Technical update report

subject: TECHNICAL UPDATE ON *DELIVERABLE* N. 2 – MONITORING AND ACTION PLAN FOR *OPUNTIA* SP. PL.

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activities: Technical report: specific monitoring protocol and relative action plan towards the IAS *Opuntia* sp. pl., aimed at the "evaluation of the threats to biodiversity caused by the IAS and relative action plan for the protection of biodiversity", inside BEST project - *Addressing joint Agro- and Aqua-Biodiversity pressures Enhancing SuSTainable Rural Development.*

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Premise

The present report aims at realizing a management plan concerning the invasive species belonging to the genus *Opuntia* sp. pl., also known as prickly pear. This plan is composed by two sections: a monitoring plan, whose goal is to characterize the spatial and quantitative patterns of the distribution of the species on the territory, and a relative action plan. The latter will be strictly related to the monitoring plan, proposing different management strategies depending on the different outcomes.

Capitolo 1. Introduction

Protecting biodiversity is one of the main and most ambitious goals of our times, requiring a strong cooperation among institutions and local managers. Many anthropic factors represent a great menace in this regard, including the introduction of Invasive Alien Species (IAS), which is considered one of the main threats to biodiversity around the world.

1.1 The Invasive Alien Species

According to Kolar & Lodge (2001), ecologically speaking a species is defined as invasive when able to quickly spread from the introduction point throughout the territory, becoming abundant and eventually dominant in this new area. This is possible thanks to the following characteristics (Life ASAP Project):

1. Resistance to parasites and diseases
2. Adaptation to different environmental conditions, including highly anthropized ones
3. Higher competitiveness in exploiting the resources, compared to the native species (sometimes producing allelopathic substances)
4. Quick growth
5. Short life cycle
6. High reproductive potential
7. High diffusion capabilities, eventual asexual reproduction
8. Adaptation of the life cycle depending on the invaded environments
9. Consociation with human activities
10. Resistance to predators/competitors in the new area

From a regulatory point of view, IAS are defined as those species threating biodiversity and related ecosystem services (CDB 2000, 2002), with negative impacts on economic activities and human health. It is thus important to

distinguish between alien species and invasive species, as a new introduced species may not necessarily be related to a menace for local biodiversity.

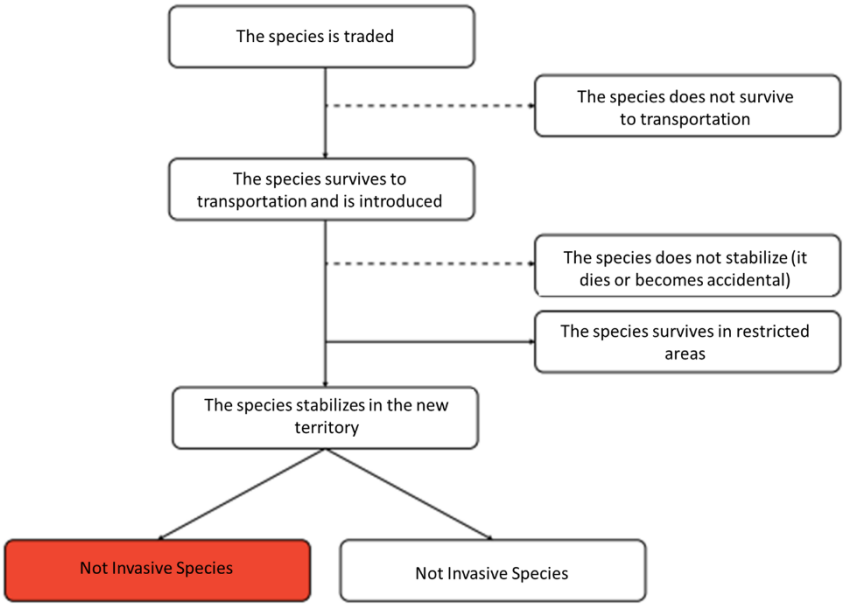

Figure 1: introduction and potential invasion process of an alien species (from lifeasap.eu).

According to the tens rule (Williamson, 1996), around 10% of introduced species survive to the transportation, and 10% of these species stabilize in the new environment. Again, a 10% of these stabilized species may become invasive, giving an overall 0,001% probability of invasion of a new introduced species. Obviously, this "rule" represents an estimation, but still remains a reference point in the study of biological invasions.

1.2 Genus *Opuntia* as an Invasive Species in the Tremiti islands

The prickly pears, belonging to the genus *Opuntia,* are succulent plants of the family of *Cactaceae,* native from America and introduced in every continent except for Antarctica. The stem can reach up to 7 m, the branches are modified into spiny cladodes, which can be elliptic to oblanceolate. Flowers are yellow/orange to red/purple, the fruits are spiny and edible, hence commercialized. Thanks to its wide root system, it can settle on dry, poor soils, as well as anthropized areas, tolerating droughts, salinity and fires. In Europe it has been introduced in the XVI century, mostly for ornamental purposes and commercialization of the fruits, and nowadays there are recordings in every country. In the introduced areas, the species do not have the natural enemies like parasites or herbivores, giving them a great advantage compared to the native species. Among the most important species we can cite *Opuntia ficus-indica* (prickly pear) and *Opuntia stricta* (erect prickly pear), and they mostly settle in low precipitation areas, on rocky and well-drained soils, including the sea cliffs. *Opuntia ficus-indica* is recognized as a problematic IAS for habitats of community interest like the 1240 ("vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* spp.") and the 5320 ("low formations of *Euphorbia* close to cliffs").

The main purposes of this Plan are the production of an eradication/containment protocol for *Opuntia* sp. pl. on the Tremiti islands. This plan focuses on the realization of a first monitoring plan, to locate the individuals of the species on the islands and a management plan dedicated to the eradication of these individuals in the area. Given the limited extension of the Tremiti islands (less than 3 km^2), all individuals will be located and georeferenced, and subsequently removed with the help of mechanical vehicles. A proper communication strategy will be set up to involve the local population in the whole process.

The Tremiti islands have been targeted because of their high conservational value, being located inside the National Park of Gargano and inside the Marine Protected Area "Tremiti Islands". In addition, they are part of a Special Protected Area (SPA) and a Special Area of Conservation (SAC), according to the CEE Habitat Directive 92/43. The flora of the Tremiti islands is rich of endemic species or subspecies, and the natural absence of great herbivores makes them a peculiar but still delicate environment. Compared to other territories, in the insular contexts eradication/containment plans appear to be relatively more efficient, thanks to their isolation and the reduced risks of reintroductions.

Table 1: Characterization of invasiveness of *Opuntia* sp.pl.

Invasiveness characteristics	Evaluation
Velocity of dispersal	Dispersive
Tendency of prevalence	Dominant
Level of threat to biodiversity	Highly competitive
Regional distribution	Widely distributed

Capitolo 2. Characteristics of the species

2.1 Morphological description

TAXONOMY

Division: Magnoliophyta
Class: Magnoliopsida
Order: Cariophyllales
Family: Cactaceae
Genus: *Opuntia*

Figure 2: taxonomical framework of *Opuntia* sp.pl., with pictures.

Opuntia species are generally shrub-like plants, with the stem evolved in cladodes and the real leaves long a few millimetres. At the base of the leaves there are the areoles, spots composed of hairy (glochids) and spiny (spines) structures. Flowers grow at the apical part of the cladodes, the fruits are indeiscent and can be both fleshy or dry when mature. The root system is widely extended but not too deep.

In Italy we can mostly find three species: *Opuntia ficus-indica* (L.) Mill., *Opuntia humifusa* (Raf.) Raf. e *Opuntia stricta* (Haw.) Haw:

- *Opuntia ficus-indica*: less than 5m high, with green/ bluish-green cladodes, 10-40 x 20-60 cm. The spines are white, with small areoles provided with yellow glochids. The mature fruit is yellow/red, 5-9 cm long, sometimes green.

Figure 3: individual of *Opuntia ficus-indica*, focus on cladodes and spines.

- *Opuntia humifusa*: shrub-like plants, 10-30 cm tall and prostrate. The roots are tuberous, the cladodes are dark green turning to red during winter, 2,5-10 x 2,5-12,5 cm of dimensions. Areoles are small and long, glochids are not evident. Flowers are yellow, and fruits are red/purple, from obovoid to oblong, 2,5-5 cm long.

Figure 4: *Opuntia humifusa* flowering (Acta Plantarum).

- *Opuntia stricta*: up to 40cm in height, obovate to oblong cladodes from green to blue 6-15 x 8-30 cm long. Areoles are few, with grey glochids. There are no spines, flowers are yellow, and fruits are purple, pear shaped, 4-6 cm long.

Figure 5: *Opuntia stricta* with fruits (Acta Plantarum).

We hereby provide a dichotomous key to easily distinguish the species of *Opuntia* from other succulent plants, in particular from those belonging to the Cactaceae family, from non-technical staff.

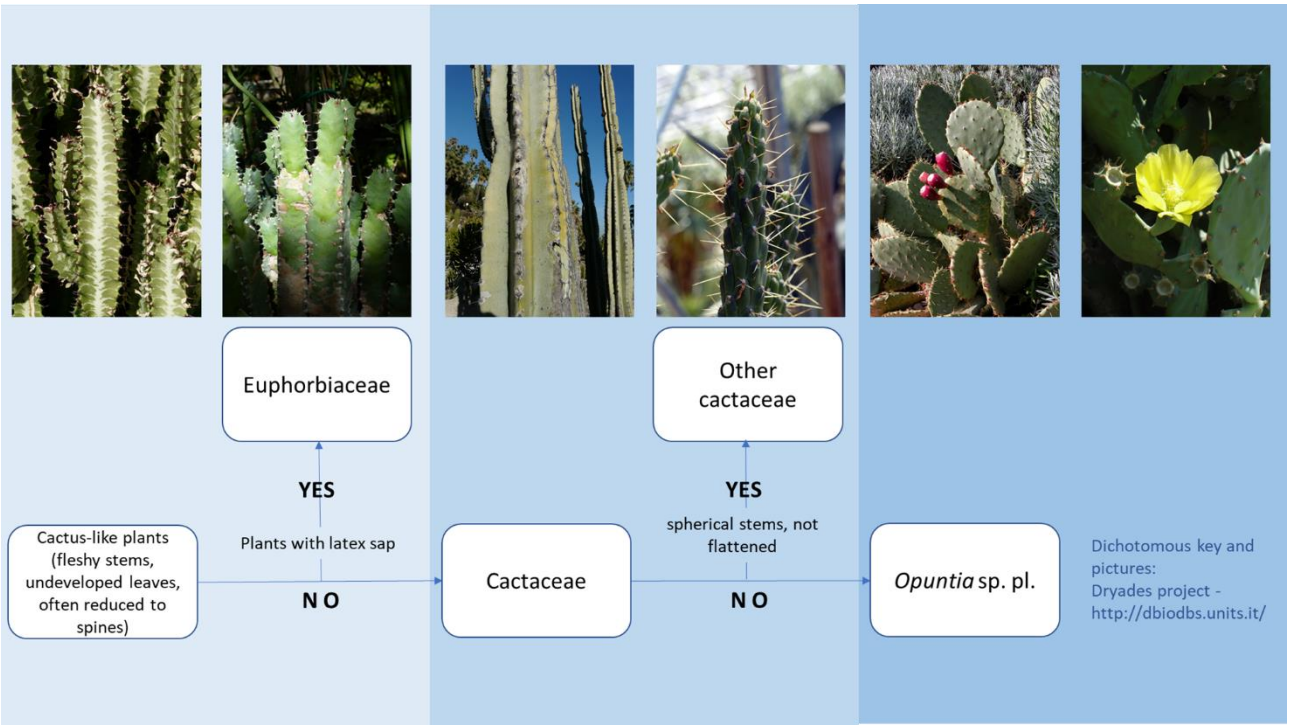

Figure 6: streamlined dichotomous key to the identification of *Opuntia* sp.pl.

2.2 Ecological features

Most of the species of the genus *Opuntia* are native the Mexican semi-arid highlands, which selected an obligate CAM metabolism that allow these species to colonize dry habitats all around the world. The low winter temperatures (-6 to -8°C) slow down the plant activity, but do not constitute a limiting factor for the species.

Thanks to their wide root system, the species can grow on poor, thin, steep soils, and they're able to tolerate different degrees of drought, salinity and fire.

Specifically, the most suitable environments for the three most frequent species in Italy are:

- *Opuntia ficus-indica*: calcareous cliffs, sea areas, cultivated areas
- *Opuntia humifusa*: calcareous and siliceous cliffs, areas close to rivers, poor, pebbly soils, dry stone walls.
- *Opuntia stricta*: calcareous cliffs, railways, poor, pebbly soils.

2.3 Reproduction and development

Opuntia species can reproduce both sexually and asexually. Concerning sexual reproduction, pollination is insect-mediated, from bees in particular, which are attracted by the big flowers and the high amounts of pollen. There are cases of hybridization among species. The fruits are unilocular and polispermic, and they can be fleshy, dry or "xoconostle-like" (with thick skin). Seed dispersion is mediated by animals, feeding on fruits, like birds and mammals.

Asexual reproduction happens mostly through fragmentation, from the cladodes, which can produce new adventitious roots, or through the rizome, which may generate new colonies surrounding the original individual.

Figure 7: adventitious roots on cladode of *Opuntia ficus-indica* (Acta Plantarum).

Capitolo 3. Distribution and pathways of introduction

3.1 Distribution

Opuntia genus contains 150-180 species, all native of American continent, from Canada to South America. The most southern species is *Opuntia fragilis,* while the most common species like *Opuntia ficus-indica* and *Opuntia stricta* are native to Mexico and Central America.

