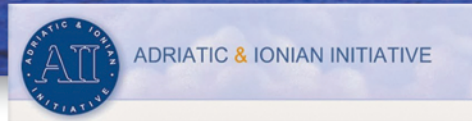


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Monitoring of threatened plants in the 'Sentina' Natural Reserve (Marche, Italy)

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Abstract

Among the plants of conservation interest in the 'Sentina' Natural Reserve, monitoring was carried out based on the red lists, the plant rarity, and the importance of their habitat. The following taxa were chosen for the monitoring from 2007 to 2012: *Ranunculus peltatus* subsp. *baudotii*, *Euphorbia terracina*, *Carex extensa*, *Rumex palustris*, *Elytrigia juncea* subsp. *juncea*, *Spartina versicolor*, *Eryngium maritimum*, *Artemisia caerulescens* subsp. *caerulescens*, *Medicago marina*, *Salicornia perennans* subsp. *perennans*, *Crypsis schoenoides*, *Crypsis aculeata*, and *Halimione portulacoides*. Following this monitoring, management activities that will be useful for the conservation of the flora of the Natural Reserve are here proposed.

Key words: coastal plants, monitoring, Natural Reserve, threatened plants.

Introduction

The Habitats Directive (92/43 /EEC) obliges EU member states to protect plant habitats and species that are listed in Annexes I, II, IV, and V. The lists of vascular plants do not meet the current conservation priorities for the Italian flora, and thus there is the need for these to be updated. The Adriatic coastal plants are certainly among the most endangered in central Italy, although some are also relatively widely spread, and so do not appear in Annex II of the Directive; however, these are often characteristic of priority habitats. To better assess the reported decline, there is the need to activate monitoring systems. Indeed, the mid-Adriatic coastline is now largely anthropised, and there are only a few patches of natural vegetation remaining. One of these natural habitats is the 'Sentina' Regional Natural Reserve (Fig. 1).

Materials and methods

Selection of plants species of conservation interest

The flora of the 'Sentina' Regional Nature Reserve has been reported on recently (Conti *et al.*, 2013). This was based on botanical reports from as early as 1800, with the observations of Orsini, and Marcantoni Marzietti that were published by Bertoloni (1833-1854). These reports were continued in more detail especially in the second half of the last century, by Brilli-Cattarini (1970, 1971, 1976), Brilli-Cattarini & Sialm (1973), Brilli-Cattarini & Ballelli (1980), Brilli-Cattarini & Gubellini (1987a, 1987b), Biondi *et al.* (1988) and Biondi & Formica (2000). We were thus able to evaluate the impoverishment of this coastal flora that was demonstrated by the considerable level of extinction. Of 464 entities surveyed, 143 were not confirmed, due

to the profound changes in the dunal, intradunal and retrodunal habitats (Conti *et al.*, 2013). We have also identified some taxa of conservation interest according to the red lists (Conti *et al.*, 1992, 1997; Rossi *et al.*, 2013), rarity in the flora of the Abruzzo and Marche regions (central-eastern Italy), as well as the rare habitats in which they are found.

Survey and analysis of the spatial distribution of the taxa under consideration

The following taxa were chosen for the monitoring from 2007 to 2012: *Ranunculus peltatus* subsp. *baudotii*, *Euphorbia terracina*, *Carex extensa*, *Rumex palustris*, *Elytrigia juncea* subsp. *juncea*, *Spartina versicolor*, *Eryngium maritimum*, *Artemisia caerulescens* subsp. *caerulescens*, *Medicago marina*, *Salicornia perennans* subsp. *perennans*, *Crypsis schoenoides*, *Crypsis aculeata*, and *Halimione portulacoides*.

For these plant species, the sampling method used was based on the presence within 'cells' that made up a georeferenced network (WGS 84/ UTM Zone 33N); for the standard cartographics, use was made of the portion pertaining to the vectorial land use of the Municipality of San Benedetto del Tronto.

