2	SR3	SR4	SR5	SR6	SR7	SR8	SR9	SR10	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	IC
The Aleppo pine forest	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Rocky slopes	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Coastal cliffs	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Limestone scree slopes	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Endemic <i>Limonium</i> spp. coastal rocks	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
The phrygana	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
IC	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

The scores for theoretical ES yielded by the project at T+5 (2022) can also be ranked as bundles of ecosystem services, and by groups of actions. The variation in ES scores between T+0 and T+5 can be represented in the form of a radar graph. This graph shows that the majority of ES were positively impacted by the actions of LIFE Habitats Calanques. More precisely, five ES were negatively impacted (though only slightly) by the following 2 actions:

- › restoration of habitat continuity (Action group 1) on the "controlling the spread of wildfires" service (RS5);
- › combating invasive alien plant species (Action group 3) on the following services: PS3, "wild food sources: wild plants"; RS2, "ecosystem service flow"; CS4, "heritage and culture", and CS8, "existence."



BUNDLE OF SERVICES PER ACTION

The ES provided at T+0 appear in red. The theoretical ES at T+1 are represented according to the five different groups of actions applied by the LIFE Habitats Calanques project. Non-assessed ES have a score of zero.

■ Outlook

The ES assessment process used is based on a systematic and participative approach that favours diagnostic assessment of the area, and highlights local knowledge and expertise. It relies strongly on the involvement and reliability of experts throughout the duration of the assessment process. This method sheds light on the wide variety of ES provided by habitats, and allows us to rapidly observe an area's potential in terms of ES. The simplified visual representation of bundles (Tschanz et al., 2015) of ES enables examination of the interconnections between them, as well as between uses of the area and compromises to be made in terms of development efforts and management priorities.

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