The prickly pear has been introduced in Europe in 1520, and in Italy in 1568. Nowadays, the species are distributed all around the world, except for Antarctica, and recognized as an invasive species in Australia, Eritrea, Ethiopia, South Africa, Hawaii, Somalia, Yemen and the Mediterranean basin.

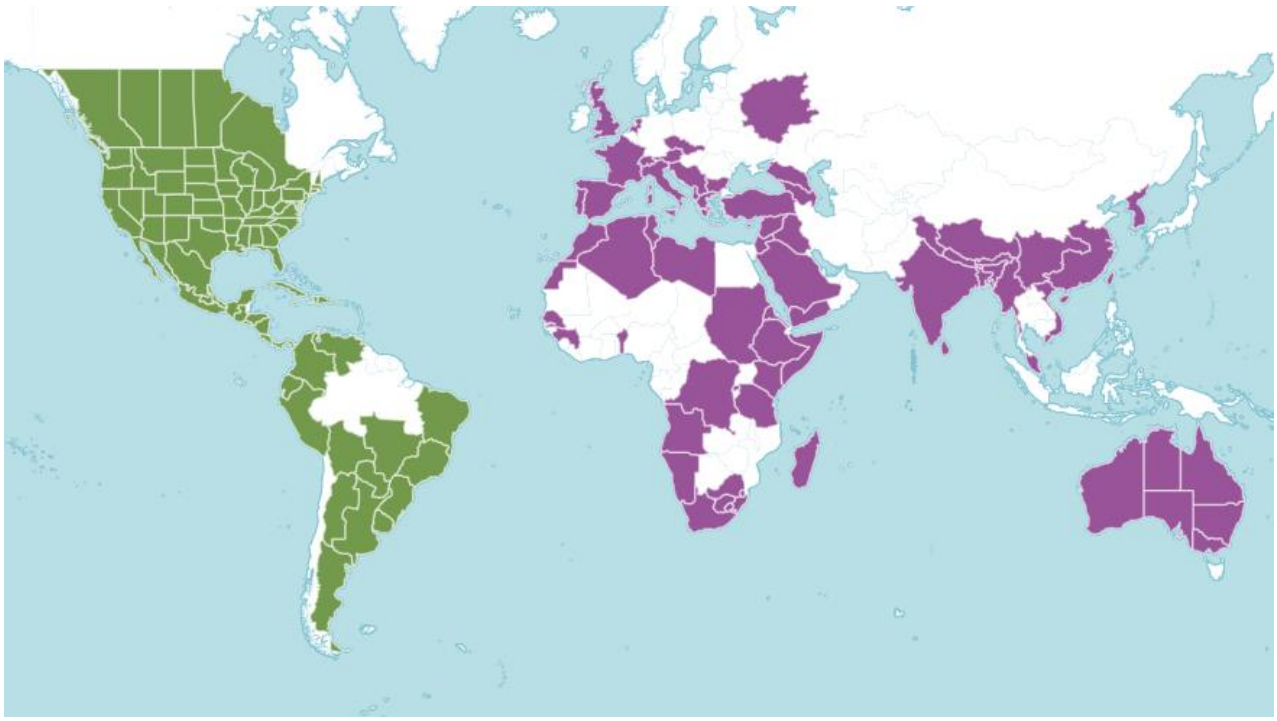

Figure 8: native (green) and introduced (purple) area of the genus *Opuntia*.

In Italy few species are cultivated, mostly in Sicily, and the most common species, mainly distributed in the South and on the islands, are *Opuntia ficus-indica*, *Opuntia stricta* and *Opuntia humifusa*.

In Apulia the species are mostly located on rocky, stony substrates, distributed in all the provinces including protected areas like Natural Regional Park Porto Selvaggio e Palude del Capitano, Natural Regional Park Dune Costiere da

Torre Canne a Torre San Leonardo, Natural Regional Park Fiume Ofanto, Natural Reserve Margherita di Savoia, National Park of Gargano and Natural Regional Park Costa Otranto Santa Maria di Leuca - Bosco di Tricase (the species appears to be quite abundant in this last protected area).. The plant is documented to be located in San Nicola Island, in the Tremiti archipelago.

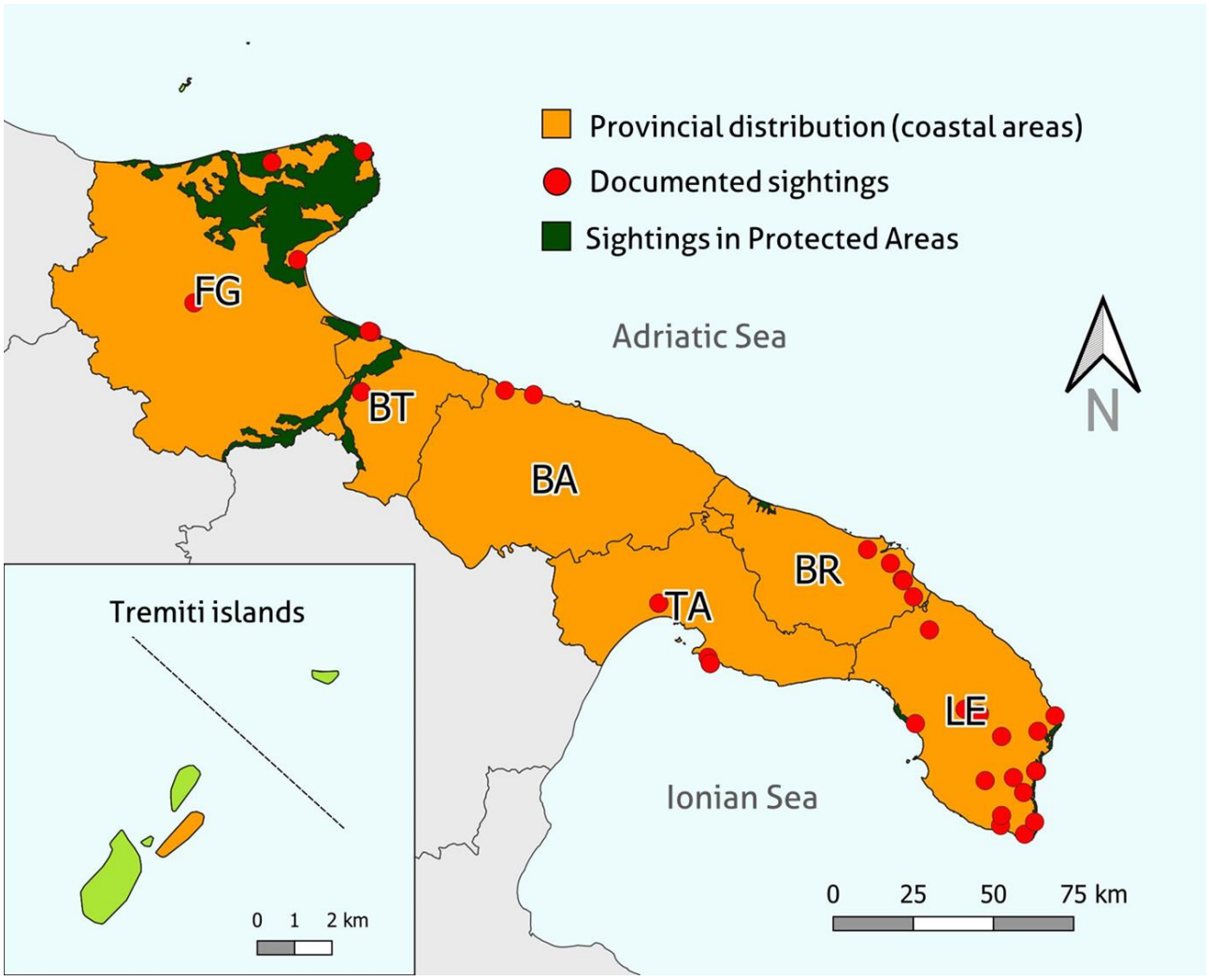

Figure 9: distribution of *Opuntia ficus-indica* in Apulia.

3.2 Pathways of introduction

Human being is the greatest vector for these species, introduced for ornamental and commercial purposes, which lead to the constitution of great plantations for the consumption of the fruits.

In the last ten years the cultivations of prickly pear have been increased significantly, and it is now cultivated in more than 30 countries, thanks to its application in cosmetics and food industry as colouring agent. More recently, the species have been used in agroforestry projects in the developing countries.

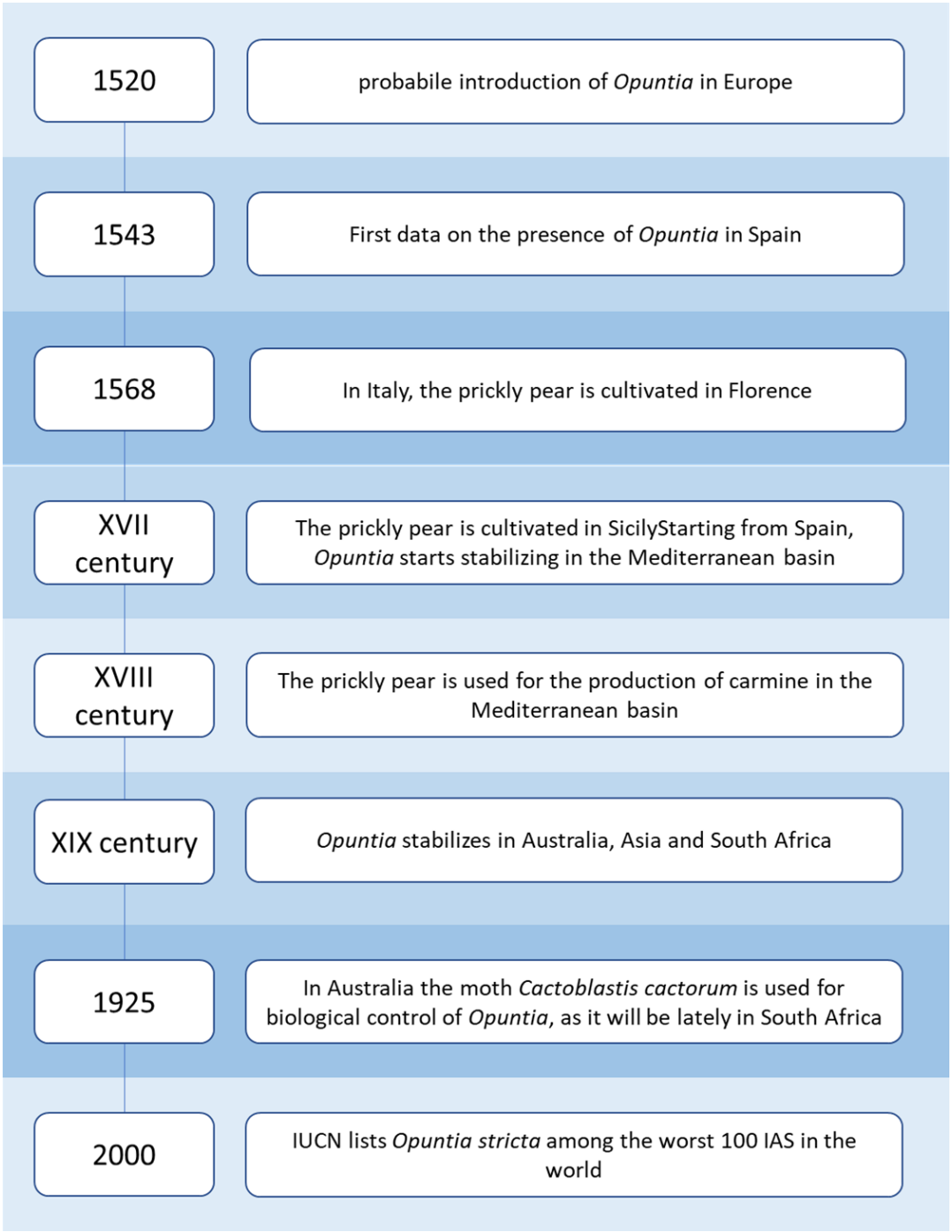

Figure 10: steps of the introduction of the genus *Opuntia* in the world.

Capitolo 4. Impacts

4.1 Ecological impacts

The prickly pear, in its native range, is not considered to be an invasive species, thanks to the control given by its natural competitors and parasites. In the introduced areas, the absence of the natural enemies makes it highly resistant and prolific, forming dense colonies and competing with the other species, inducing selective grazing by the local herbivores, hence reducing biodiversity.

The invasiveness of the species is mainly due to its vegetative reproduction, as even small fragments of the mother plant may give birth to other close by colonies. Their capabilities of living in dry environments and tolerating low temperatures allow to colonize different kind of environments, including cliffs, maquis, or dunes rich in highly adapted species, which may not tolerate the competition with other species.

Sexual reproduction as well represent a great advantage, as seed dispersion by mammals and birds allow the species to colonize distant areas.

Figure 11: presence of *Opuntia* sp.pl. on Pontine islands (http://www.ponderat.eu/)

Figure 12: invasiveness of *Opuntia* sp.pl. in Africa. (https://www.cabi.org/)

4.2 Economic impact

The prickly pear constitutes an economic issue mainly for grazing. Herbivores do not eat individuals of *Opuntia* sp.pl., and it even cause an aversion effect towards the animals, which may avoid grazing the surroundings of the species. It has been observed that in a field with a 20% coverage of *Opuntia,* 30-40% of the surface can be not available to animals, estimating a 7.500$ loss for a 400-hectare field. The eventual ingestion of the fruit by the animals may cause gastrointestinal problems as well.

The economic loss due to the alteration of the habitats are difficult to estimate. Nevertheless, the issue may represent a wake-up call for the correct management of the resources, not only in terms of biodiversity.