Considering the total area of the Natural Reserve (177.55 ha) we choose a grid spacing of 0.25 ha (i.e. 50 × 50 m) (Fig. 2). With the use of a handheld PC, the global positioning system, and the ArcPad 7 software, the geo-referenced points were defined, to which were associated the information on the presence of the plant species being monitored (Fig. 3). Through the work carried out from 2007 to 2009 as part of the technical studies of the Management Plan of the Natural Reserve (Conti *et al.*, 2011), the distribution areas of the species of particular conservation interest in these previous surveys were monitored to confirm whether

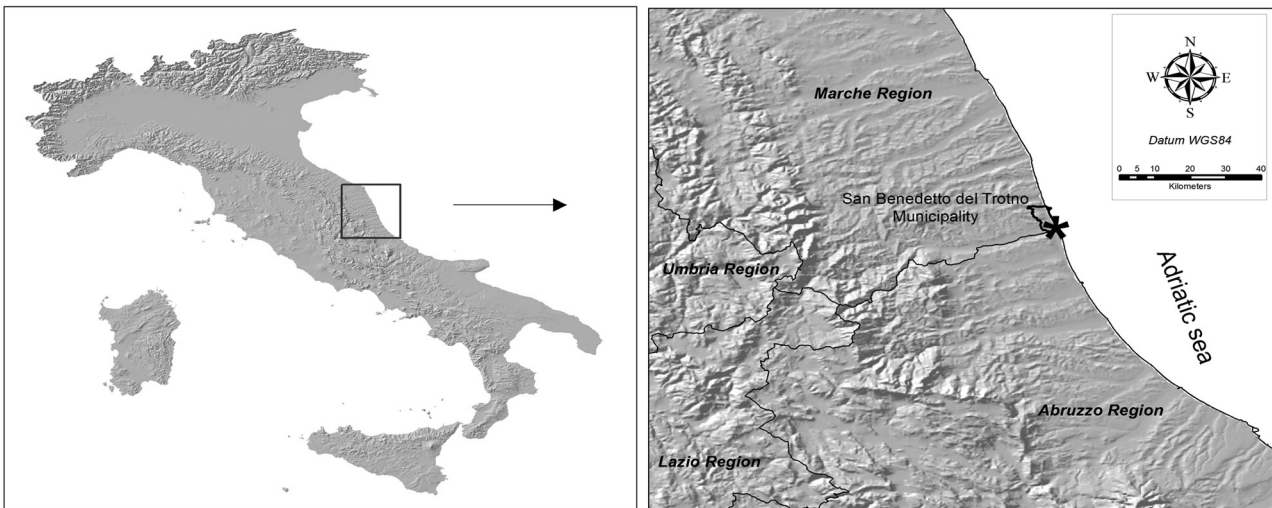


Fig. 1 - Map showing the study area: the 'Sentina' Regional Natural Reserve.

or not the given species was still present in 2012.

The data thus obtained were processed in the geographic information systems environment, which defined the presence or absence of any given species of plant within the individual units of the grid sampling area described above (Fig. 3). These were then applied to the cartography (i.e., as 2012 vs. 2009).

The same procedure was applied to the computation of the data relating to recent and future reintroductions of the following plant species: *Artemisia caerulescens* subsp. *caerulescens*, *Erianthus ravennae*, *Cladium mariscus*, *Imperata cylindrica*, *Juncus acutus* subsp. *acutus*, *Juncus maritimus*, *Schoenus nigricans*, *Son-*

chus maritimus, *Isolepis cernua*, *Linum maritimum*, *Rorippa palustris*, *Cyperus capitatus*, *Echinophora spinosa*, *Eryngium maritimum*, *Medicago marina*, and *Silene canescens*.

Although the last campaign for the georeferenced detection of the presence or absence of any given species dates back to 2012, the present modifications of the status are also given in the results and the subsequent discussion, which have arisen from more recent direct observations. To monitor the coastal dynamics that have affected the coast of the Natural Reserve over time, spatiotemporal comparisons were performed for the coastline, through the use of overlapping aerial images that dated back to 1976, 1994, 2009 and 2013. For the starting situation, use was made of georeferenced maps of the Management Plan for San Benedetto del Tronto that dated back to 1961.