Capitolo 5. Regulatory aspects

The cornerstone of European legislation, and subsequently the Italian and Regional legislation, is Regulation (EU) n. 1143/2014 of the European Parliament and the Council, of 22 October 2014, laying down provisions to prevent and manage the introduction and spread of invasive alien species. It requires, *inter alia*, the rapid eradication or control of those species by the Member States.

This decree introduces the prohibition of "introduction, transport, detention (even in confinement), exchange, breeding, reproduction, trade and release into the environment" of the species, for public and private subjects (including individual citizens), and requires eradication, where possible, and control or containment of populations of naturally occurring invasive alien species to prevent further dissemination and mitigate adverse impacts on biodiversity. MiTE (Ministero della Transizione Ecologica) may grant derogations from the prohibitions, subject to authorisation, to botanical and zoological gardens, research institutes and other entities carrying out research or conservation activities *ex situ*. In exceptional cases, derogation shall be granted on grounds of overriding public interest, including those of an economic or social nature. No derogation shall be granted for trade and release into the environment of species listed in the relative Annexes.

The allochthonous species to which the aforementioned regulations apply were subsequently identified through the establishment of lists of invasive alien species of Union relevance or IAS (Invasive Alien Species), through the Implementing Regulation (EU) of 13 July 2016, Commission Implementing Regulation (EU) 2017/1263 of 12 July 2016, Commission Implementing Regulation (EU) 2019/1262 of 25 July 2016.

Italian legislation transposes Regulation (EU) No. 1143/2014 of the European Parliament and of the Council by means of Legislative Decree 230/2017 of 15 December 2017. The measure establishes rules to prevent, minimize and mitigate the adverse effects on biodiversity caused by the introduction and spread, both deliberate and accidental, of invasive alien species within the European Union, and to minimise and mitigate the impact that these species may have on human health or the economy in Italy. The Ministry of the Environment and the Protection of the Territory and the Sea has moreover published two decrees directly connected to the D.Lgs. 230/2017, that is the Ministerial Decree of 6 March 2020, that regulates the institution and the compilation of the register of the exotic species, and the Ministerial Decree of 29 April 2021, which regulates tariffs for activities provided for by Legislative Decree no. 230/2017.

The Apulia Region, in addition to the provisions of Community and Italian legislation on the problem of alien species, establishes a regional coordination table for the control of invasive alien species, through the Decree 815/2019, of 2 May 2019.

No species of the genus *Opuntia* has been defined as invasive alien species of Union concern. *Opuntia stricta* has however been included by the International Union for Conservation of Nature (IUCN) among the 100 worst invasive species in the world (Lowe et al. 2000), a document that, although without normative value, is an important source of information for conservation actions around the world.

Capitolo 6. Monitoring plan

Considering the regulatory aspects of the European Union, monitoring appears to be a key tool to determine the status of the species, by individuating the essential parameters to determine its presence, distribution, abundance, habitats and future trends.

Data must be collected through standardized methodologies, and these must be combined with information collected through previous monitoring campaigns, scientific literature, sightings, and so on. This chapter will then focus on the monitoring techniques required to reach the aforementioned goals.

6.1 Data collection

Collecting the data through bibliography represents a crucial step, as a high-quality information allows to correctly set up the monitoring protocol, together with regards to the techniques and the time scale. This information itself cannot substitute the direct data collection on the field, but it can optimize the sampling effort, with a positive impact on the economy of the project.

The information is collected from three sources:

- Scientific papers
- *on-line databases*
- Protected area manager survey.

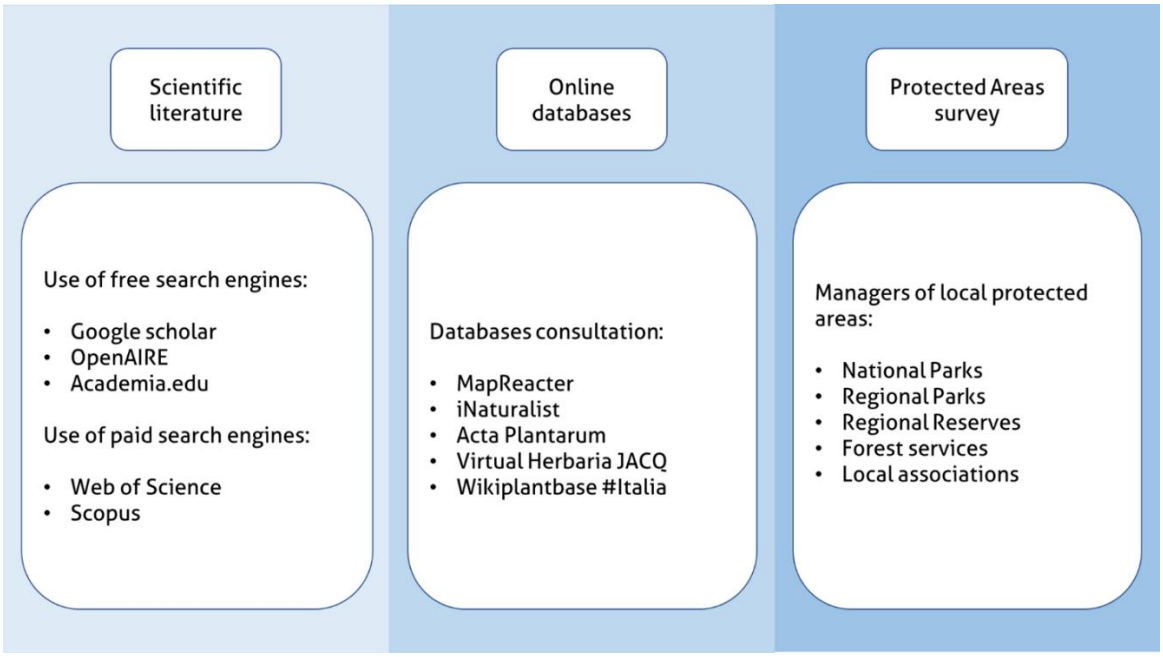

Figure 13: diagram of the sources of the data.

6.1.1 SCIENTIFIC LITERATURE

This source is represented by highly specific scientific journals or technical/informative material, with a major attention to the most authoritative papers (high-impact periodicals, subjected to peer-review; local journals, with high attention to the small-scale patterns). This source may give us information about distribution and abundance of the species. For the present project dedicated search engines have been consulted, as for example *Google Scholar, OperAIRE, Academia.edu, Web of Science, Scopus*.

6.1.2 CONSULTATION OF ONLINE DATABASES

This source is represented by online data collectors, like for geographical information (from which we can determine part of the spatial distribution of a species). There may be some biases due to the upload of incomplete/wrong data, especially by people participating to citizen science projects; specific databases periodically review by experts or technical staff. This tool has the advantage of being continuously updated, avoinding the usual gap between the writing of scientific papers and their publication.

For the present project two main databases have been used: *Mapreacter* from ISPRA and *iNaturalist.*

6.1.3 SURVEYS

Many projects rely on the contribution of citizen science protocols, by gathering information from citizens or stakeholders. For the present project, a specific survey has been proposed to the managers of the local protected areas concerning the presence and distribution of IAS (available at the end of the document, appendix A, produced by Puglia Region and ERSE soc. coop. s.t.p.). This tool aimed at evaluating the critical points about the impacts of these species on the habitats and on the other species, together with gathering information on existing projects for this issue.

6.2 Description of the monitoring plan

This chapter will define the specific modalities to carry out the Monitoring Plan of species belonging to the genus *Opuntia* within the territory of the Tremiti Islands. The presence of *Opuntia ficus-indica* has been reported only on the island of San Nicola. Due to this lack of available information, it is necessary that the plan interest all the islands pertaining to the Archipelago in order to be able to detect the presence of all individuals of *Opuntia* sp.pl. Urbanised areas, public parks and agricultural areas are excluded from this monitoring unless they are authorised by the local authorities or private individuals to whom the land belongs.

The Monitoring Plan is divided into two phases:

- Mapping of areas with *Opuntia* sp.pl.
- Floristic surveys for surveillance monitoring.

6.2.1 MAPPING OF AREAS WITH *OPUNTIA* SP.PL.

This phase is necessary for the identification and assessment of the presence of *Opuntia* sp.pl. on the Tremiti Islands. The staff should be trained in the recognition of species belonging to this genus, possibly using the taxonomic key presented in Chapter 2 (Figure 6). It shall also have the capability to use a GPS device capable of mapping the affected area. With regard to the monitoring of cliffs with high inclination, in order to allow greater operator safety, it is recommended to carry out this step by boat, from the coast. The use of binoculars will facilitate the identification and assessment of the coverage of prickly pear individuals. There is no preferential period for monitoring activities as the

species of the genus *Opuntia* are perennial and can be identified in each season. However, as described in paragraph 6.5, it is advisable to follow the timing of the work to facilitate the performance of the activities. The operator shall proceed by the following protocol:

- Finding of *Opuntia* sp.pl.: the operator must detect the presence of *Opuntia* sp.pl. on sight. The monitoring must be carried out by sight, using motorized means only for small movements in order to ensure an organic census of all prickly pear stations. Such monitoring shall be carried out on all islands of the archipelago. In case of presence of steep cliffs, in case the observation of the escarpment is dangerous, it is recommended the monitoring by boat using binoculars to improve the observation. It is recommended to carry out an effort to maximise the sampling effectiveness taking into account the above recommendations:
    - maximize attention in environments particularly suited to the presence of *Opuntia* sp.pl. (arid soils, cliffs, uncultivated)
    - do not underestimate the wooded areas; although these environments are not particularly suitable for the presence of *Opuntia* sp.pl., in any case, clearings may exist inside them, in addition to the ecotonal belt, which may contain individuals of these species
    - always take into account the extent of the view; this can be prevented by obstacles or vegetation and can vary depending on the light and weather.

  The following map identifies the main botanical aspects present in the intervention territory. The phase of identification of *Opuntia* sp. pl. shall include the following minimum interventions:

    - n. 1 linear transept intersecting each square of approximate 300x300m surface on the intersecting grid for natural and semi-natural areas identified under the cartography Corine Land Cover (in green on the map, figure 14). Subdividing the area of intervention of the Tremiti archipelago in plots of 300x300 will produce n.64 linear transects relatively to this category (see figure 15);
    - n. 1 linear transept intersecting each square of approximate 600x600m surface on the intersecting grid for the agricultural or artificial areas identified under the cartography Corine Land Cover (in brown on the map, figure 14). Subdividing the area of intervention of the Tremiti archipelago in plots of 600x600 will produce n.14 linear transects relatively to this category (see figure 16);
    - linear transepts of sufficient number and length to visually cover the entire extension of the 5320 habitat, for each of the areas in which it has been identified according to the attached cartography (in red on the map, figure 14). Following the subdivision in the same plots above of 600x600 m will produce n.14 linear transects;
    - linear transepts of sufficient number and length to visually cover the entire extent of the 1240 habitat, for each of the areas in which it was identified according to the attached cartography (in yellow on the map, figure 14). Following the subdivision in the same plots above of 600x600 m will produce n.16 linear transects;
    - linear transepts, conducted by boat with operator equipped with binoculars, of sufficient number and length to visually cover the entire extent of the cliff habitat, for each of the areas in which it was identified according to the attached cartography (in blue on the card, Figure 14). Following the subdivision in the same plots above of 600x600 m will produce n.14 linear transects;

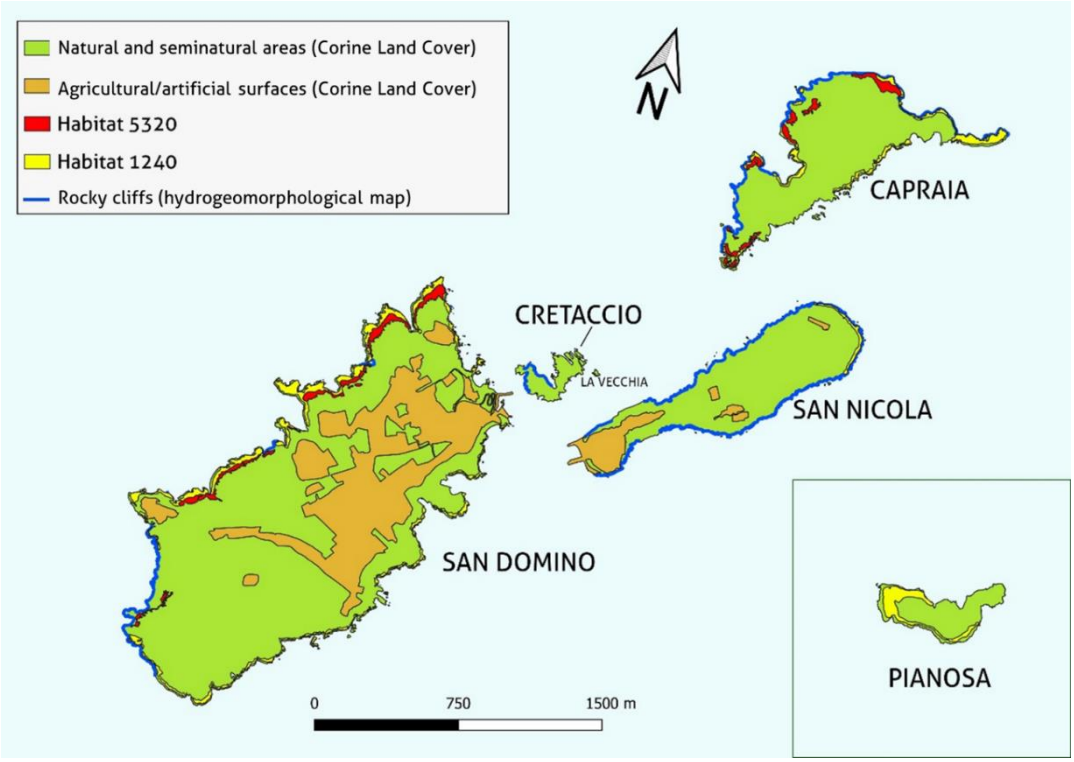

Figure 14: map of the Tremiti Islands with visualization of the categories of land use of interest, habitat and environments of cliff for which to patrol the presence of *Opuntia* sp.pl.

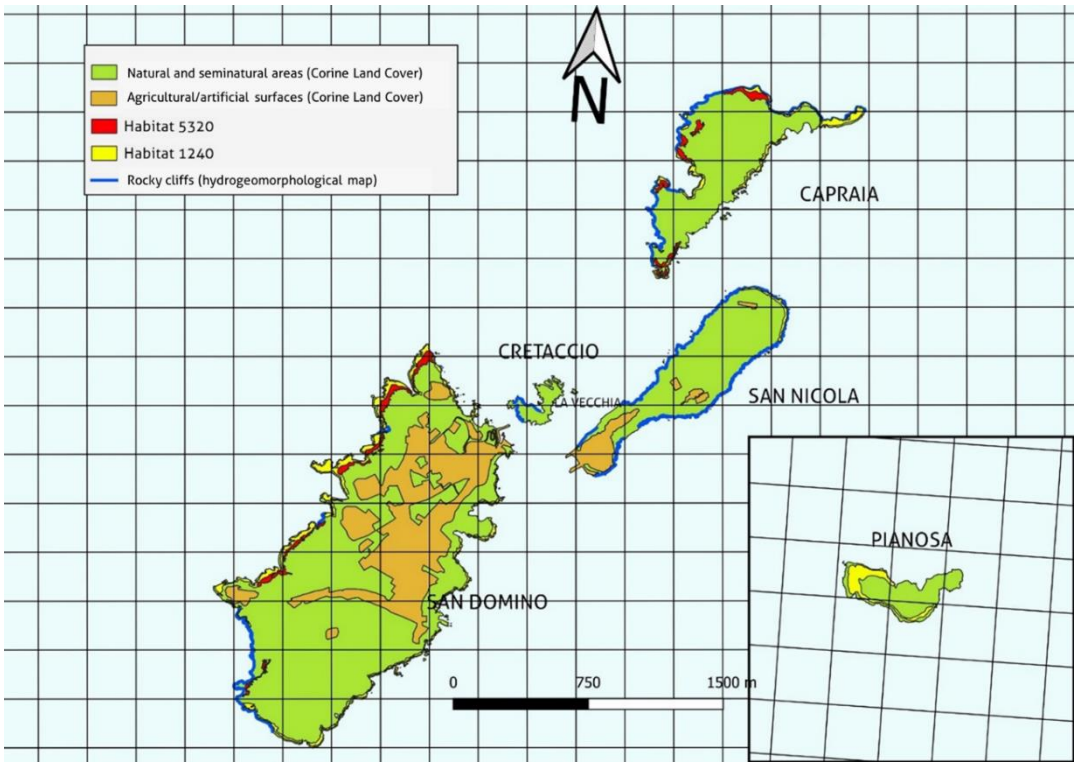

Figure 15: Map of the Tremiti Islands with a grid of 300x300m for the definition of linear transects related to natural and semi-natural areas identified under the cartography Corine Land Cover (green in the paper).

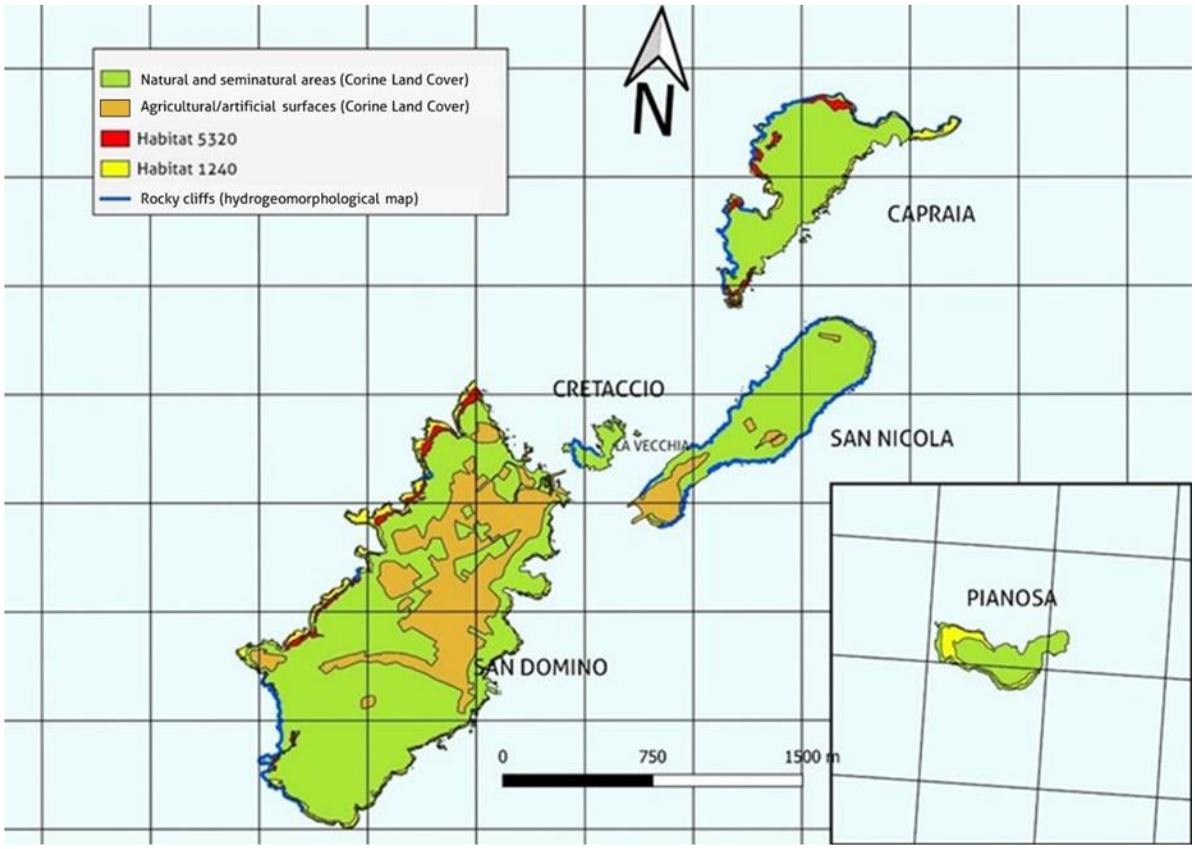

Figure 16: Map of the Tremiti Islands with a 600x600m grid for the definition of linear transects related to agricultural and artificial areas identified under the Corine Land Cover cartography (green in the map).

- Mapping of *Opuntia* sp.pl.: Using a GPS device, the operator must map the perimeter of the area containing Opuntia sp.pl, creating a perimeter track. This area may have a cover of the exotic cluster species, in those cases is however recommended to make polygons of considerable extension (greater than 10m2) in order to facilitate the perimeter with GPS instruments even with limited sensitivity. Perimeter identification should take into account all individuals, including small seedlings, so an accurate investigation of the area is recommended before GPS tracking. In case of monitoring by boat from the coast, the GPS track can be linear and consider the entire stretch of coast concerned.

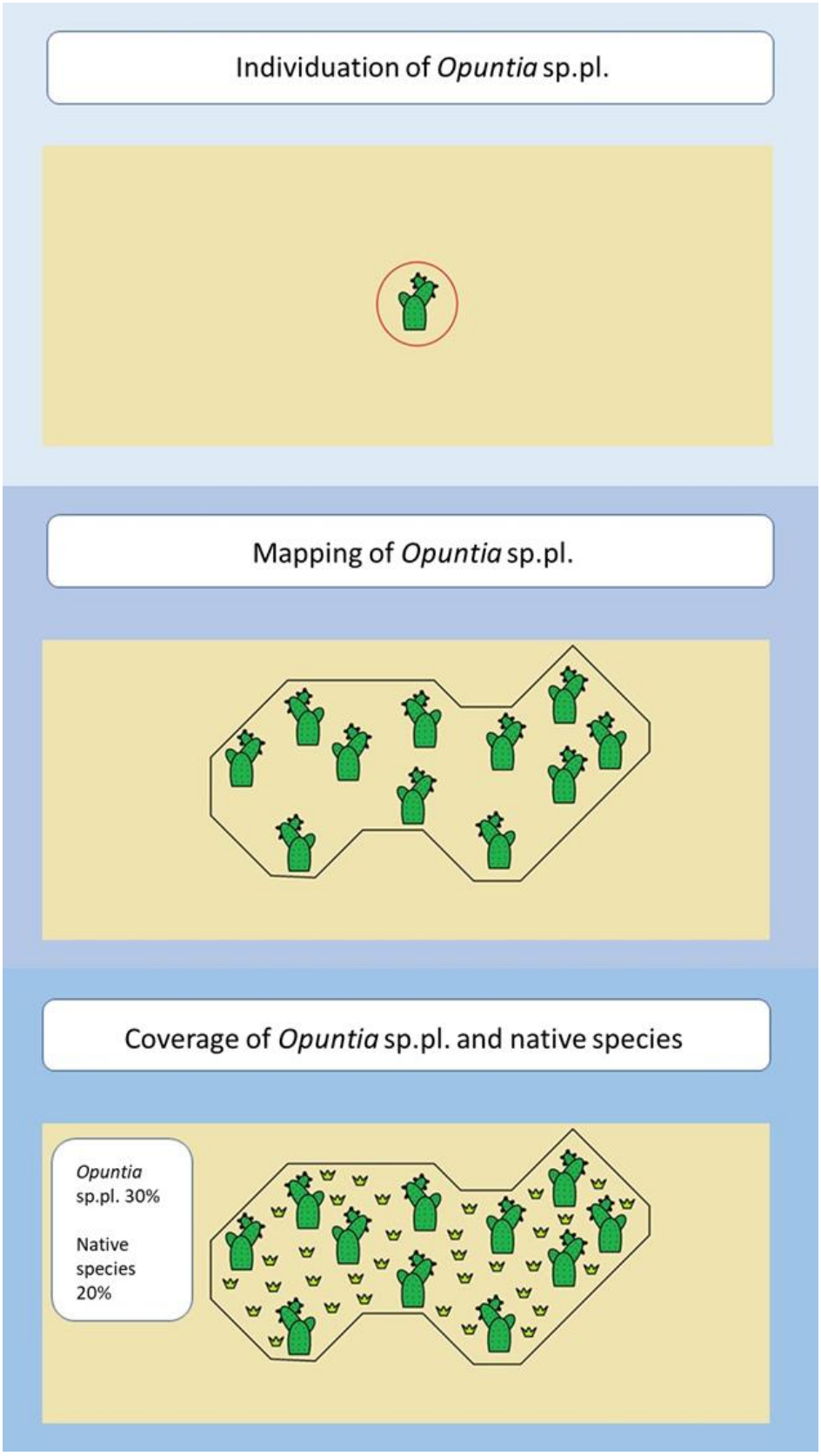

Figure 17: diagram of the phases of the mapping of the areas with presence of *Opuntia* sp.pl.

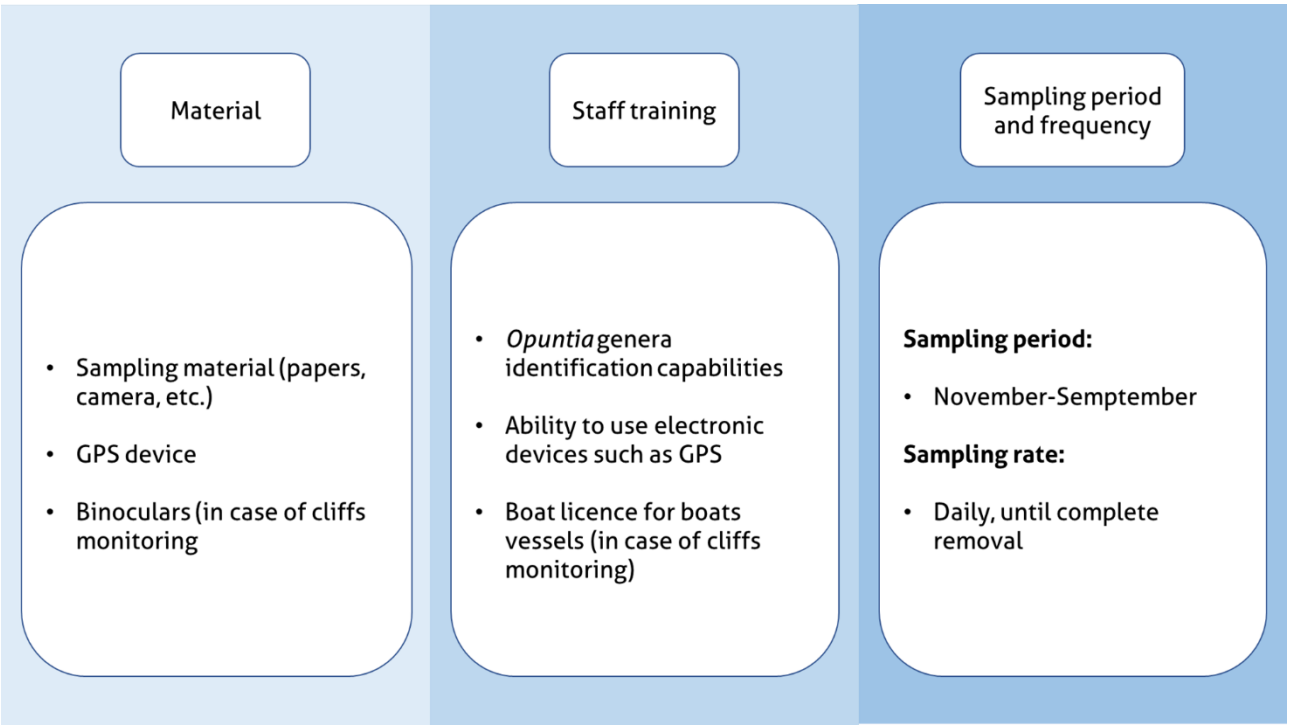

Figure 18: Basic information for mapping areas with *Opuntia* sp.pl.