Results and discussion

We compiled the lists of the past and present distributions of the plant species being monitored following the methods of analysis described above, as, for example, seen for the distribution of *H. portulacoides* (Fig. 4). The results of the field sampling of the species under study are shown below, followed by observations relating to the coastal erosion.

Distribution areas of the taxa under consideration

RANUNCULUS PELTATUS Schrank subsp. **BAUDOTII** (Godr.) C.D.K. Cook

For the period from 2007 to 2009, *R. peltatus* subsp. *baudotii* was exclusively reported for a depression that was periodically flooded, and was located near the north entrance of the Natural Reserve, between the road and the cultivated fields. This was no longer detected in the recent survey, probably due to the exten-



Fig. 2 - Illustration of the division of the territory of the 'Sentina' Regional Natural Reserve divided according to the sampling 'cells' (50 × 50 m). The symbols correspond to the information on the presence of the plant species considered.



Fig. 3 - Detail of the territory of the 'Sentina' Regional Natural Reserve illustrating the presence of *Artemisia caerulescens* subsp. *caerulescens* (+) and the corresponding sampling units (■) extracted from the relevant network. This species was found in a discontinuous form until the first half of 2012, and then because of the successive storms, this natural site was particularly compromised.

sion of the agricultural land, which in recent years has spread from the access road to the Natural Reserve, which altered this singular site.

EUPHORBIA TERRACINA L.

The distribution of *E. terracina* has been practically unchanged, as it occupies the same area (to the right and left of the dirt road that leads to the Tower). Of note, in recent years, a positive increase in the number of individuals has been observed. In light of this, the perimeter of the site has been defined, to prevent any impairment of this area during construction work for two ponds that are planned for the Life+ Project.

CAREX EXTENSA Gooden.

C. extensa has remained stable in terms of its occupation of the area, because two small new stations have been detected in the northern part of the Natural Reserve. However, in the southern areas where *C. extensa* was present previously, it was not found again, due to the rearrangement of its habitat caused by the intense coastal erosion.

RUMEX PALUSTRIS Sm.

R. palustris was previously found along the banks of the main ditch and in a depression behind the dunes, just north of the Tower. At present, it has been confirmed only for the first of these two sites. However, *R. palustris* was also found in an additional site, with some individuals close to the Tower.

ELYTRIGIA JUNCEA (L.) Nevski subsp. *JUNCEA*

With regard to the strong coastal erosion that characterises the stretch of coast under study, an appreciable adaptive response by *E. juncea* subsp. *juncea* has been detected. Indeed, until 2012, as well as showing an expansion in its distribution throughout the Natural Reserve, *E. juncea* subsp. *juncea* has shown a shift towards the more inner areas of the Natural Reserve, through which it maintained the same distance from the shoreline, which has also continued to move in the same direction. However, in the more recent years from 2012 to date, the intensity of the coastal erosion has increased, and this is no longer compatible with the speed of movement of *E. juncea* subsp. *juncea*. This phenomenon is evident in the southern portion of the Natural Reserve, where this species has consequently become extremely rare.

SPARTINA VERSICOLOR E. Fabre

Similar to the situation seen for *E. juncea* subsp. *juncea*, *S. versicolor* has shifted its sites towards the more inner areas of the Natural Reserve. Indeed, the plants that in 2009 were closer to the beach are no longer present today. In contrast, *S. versicolor* can now be found in the more internal sites where it was not



Fig. 4 - Distribution map of *Halimione portulacoides* in the 'Sentina' Regional Natural Reserve for 2007 to 2012.

present previously. This trend can be considered in the framework of the adaptive response of *S. versicolor* to coastal erosion. After 2012, the situation indicated for *E. juncea* subsp. *juncea* above is also relevant to *S. versicolor* (Fig. 5).