6.2.2 *OPUNTIA* SP.PL. MAPPING VIA GIS

Spatial mapping is an important phase of data collection, in which the information found must be standardised so that it can be analysed using GIS spatial processing software. Therefore, the data to be collected during the mapping phase, necessary for the production and processing of spatial geometries, shall be provided:

- **Punctual sites with presence of *Opuntia* sp.pl.**: collection of GPS points representing individual isolated individuals of *Opuntia* sp.pl. and/or the best representative centroid of the identified populations, in order to produce point geometries of the sites where both individuals and populations are located.
- **Extension of *Opuntia* sp.pl. population**: Collection of GPS points representing the vertices of the area concerned by *Opuntia* sp.pl., in order to produce polygonal geometries and to be able to subsequently calculate the area through software.
- **Extension of the linear monitoring transepts:** GPS rescue of the linear transepts carried out, in order to produce linear geometries that will be used to identify in the following years the exact location of the same transepts.

With regard to the information to be included in the attribute table of the geometries described above, the following data shall be recorded:

- **Scientific name of the species of *Opuntia* sp.pl. identified** (e.g. *Opuntia ficus-indica*).
- **Location** (site).
- **Environmental typology/habitat affected/or the presence of *Opuntia* sp.pl** (e.g. cliff or habitat N2000 5320).
- **Extent of *Opuntia* sp.pl.** (area).

Table 2: Example of an attribute table for point geometries for individuals/stands of *Opuntia* sp.pl.

ID	Species	Site	Env. typology	Det/Pop	Area
1	*Opuntia ficus-indica*	San Domino Island	Habitat 5320	Cluster	45
2	*Opuntia ficus-indica*	San Nicola Island	Cliff	isolated individual	/

6.2.3 VEGETATION SURVEYS FOR SURVEILLANCE MONITORING

At this stage, the effectiveness of eradication/containment techniques used should be assessed following the evolution of plant communities in the detected areas. This task requires a staff with a high level of training in the field of botany able to identify the plant species present in the detection area and able to carry out a botanical analysis, although not very detailed. The operator must at least be able to identify the habitats included in Directive 92/43/EEC. The use of the Braun-Blanquet method, a method widely used in botanical studies and therefore easily correlated with other phyto-morphological associations already described in the relevant bibliography, is recommended for phyto-morphological analyses. This method involves the following logical steps:

- **Identification of an elementary stand:** by elementary stand means a section of vegetation homogeneous from the point of view of flora, physiognomy and structure. To determine the size of the elementary stand, in order to maximise the effort/sampling ratio, standard tabulated sizes shall be used broken down by vegetation type. In our case the elementary stand must be represented by an area where the cover of *Opuntia* sp.pl. is representative of the survey site. Considering that the populations of prickly pear will generate associations of shrub type, the size of the elementary stand must be of 25-100 m^2. In order to minimise the margin effect, it is recommended that sampling be carried out on square plots with a minimum size of 5 m per side. The primary stand shall be defined for each survey site and shall be made permanent for monitoring in the same areas in subsequent years. Therefore, it is recommended to materialize in situ the detection area, for example by placing at each vertex of the area of metal or wood poles appropriately painted with flashy colours to allow easier detection in subsequent years.
- **Creation of an inventory of all the species present (floristic list):** the operator must be able to visually recognize the species or to take samples to be subsequently identified in the laboratory with the help of a stereoscopic microscope and identification keys. In order to facilitate species identification, it is recommended to carry out such surveys during spring, when most species have diagnostic characteristics such as flowers and fruits. Conversely, it is strongly advised not to take samples in winter, when the annual species may be totally absent.
- **Vegetation cover estimation:** The operator shall estimate the vegetation cover for each identified species. This shall be done for each individual vegetation layer. A layer is a range of heights on which cover of the plant species is assessed as described in Table 2.

Table 3: Vegetation layers.

Layer n.	Height
7	> 25 m
6	12 - 25 m
5	5 - 12 m
4	2 - 5 m
3	0,5 - 2 m

2	25 - 50 cm
1	0 - 25 cm

For vegetation coverage, it shall be defined in coverage classes as defined in Table 3.

Table 4: Braun-Blanquet classes of coverage.

Coverage class	Percentage
5	75-100%
4	50-75%
3	25-50%
2	5-25%
1	1-5%
+	< 1%

Information shall also be provided on the reproductive phenology of the plant according to the Marcello scale (see Table 4) and the shape of the plant species according to Table 5.

Table 5: phenological symbols and description (Marcello scale).

Phenological symbol	Description
000	Absence of the phenomenon
+00	Beginning of the phenomenon
++0	Progress of the phenomenon
+++	Climax of the phenomenon
0++	Decline of the phenomenon
00+	Phenomenon at the end
000	Phenomenon ended

Table 6: acronyms forms and description

Acronyms forms	Description
W	Tree
L	Liana
AL	Woody shrub
E	Epiphyte
H	Grass
M	Moss o lichen

Vegetation measurements shall be made before and after the eradication stage and at the same sites to identify the situation at zero time and thereafter on an annual basis, in order to observe the possible resumption of native vegetation or on the contrary the recolonization of *Opuntia* sp.pl.

In addition to botanical analysis, surveillance monitoring shall also include visual monitoring of the previously mapped area according to the protocol described in paragraph 6.2.1. This monitoring foresees to note the presence of the species afferent to the genus *Opuntia*.

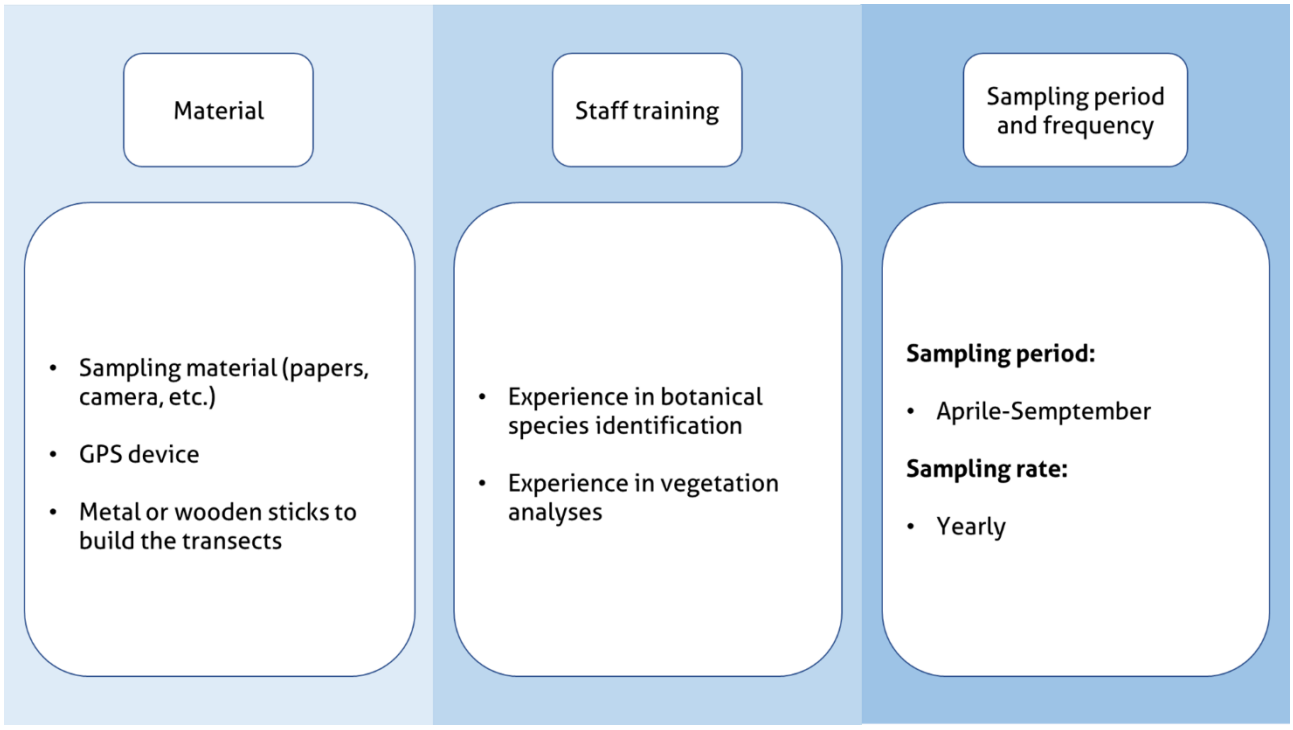

Figure 19: Basic information for botanical surveys.

6.2.4 MONITORING PERIOD, FREQUENCY, AND INTENSITY

Mapping of areas with presence of *Opuntia* sp.pl.

- *MONITORING PERIOD* - The period of identification and mapping of areas in Opuntia sp.pl. will take place in the months from November to September (see para. 6.5 on the monitoring time structure), a period established taking into account the ecological needs of the other subsequent phases, which will not overlap for organizational issues.
- *MONITORING FREQUENCY* - Monitoring involves the performance of activities over 11 months, divided into a first phase of identification and mapping of areas with the presence of *Opuntia* sp.pl. for 5 months (November-March) and a second phase of calculation of these areas (November-September). The frequency of monitoring will be functional to the amount of transects, which will be monitored overall in the months from November to September.
- *MONITORING INTENSITY* - For each of the monitoring areas recognised in par. 6.2.1, the following number of transects are identified:
    - Linear transepts within 300x300m plots intersecting natural and semi-natural areas – 64
    - Linear transepts within plots of 600x600m intersecting agricultural or artificial areas - 14
    - Linear transepts for habitat monitoring 5320 - 14
    - Linear transepts for habitat monitoring 1240 - 16
    - Linear transepts for cliff environment monitoring – 14

To sum up, there will be 122 transects to be covered over 5 months from November to March, while the following months from April to September will serve to complete the mapping of these areas and perform the coverage calculations.

Vegetation surveys for surveillance monitoring

- *MONITORING PERIOD* - The period during which botanical surveys for monitoring will be carried out from April to September (see para. 6.5 on the monitoring temporal structure).
- *FREQUENCY OF MONITORING* - This phase provides for the development of activities over a period of 6 months, from April to September, in which to carry out surveys of population, drawing up lists of flowers and percentages of vegetation coverage. Operations will be carried out in the periods following eradication activities on an annual basis.
- *MONITORING INTENSITY* - The intensity of the monitoring will be definable only after identifying the areas with presence of Opuntia sp.pl. and after removing the individuals present.

6.2.5 COLLECTION OF DATA BY SURVEY CARD

Concerning the calculation of the coverage of *Opuntia* sp.pl. and native species, in order to make an accurate inventory of their presence and the influence of the former on the native flora. The tab "Monitoring Protocol", available in Annex B, must contain the following information:

General information

- **Number det.:** sequential survey number of each station
- **Operator**: name of/operator/s
- **Date**
- **Coordinates**

- Altitude
- Inclination: slope of the ground
- Geological substrate
- GPS track denomination

Data concerning *Opuntia* sp.pl.

- Coverage %: vegetation coverage as a percentage of area perimeter
- Average height cm: average height in cm of plants of the species
- Presence of seedlings: 0 absent, + present, ++ abundant
- Phenology: plant reproductive phenology: 0 absent, + in bloom, ++ in fruit
- Notes

Data concerning native plant species

- Coverage %: vegetation coverage as a percentage of area perimeter
- Average height cm: average height in cm of plants of the species
- Notes
- Number of photos: number of photos taken in the survey station
- Design of the station: recommended especially in the presence of clusters of *Opuntia* sp.pl.

With regard to the vegetation surveys for monitoring purposes, the operator shall record all data on the appropriate "Vegetation Survey Sheet" available in Annex C, which shall contain the following information:

General information

- Number det.: sequential survey number of each station
- Operator: name of/operator/s
- Date
- Coordinates
- Altitude
- Inclination: slope of the ground
- Geological substrate
- Formation of vegetation
- Type of vegetation
- Government and treatment: vegetation management and treatment (including activities related to management methods)
- Method of detection: if alternative methods to the Braun-Blanquet method are used
- Surface mq

- Total coverage

Data for each layer

- Coverage %
- Average height
- Notes

Data for each plant species per layer

- F: form
- Clas. Cov.: class of cover
- Cov. %: percentage coverage
- Phenolog: phenological symbol
- Notes

6.3 Possible risks

The risks related to the monitoring phase are mainly related to the disturbance caused by the operators during the research phases of the *Opuntia* sp.pl. with regard to the local fauna, whose main target is the nesting bird populations, whose most important and conservation sensitive species are represented by: the Scopoli's shearwater (*Calonectris diomedea*), the yelkouan shearwater (*Puffinus yelkouan*), the European shag (*Phalacrocorax aristotelis*), the Audouin's gull (*Ichthyaetus audouinii*), the slender-billed gull (*Larus genei*), the Mediterranean gull (*Ichthyaetus melanocephalus*), the peregrine falcon (*Falco peregrinus*), the Eleonora's falcon (*Falco eleonorae*) and the common tern (*Sterna Hirundo*). The development of the monitoring phase during the winter phase will ensure that there is no overlap with the nesting period of these species, for which maximum precautions are recommended in the most sensitive areas.

As for the safety of operators, these must be covered by appropriate accident insurance policy. In particular, the greatest risks are attributable to falls from above, especially in areas more exposed and closer to heights, as well as the risks related to excessive exposure to high temperatures, during the warmer months of the summer season. With regard to the risks related to falls, precautionary measures will consist in entrusting monitoring actions in areas exposed to highly qualified technical personnel and equipped with appropriate personal protective equipment. While about heat risks it is recommended not to perform activities during the middle hours of the day, in addition to adopting the basic behaviours of proper conduct (abundant amounts of water, sunscreen, protective clothing).

6.4 Evaluation of monitoring outcomes

The monitoring of *Opuntia* sp.pl. on the territory of the Tremiti Islands may hesitate in an absence of the species or in their presence in nature or in private or public areas used for urban areas, gardens, or crops. This presence/absence may occur in one or more islands of the archipelago. Having the objective of eradicating the species afferent to this genus, the management protocol will be applied to all the areas with presence of *Opuntia* sp.pl. regardless of the size of the

population. Following the start of management practices in areas where the prickly pear tree is proven to be present in the wild, surveillance monitoring as described in paragraph 6.2.2 should be implemented, before and in the years following the management actions. If the result of the surveillance monitoring shows a vegetative resurgence of *Opuntia* sp.pl. the repetition of management actions is necessary. In all the islands where the presence of *Opuntia* sp.pl. Communication and awareness-raising actions, both for the local population and for tourists, must be implemented in nature and in public or private areas.

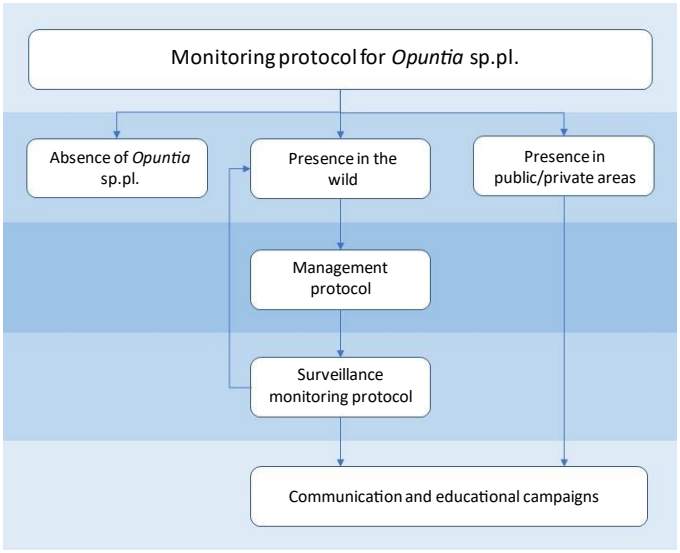

Figure 20: Diagram of evaluation of monitoring outcomes.

6.5 Temporal structure of the monitoring

The following diagram outlines the time sequence in which monitoring is to be carried out for the purposes described above. The monitoring step is planned in the first year and in the third year of the entire management plan. As regards the second year, the presence of eradication activities does not allow for any useful monitoring of the assessments of the success of the objectives of the plan. The mapping phase of the areas at *Opuntia* sp. pl. is not dependent on the solar year, since the plant is easily identifiable throughout the year.

	Months	Nov	Dic	Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
Year 1	Mapping of areas	Detection of *Opuntia* sp.pl.											
		mapping											
		Calculation of coverage											
	Surveillance monitoring						Elementary population						
							Floristic list						
							Estimated coverage						
	Evaluation of monitoring outcomes												Evaluation
	areas	All the island of Tremiti archipelago					Only for areas interesting by the presence of *Opuntia* sp.pl.						

	Months	Nov	Dic	Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
Year 3	Surveillance monitoring						Elementary population						
							Floristic list						
							Estimated coverage						
	Evaluation of monitoring outcomes												Evaluation
	areas	Only for areas interesting by the presence of *Opuntia* sp.pl.											

Capitolo 7. Management plan

7.1 Objective of the management plan

The management of exotic species can basically involve two types of action: control or eradication.

The control of an exotic species involves the periodic removal of individuals of that species from a given territory, without ever leading to its complete absence. This type of action is effective as long as management activities continue and is therefore recommended for long-term management practices.

The eradication of an exotic species from a territory provides instead the complete removal of all the individuals of that species in a single solution (even several times over time, but still included in a single plan of intervention). This type of action usually involves time-limited management activities and is therefore recommended where possible. The main limits to eradication activities consist in the difficulties of realization, both in practical and economic terms; therefore, they can be carried out more easily on limited and isolated territories and are strongly correlated with the biology of the species.

In the present case, the territory of the Tremiti Islands is relatively restricted (less than 3 km^2). The species of the genus *Opuntia* are easy to identify, of important dimensions and have a superficial rooting apparatus, but have the capacity to propagate vegetatively both through fragmentation and through rhizoids, as well as being prickly and irritating species and therefore difficult to remove. For prickly pear, therefore, although it has problematic invasive characteristics, it is possible to implement an eradication plan, if linked to surveillance monitoring in the medium to long term. In the light of these considerations, the objective of this plan, that is to eradicate species of the genus Opuntia from the territory of the Tremiti Islands, is achievable.

7.2 Phase of eradication

At the end of the application of the Monitoring Plan, all areas with the presence of the genus *Opuntia* in the territory of the archipelago will be identified and mapped. Areas, public or private, used for housing, public parks and crops for which access to land has not been authorised will be excluded from this map. The plan provides for the following protocol:

- Complete removal of *Opuntia* sp.pl.: In order to completely remove the individuals of prickly pear, it is necessary to implement procedures that remove the whole plant. The capacity of vegetative reproduction by rhizomes allows the individuals of *Opuntia* to regenerate from the roots even after the loss of the aerial part. It is therefore not recommended the implementation of removals to the collar, whether they are carried out manually or with light tools (cut) or if carried out by small excavators. The use of shredding machines is even more discouraged. Although they facilitate operations in terms of timing, they release small fragments that can subsequently vegetate. Recommended techniques are described below.
- Removal by truck with hydraulic arm and gripper head: this technique is recommended for the removal of individuals of considerable size, because the use of the machine is demanding and takes a long time, being unproductive for

small individuals. This technique involves the coupling of the base of the individual with a gripping head and the vertical extraction of the whole plant. If the individual has a good rate of lignification this procedure should not involve the rupture of the individual and a good part of the root system should consequently be eradicated. In case of partial removal of the plant, is possible to finish the work manually. It is recommended to limit the excavation to the part affected by the presence of the plant in order not to affect the health of the native vegetation.

Figure 21: Dump truck, hydraulic arm and grab head. (https://www.customtruck.com/)

- Manual removal by means of light tools: to remove small individuals or non-lignified individuals, it is advisable to pursue manual removal using gardening tools. They include protective instruments (gloves, glasses, reinforced clothing) and tools for cutting and excavating (hand saws, picks, machetes, billhooks, shovels). It is also possible to build pulley systems that are more easily positioned and usable than a truck with hydraulic arm and gripper head, but with the same vertical extraction capacity. Again, the excavation of the soil must be limited in order not to damage native flora and habitats. In these procedures, it is necessary to limit the reduction of the plant in medium-small parts to avoid accidental dispersion.
- Drying of the removed material of *Opuntia* sp.pl.: the previously removed material shall be placed on highly resistant sheeting or, alternatively, on pre-existing cemented soil. This storage can take place at the removal site or the material can be transported by means: in any case, any storage area, even temporary, of parts of *Opuntia* sp.pl. shall be provided with tarpaulins or other waterproofing surfaces to prevent possible soiling. The accumulated material must be dried in the sun for several weeks until it takes on a parchment-like appearance. As a control method, it is possible to make test cuts to observe that there is no residual humidity inside the stems or cladodes, which would determine the possibility of vegetative recovery of the plant. The material must be spread as far as possible so that there is no differential drying of the various parts of prickly pear. In any case, the tarpaulin or the cemented soil must be large enough to have a buffer band along the edge not occupied by the plant material, to avoid accidental dispersion of the material due to the wind.
- Trimming of dried *Opuntia* sp.pl.: The previously dried material must be trimmed. In order to improve the effectiveness of combustion more easily flammable plant material can be added, like twigs or dry wood. Usually, for a complete combustion, several shortenings are needed on the same stack. Such combustion, in accordance with the L.R. n 38/2016 "Rules on the fight against forest fires and interface", must not take place in the period between 1 June and 30 September, and must not be performed on windy days or with excessive heat. The extract of Article 4 of the same regional law is also given:
  "In protected natural areas and in "Natura 2000" sites, stubble and plant residues resulting from agricultural forestry activities cannot be burnt and must be chipped/chopped on site. In protected natural areas and in "Natura 2000" sites, in order to contain the spread of weeds resulting in the dissemination and increase of the infestation load of pathogens present on the residues of the finished crop and the infestation load, subject to certification by the Regional Phytosanitary Observatory Section, or under obvious conditions of impossibility to perform other type

of destruction, subject to certification by the Section Sustainable Management and Protection of Forest and Natural Resources, the owner, the holder or the holder of any land may, by way of derogation from the cross-compliance scheme and the requirements laid down in Article 3, ignite and burn the stubble and plant residues.";
According to what has just been reported, since the prickly pear is an allochthonous weed plant species, the reduction of plant residuals can be done even if in a protected natural area, after certification by the Regional Phytosanitary Observatory Section. It is specified that this material does not in itself constitute solid urban waste (R.S.U.), and therefore its management does not fall within the waste framework unless otherwise specified. The material may be landfilled by incineration if it is not possible or economically feasible to shorten it in designated areas: its management may in this case be assimilated to that of green-green cuttings not intended for composting or similar recycling/re-use procedures.

Special consideration should be given to the possible removal of *Opuntia* sp.pl. from steep cliffs. On these grounds, the use of vehicles as trucks is not possible; therefore, the machining can be carried out only by hand or with light tools. The staff shall be specially trained to work in cliffs or cliffs and shall be equipped with safety equipment typical of rock climbers. Specific equipment such as cranes or pulley systems equipped with high-strength sheeting for the vertical transport of plant material shall also be used for material removal.

It is also recommended, during each stage of the management plan, to limit the use of means in order to avoid the accidental transport of plant material that could colonize other areas. Every operation of loading, unloading, transport of plant material must be carried out with the utmost care to avoid the dispersion of even small fragments. The recommended period for carrying out the management plan procedures is from December to May, a period in which no ripening fruit is likely to be present, which therefore cannot be used as a source of food for local fauna at storage sites.

Figure 22: Example of reef eradication activity of the species *Carpobrotus edulis* with safety equipment (Giunti 2015).

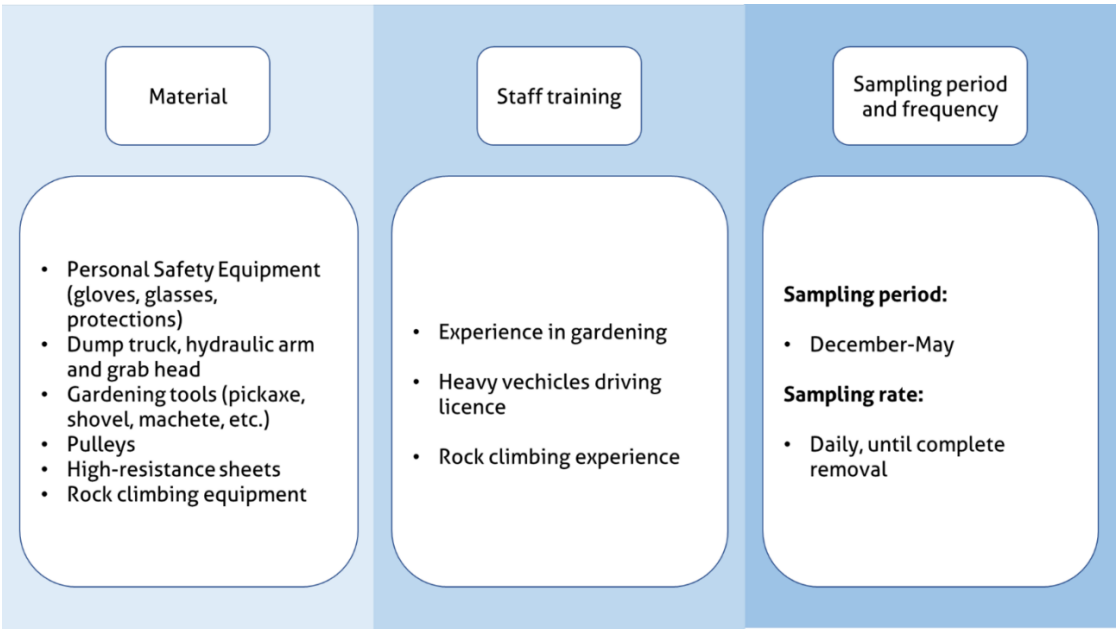

Figure 22: Basic information on the implementation of the Management Plan.

7.3 Temporal structure of the eradication plan

The following diagram outlines the time sequence in which the phases of the eradication campaign are to be carried out for the purposes described above, in conjunction with the previous phase of evaluation of the monitoring outcomes. This phase is planned for a period of 6 months, in order not to have to shorten during the summer season in accordance with regional legislation. The eradication phase is planned for the second year of the entire plan and is consequently linked to the mapping phase of the areas planned in the first year.

	Months	Nov	Dic	Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
Year 2	Evaluation of monitoring outcomes	Evaluation											
	Eradication step		Physical removal										
			Drying										
				Browning									
	areas	Only for areas interesting by the presence of *Opuntia* sp.pl.											

It should also be noted that the timing of the eradication phases must be respected even if, at the end of each year, on the basis of the results of the final evaluation phase of the monitoring plan (see the relevant paragraph for more details) the need to continue with the eradication plan for the following year (see next paragraphs) should be assessed. The time scale of the entire management plan, including the monitoring and eradication phases, shall be 36 months. By overlapping the whole monitoring phase (including monitoring activities) with the eradication phase, the timing of the activities can be summarised using the following Gantt diagram:

	Months	Nov	Dic	Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
Year 1	Mapping of areas	Detection of *Opuntia* sp.pl.											
		mapping											
		Calculation of coverage											
	Surveillance monitoring						Elementary population						
							Floristic list						
							Estimated coverage						
	Evaluation of monitoring outcomes												Evaluation
	areas	All the island of Tremiti archipelago					Only for areas interesting by the presence of Opuntia sp.pl.						
Year 2	Months	Nov	Dic	Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
	Evaluation of monitoring outcomes	Evaluation											
	Eradication step		Physical removal										
			Drying										
				Browning									
	areas	Only for areas interesting by the presence of Opuntia sp.pl.											
Year 3	Months	Nov	Dic	Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
	Surveillance monitoring						Elementary population						
							Floristic list						
							Estimated coverage						
	Evaluation of monitoring outcomes												Evaluation
	areas	Only for areas interesting by the presence of *Opuntia* sp.pl.											

7.4 Disposal of waste plant material

As already defined in paragraph 7.2, the material resulting from eradication activities does not in itself constitute solid urban waste (R.S.U.) and therefore its management does not fall within the waste framework unless otherwise specified. The material may be landfilled by incineration if it is not possible or economically feasible to shorten it in designated areas: its management may in this case be assimilated to that of green-green cuttings not intended for composting or similar recycling/re-use procedures.

7.5 Staff employed

The implementation of this Management Plan requires the presence of adequately trained technical and operational staff, capable of coordinating, controlling and carrying out field activities.

7.5.1 COORDINATION TEAM

The first phase will be that of technical-operational coordination regarding the organization of the intense activities, the timing of the activities, the acquisition and management of the equipment and the support for the activities on the field, both as regards the monitoring plan and eradication measures. We recommend a staff of at least 2 people, whose main tasks are summarized below:

- Scheduling the detailed calendar of activities.
- Research and organization of personnel involved during the operational phase (see para. below).
- Identification of monitoring transects.
- Equipment preparation and retrieval (GPS, field material, binoculars, boats, etc.).
- Collection, analysis and organization of collected data; mapping of areas in *Opuntia* sp.pl.

7.5.2 FIELD TEAM

In this phase, the staff will require to coordinate the field operations, both for monitoring and eradication steps.

Monitoring phase

For the monitoring phase, consisting of mapping activities of the areas in *Opuntia* sp.pl. and from the botanical surveys, operators will have to possess a high level of training in the field of botany, in order to identify the plant species present in the detection area, together with being able to carry out a botanical analysis, although not very detailed.

For the finding part of *Opuntia* sp.pl., assuming that 4 linear transepts can be performed per day, for a total of 122 linear transepts, a number of 31 working days can be estimated, executable by a single operator adequately trained, as specified above. The same operator will subsequently have the role, in the following months, to map and to calculate the coverage of the areas with presence of *Opuntia* sp.pl.

The intensity of the vegetation survey phase, to be carried out over 6 months, from April to September, will have to be calibrated on the basis of the results of the eradication campaign; therefore, a complete quantification is currently not possible. However, a conservative estimate can be used by a single operator to carry out two phyto-mineral surveys per working day, basis from which to calculate the number of actual working days after becoming aware of the areas to be investigated.

Phase of eradication

During the eradication phase there are two specialized groups of operators, the first ones used to drive the motorized vehicles, represented by the vehicles with hydraulic arm and gripper head, the second ones used to remove the stands of *Opuntia* sp.pl. from steep cliffs, for which special skills will be needed in the field of rock climbing. For the non-rock eradication phase, a team of min. 3 operators is provided in the case of driven vehicle (one driver and two additional operators) and min. 4 operators in the case of manual removal, where all operators will be involved through the use of gardening tools. Regarding the phase of eradication on rock will be necessary min. 3 operators, of which 2

involved in the phase of climb and a third operator of logistic support and safety, as well as for the subsequent transport of the material removed to the appropriate areas.

The same operators involved in the eradication phases will then have to take care of the storage of the material removed, in its drying and in the subsequent disposal by landfill and/or shortening.

NB - The distinction between coordination team and operational team is a functional division of roles, which does not affect the possibility that the same operators may perform both functions.

7.6 Cost estimates

In this paragraph the cost estimates for the project are provided, divided per year and per phases, in reference to the previous chapters. Fares and estimated costs include staff, vehicles and material costs, and they are based on mean market values, thus they may undergo downward adjustments during the executive steps of the project, where the real costs are produced by local operators or through specific administrative procedures (which may take into account downward offers), or where the costs may be optimized according to the local specific conditions (which may differ to those proposed by the theoretical plan). In order to ease these revisions, for each cost item the unit cost is provided (day/man, daily expense, etc.), which may be used in eventual recalculations of the final balance according to the new conditions.

Estimates are to be considered inclusive of all the expected expenses for the execution of the Plan, without taking into account eventual fundings provided by the local managers through the use of resources at their disposal (internal staff, agreements/contracts with local companies, etc.). These resources could eventually be allocated as components to co-finance the project, in order to request specific funds.

	Team	Job	Daily operators cost	Daily vehicles cost	Dailty cost	Maximum of days	Minimum of days	Maximum estimated expense	Minimum estimated expense
Year 1	Coordination team	Coordination	500 €	/	500 €	20	20	10.000 €	10.000 €
							TOT. TEAM	**10.000 €**	**10.000 €**
	Field team	Mapping of cliffs	600 €	500 €	1.100 €	3	3	3.300 €	3.300 €
	Field team	Mapping of inland areas	600 €	/	600 €	28	28	16.800 €	16.800 €
	Field team	Surveillance monitoring	600 €	/	600 €	61	16	36.600 €	9.600 €
	Field team	Materials	/	/	/	/	/	400 €	400 €
							TOT. TEAM	**57.100 €**	**30.100 €**
							TOT. YEARLY	**67.100 €**	**40.100 €**
Year 2	Team	Job	Daily operators cost	Daily vehicles cost	Dailty cost	Maximum of days	Minimum of days	Maximum estimated expense	Minimum estimated expense
	Coordination team	Coordination	500 €	/	500 €	10	6	5.000 €	3.000 €

							TOT. SQUADRA	5.000 €	3.000 €
	Field team	Eradication phase (cliffs)	1.100 €	700 €	1.800 €	28	7	50.400 €	12.600 €
	Field team	Eradication phase (manual)	400 €	700 €	1.100 €	44	11	48.400 €	12.100 €
	Field team	Eradication phase (mechanical)	350 €	2.200 €	2.550 €	22	6	56.100 €	15.300 €
	Field team	Materials	/	/	/	/	/	1.400 €	1.400 €
							TOT. TEAM	156.300 €	41.400 €
							TOT. YEARLY	161.300 €	44.400 €
Year 3	Team	Job	Daily operators cost	Daily vehicles cost	Dailty cost	Maximum of days	Minimum of days	Maximum estimated expense	Minimum estimated expense
	Coordination team	Coordination	500 €	/	500 €	20	16	10.000 €	8.000 €
							TOT. TEAM	10.000 €	8.000 €
	Team field	Surveillance monitoring	600 €	/	600 €	61	16	36.600 €	9.600 €
							TOT. TEAM	36.600 €	9.600 €
							TOT. YEARLY	46.600 €	17.600 €
							TOT. PROJECT	275.000 €	102.100 €

7.7 Possible risks

Similarly to the monitoring phase, the risks associated with the eradication phase are mainly linked to the disturbance caused by operators during the research phases of Opuntia sp. pl. nuclei, with regard to the local fauna, whose main target is the nesting bird populations, whose most important and conservation sensitive species are represented by the Scopoli's shearwater (Calonectris diomedea), the yelkouan shearwater, (Puffinus yelkouan), the European shag (Phalacrocorax aristotelis), the Audouin's gull (Ichthyaetus audouinii), the slender-billed gull (Larus genei), the Mediterranean gull (Ichthyaetus melanocephalus), the peregrine falcon (Falco peregrinus), the Eleonora's falcon (Falco eleonorae) and the common tern (Sterna Hirundo). The development of the monitoring phase during the winter phase will ensure that there is no overlap with the nesting period of these species, for which maximum precautions are recommended in the most sensitive areas. This risk is intensified during the reef eradication phases carried out by specialised personnel, as the extent of the disturbance is amplified. In this regard, it is advisable not to carry out such operations during the nesting phases of susceptible species of birds.

In addition, there is the risk of damage to flora caused by the passage of heavy goods vehicles during eradication, for which it is recommended the utmost caution and the assessment of alternative routes where species of particular conservation interest are found.

The risks in human terms are mainly related to the safety of operators, which will have to be covered by appropriate accident insurance policy. In particular, the greatest risks are attributable to falls from above, especially in areas more exposed and closer to heights, as well as the risks related to excessive exposure to high temperatures, during the warmer months. As regards the risks related to falls, precautionary measures will therefore consist in entrusting monitoring actions in areas exposed to highly qualified technical personnel equipped with appropriate personal protective equipment, while with regard to heat risks it is recommended not to perform activities during the middle hours of the day, in addition to adopting the basic behaviours of proper conduct (abundant amounts of water, sunscreen, protective clothing).

In addition to the risks mentioned above, there are those arising from the use of heavy goods vehicles and the removal of the stands of Opuntia sp. pl. from steep cliffs. In both cases, risk containment will be carried out by entrusting the above activities to specialised technical personnel, provided with appropriate insurance policies and experts in the field.

7.8 Monitoring of the progress of the intervention and future actions

The protocol of the management plan, if correctly applied, should provide for the removal of all individuals of *Opuntia* sp.pl. from the territory of the Tremiti Islands. It is however possible that the species recolonizes the area following dispersion by seed or by vegetative propagation by fragmentation or by rhizoids escaped eradication. It is therefore necessary to draw up a monitoring plan for surveillance as described in Section 6.2.2. In fact, the sites where the prickly pear was found must be analysed annually, both to evaluate the resumption of the native vegetation, the end of the operations, and to observe the presence of a possible recolonization. In case of the vegetative resumption of *Opuntia* sp.pl. is necessary to carry out the actions foreseen by the Management Plan. These actions must be carried out quickly, both to avoid a more widespread colonization of the species and to reduce the operating costs of management.

Vegetation monitoring by floristic surveys should continue at least until species belonging to the genus Opuntia are present in the station for three consecutive years. It is specified that by station, means all the area included in the perimeter identified during monitoring and not only the plot dedicated to botanical analysis.

In any case, it is possible to observe a transposition of occasional reports of the presence of Opuntia sp.pl., escaped the Monitoring Plan or due to growth after the development of the entire plan. In this case, there shall be *ad hoc* activities, similar to those described in paragraph 6.2 (mapping, vegetation analysis) and paragraph 7.2 (management actions).

These actions should be related to prevention and communication strategies described below (Chapter 8).

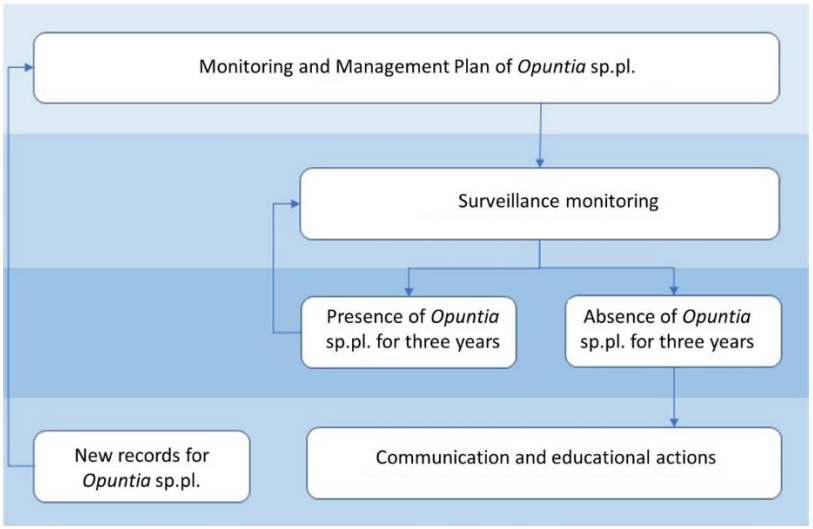

Figure 23: Diagram of future actions.

Capitolo 8. Prevention and communication

These chapter contains the main guidelines concerning prevention and communication strategies to adopt about the management of *Opuntia* species. The strategy is divided in three steps: Pre-Monitoring plan, Pre-Management plan and post-Management Plan.

- pre-Monitoring Plan step: communication is mainly dedicated to the Tremiti islands stakeholders, especially to the staff of the National Park of Gargano. Secondarily, the local municipalities and the privates who manage the properties of the targeted areas must be taken in account, to get the proper permissions to proceed. In order to do so, specific informative and non-technical material must be produced, with the organization of dedicated roundtables to let a correct flow of information.
- pre-Management Plan: in this step, citizenship and authorities must be informed about the operative procedures of the Plan, through meetings, seminars and conferences aiming at informing the people about IAS (with a focus on *Opuntia*) and their threats to biodiversity and economy. Particular attention must be dedicated to the trade of exotic plant species, for ornamental and/or commercial purposes, together with communicating the conservational value of the Tremiti islands and in general to the fragility of insular ecosystems. Specific signs/billboards must be placed close to the areas of intervention, explaining the purposes of the Plan, the issues related with *Opuntia* sp.pl. and the species and the habitats threatened by its presence. All the material must be produced both in Italian and in English. Internet and more specifically the social platforms can be used, as a practical tool to quickly spread the information about the project.
- post-Management Plan: this step is focused con communicating the outcomes of the management activities, through the production of reports which will be provided to the stakeholders. The results must be communicated to the citizenship as well, through specific meetings/seminars/conferences.

  Special attention will be given to the future actions and to the prevention strategies aiming at avoiding new colonization processes in the Tremiti islands, including citizen science projects involving the collaboration of the local population.

  Similarily to the previous step, internet and social platforms can play a crucial role in this direction.

Figure 24: example of a final seminar of a project (http://www.lifelagnature.org/)

Finally, specific signs and billboards concerning the proposed activities, the purposes of the project, the description of the threatened species and habitats must be produced, eventually comparing the situation before and after the interventions. Modalities to report new sightings of *Opuntia* must be cleared out, as well as the authorities to communicate with.

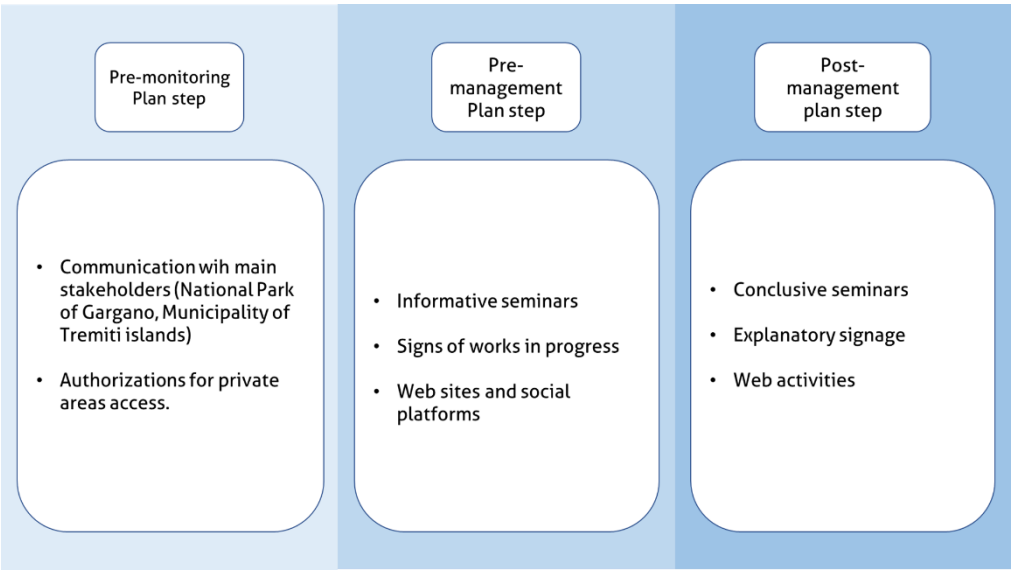

Figure 25: communication and prevention strategies of the different steps of the Plan.

Capitolo 9. Conclusions

The correct application of the Monitoring Plan and Management Plan on *Opuntia* sp.pl will provide:

- **Mapping and characterization of areas with presence of *Opuntia* sp.pl.:** These operations aim at better planning the future management actions. Mapping allows to selectively monitor the areas with higher probabilities of recolonization by the prickly pear after the eradication, easing the post-eradication monitoring. The main issue will be related to the mapping of private properties, where the authorization will be required. A proper communication before the monitoring step will play a major role in this direction.
- **Surveillance monitoring to evaluate the change in composition of the vegetation**: through plant surveys it will be possible to monitor the change in structure and composition of the vegetation, since the start of the project till the following years. Monitoring aims at individuating new colonization areas of *Opuntia* sp.pl. in the previously mapped areas. The main issue of this step will be the presence of a highly formed staff, able to identify all the plant species and to deduce the vegetation associations, which could be solved by contacting external experts.
- **Eradication of all the individuals of *Opuntia* sp.pl.:** Through the help of mechanical vehicles or manually, it will be possible the removal and disposal of all the individuals of *Opuntia* sp.pl. from the Tremiti islands. The management protocol must be followed properly in order to achieve this challenging result. Highly specialized staff will be in charge of the removal of the prickly pear clusters on the roughest areas, like rocky cliffs.
- **Communication strategies to prevent new recolonizations of *Opuntia* sp.pl.:** Preventing new reintroduction and colonisations is fundamental for the success of the Plan. Local population must then be informed about IAS and their threats to local native ecosystems, specifically on *Opuntia* sp.pl. and on flora and habitats of the Tremiti islands. This step will be achieved through the organization of specific informative material, seminars, web pages and by contacting the population and the local stakeholders.

The activities are in accordance with the goals of the Management Plan, i.e. the eradication of the prickly pear from the Tremiti islands. Specifically, methods involving the prosecution of these actions through the years, in case of detection of new clusters, will be fundamental to achieve these goals, and surveillance monitorings will be the correct tool. In addition, a proper communication campaign and the production of specific informative material will increase the chances of success.

It is finally fundamental to stress out that the present Plan takes part of a broader context, characterized by many projects involving the protection of the insular ecosystems (for example Life+ Montecristo 2010, Life PonDerat 2014, Life LETSGO Giglio 2018, Life Diomedee 2018), and that the proposed protocols, if properly readapted, could be extended to the management of other invasive species, or to other territories. Given the high conservational value of the Tremiti islands (SPA, SAC, Protected Marine Area, National Park), the application of the plan in this area appears to be particularly suitable to protect the natural resources at a regional, National and European level.

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Project LIFE + LAG'Nature Ensemble protégeons non lagunes: http://www.lifelagnature.org/

RESTO CON LIFE "Island conservation in Tuscany, restoring habitat not only for birds": https://www.restoconlife.eu/

Tremiti Genius Loci: https://www.tremitigeniusloci.it/geologia/

Annex A – Survey on IAS in the Apulian territory

The following survey is part of the "BEST Project - Addressing joint Agro- and Aqua-Biodiversity pressures Enhancing SuSTainable Rural Development - Interreg Programme V-A Greece-Italy 2014/2020" (www.interregbest.eu), aiming to elaborate a monitoring protocol for evaluating threats to biodiversity caused by the presence of invasive alien species, together with a dedicated action plan for biodiversity conservation. We need to obtain a simple and clear information from the institutions directly involved in managing local flora and fauna about the most-pressing invasive alien species on the territory, ultimately looking for a monitoring protocol for the management of the 5 priority target species.

We are presently asking you a few minutes of your time to answer the following questions.

Full name

Name of the institution

E-mail contact

Which are the terrestrial plant invasive alien species that cause major threats within your territory/protected area? (Write at least one species up to a maximum of 5, or write "not relevant")

Which are the terrestrial animal invasive alien species that cause major threats within your territory/protected area? (Write at least one species up to a maximum of 5, or write "not relevant")

Which are the aquatic plant invasive alien species that cause major threats within your territory/protected area? (Write at least one species up to a maximum of 5, or write "not relevant")

Which are the aquatic animal invasive alien species that cause major threats within your territory/protected area? (Write at least one species up to a maximum of 5, or write "not relevant")

List the biotic and abiotic features (habitats and ecosystems, vulnerable species/populations) most affected by the the species mentioned above.

Define the area where the effects of the alien species take place.

Are there already ongoing monitoring protocols or action plans (eradication/containment) with respect to these species (i.e. LIFE+ Projects)? If available, share the link to the project

Within your territory of competence, are there any prevention programs with respect to future introductions of alien species? If so, which ones? If available, share the link to the program/project

Annex B – Monitoring protocol for *Opuntia* sp.pl. in the Tremiti Islands

Site Code…..... Operators ..... Date .....Locality…..... .....

Altitude…….. Steepness (°)…… geological substrate…… GPS track……

Opuntia sp.pl.	Coverage	Mean height	Presence of young individuals	Phenology	Notes

Other species	Coverage %	Mean height	Notes

Number of photo
Drawing of the site

Annex C – Vegetation survey card

VEGETATION SURVEY CARD

Site Code…..... Operators ..... Date .....

Locality ……..

Exposition				
	N	NE	E	SE
	S	SW	W	NW

Coordinates.....

Altitude..... Steepness (°) ..... geological substrate .....

vegetational composition.....

vegetational series .....

management .....

survey method. ..... surface mq .....total coverage……..... %

STRUCTURAL ANALYSIS

Layer n.	Height	Coverage %	Medium height m	Notes
7	> 25 m			
6	12 - 25 m			
5	5 - 12 m			
4	2 - 5 m			
3	0,5 - 2 m			
2	25 - 50 cm			
1	0 - 25 cm			

COVERAGE
5 = continuous (> 75 %)
4 = interrupted (50 - 75 %)
3 = sparse (25 - 50 %)
2 = low (5 - 25 %)
1 = sporadic (1 - 5 %)
+ = almost no coverage (< 1 %)

BRAUN-BLANQUET SCALE:
5 = coverage > 75 %)
4 = coverage 50 - 75 %)
3 = coverage 25 - 50 %)
2 = abundant, but with coverage < 25 %)
1 = well represented, but with cov. < 5 %)
+ = present, but with very low coverage

PHENOLOGICAL SYMBOLS (MARCELLO)
000 = absence of the phenomenon
+00 = beginning of the phenomenon
++0 = progression of the phenomenon
+++ = apex of the phenomenon
0++ = decline of the phenomenon
00+ = ending of the phenomenon
000 = ended of the phenomenon

FORM
W = woods
L = lianas
AL = woody shrubs
E = epiphytes
H = herbs
M = bryophytes and lichens

Num.	Floristic composition	Layer	F	Cov. Class	Cov. %	Phenolog.	Notes
1		7					
		6					
		5					
		4					
		3					
		2					
		1					
2		7					
		6					
		5					
		4					
		3					
		2					
		1					
3		6					
		5					
		4					
		3					
		2					
		1					
4		6					
		5					
		4					
		3					
		2					
		1					
5		6					
		5					
		4					
		3					
		2					
		1					
6		6					
		5					
		4					
		3					
		2					
		1					
7		6					
		5					
		4					
		3					
		2					
		1					
8		5					
		4					
		3					
		2					
		1					

Num.	Floristic composition	Layer	F	Cov. Class	Cov. %	Phenolog.	Notes
9		5					
		4					
		3					
		2					
		1					
10		5					
		4					
		3					
		2					
		1					
11		5					
		4					
		3					
		2					
		1					
12		5					
		4					
		3					
		2					
		1					
13		5					
		4					
		3					
		2					
		1					
14		5					
		4					
		3					
		2					
		1					
15		5					
		4					
		3					
		2					
		1					
16		5					
		4					
		3					
		2					
		1					
17		5					
		4					
		3					
		2					
		1					
18		4					
		3					
		2					
		1					

Num.	Floristic composition	Layer	F	Cov. Class	Cov. %	Phenolog.	Notes
19		7					
		6					
		5					
		4					
		3					
		2					
		1					
20		7					
		6					
		5					
		4					
		3					
		2					
		1					
21		6					
		5					
		4					
		3					
		2					
		1					
22		6					
		5					
		4					
		3					
		2					
		1					
23		6					
		5					
		4					
		3					
		2					
		1					
24		6					
		5					
		4					
		3					
		2					
		1					
25		6					
		5					
		4					
		3					
		2					
		1					
26		5					
		4					
		3					
		2					
		1					

Num.	Floristic composition	Layer	F	Cov. Class	Cov. %	Phenolog.	Notes
27		5					
		4					
		3					
		2					
		1					
28		5					
		4					
		3					
		2					
		1					
29		5					
		4					
		3					
		2					
		1					
30		5					
		4					
		3					
		2					
		1					
31		5					
		4					
		3					
		2					
		1					
32		5					
		4					
		3					
		2					
		1					
33		5					
		4					
		3					
		2					
		1					
34		5					
		4					
		3					
		2					
		1					
35		5					
		4					
		3					
		2					
		1					
36		4					
		3					
		2					
		1					

Num.	Floristic composition	Layer	F	Cov. Class	Cov. %	Phenolog.	Notes
37		7					
		6					
		5					
		4					
		3					
		2					
		1					
38		7					
		6					
		5					
		4					
		3					
		2					
		1					
39		6					
		5					
		4					
		3					
		2					
		1					
40		6					
		5					
		4					
		3					
		2					
		1					
41		6					
		5					
		4					
		3					
		2					
		1					
42		6					
		5					
		4					
		3					
		2					
		1					
43		6					
		5					
		4					
		3					
		2					
		1					
44		5					
		4					
		3					
		2					
		1					

Num.	Floristic composition	Layer	F	Cov. Class	Cov. %	Phenolog.	Notes
45		5					
		4					
		3					
		2					
		1					
46		5					
		4					
		3					
		2					
		1					
47		5					
		4					
		3					
		2					
		1					
48		5					
		4					
		3					
		2					
		1					
49		5					
		4					
		3					
		2					
		1					
50		5					
		4					
		3					
		2					
		1					
51		5					
		4					
		3					
		2					
		1					
52		5					
		4					
		3					
		2					
		1					
53		5					
		4					
		3					
		2					
		1					
54		4					
		3					
		2					
		1					