Fig. 5 - Foliage of *Spartina versicolor* directly exposed to the force of the sea.

ERYNGIUM MARITIMUM L.

E. maritimum has not been able to adapt to the rapid changes in the coastline. Therefore, beyond its occasional and temporary discovery in July 2009, *E. maritimum* has not been detected any more.

ARTEMISIA CAERULESCENS L. subsp. CAERULESCENS

The negative effects of coastal erosion have also been felt by the small population of *A. caerulescens* subsp. *caerulescens* recorded in June 2012. As part of the work on the dune protection under the Life+ Project (Restoration of Sentina Coastal Wetlands), and together with the competent authorities, it was decided to fence off the site and to protect it by placing fagots along the beach. However, a strong storm occurred a few months afterwards, which has compromised this

protection. Subsequently, again as part of Life+, several individuals of *A. caerulescens* subsp. *caerulescens* have been reintroduced, both in the retrodunal environment, which is the most appropriate, and in sites set further back from the sea. At present, the original site has been destroyed due to a recent storm (Fig. 6). There are also further individuals of *A. caerulescens* subsp. *caerulescens* in the Natural Reserve, and although these are found in environments that are not really typical, they are surviving well enough.

MEDICAGO MARINA L.

The site on which a localised population of *M. marina* was recorded for 2008, as indeed for the entire stretch of coast that belongs to the Natural Reserve, is currently affected by severe morphological changes due to the coastal erosion, which has resulted in its disappearance. Just outside the northern perimeter of the Natural Reserve, there is another site where this species has been able to survive due to the protective action of the breakwaters, which are just to the north of this area.

SALICORNIA PERENNAS Willd. subsp. PERENNAS (= *S. patula* L.)

Until 2012, *S. perennans* subsp. *perennans* was the species that more than any other saw a quantitative reduction in its distribution. With respect to the distribution recorded in 2009, this decline occurred throughout the entire Natural Reserve. The populations that were recorded in 2012 were indeed significantly poorer in numbers of individuals and area covered. There are no longer any extensive populations of *S. perennans* subsp. *perennans*. At the moment, the space occupied by *S. perennans* subsp. *perennans* appears to be linked to the massive spread of *H. portulacoides*. Indeed, where a few years ago there were *Salicornia*, today there are dense populations of *H. portulacoides*. Locally, where *H. portulacoides* is more sparse, there is some space left for a few individuals of *Salicornia*. It should be



Fig. 6 - Right: Georeference point in which an example of *Artemisia caerulescens* subsp. *caerulescens* was re-introduced in 2013. Of note, at the time of planting, the site was part of the retrodunal area. Left: Photograph of the same point taken in spring of 2014, where the coastal erosion can be easily seen.

noted, however, that there have been profound modifications to the retrodunal environments, which over the last 10 years or so have seen a change of use. For this reason, under the Life+ Project indicated above, in 2012 the timely thinning of *H. portulacoides* took place, to encourage the residual populations of *S. perennans* subsp. *perennans*. Today, these actions have brought about the expected result, with the development of *S. perennans* subsp. *perennans* in terms of the number of individuals and area covered (Fig. 7).

CRYPISIS SCHOENOIDES (L.) Lam.

Although the population of *C. schoenoides* recorded in 2009 was very small, this did not shown any changes for to the observations of 2012.

CRYPISIS ACULEATA (L.) Aiton

The distribution of *C. aculeata* has not shown any changes in terms of the area covered. The stations south of the Tower have moved inland significantly, although in parallel with the erosion of the coastline. *Crypsis aculeata* has been able to colonise the newly formed retrodunal habitats.

HALIMIONE PORTULACOIDES (L.) Aellen (*Atriplex portulacoides* L.)

H. portulacoides is certainly the species that has shown the greatest increase in its spread in the territory of the Natural Reserve. As for *E. juncea* subsp. *juncea* and *S. versicolor*, *H. portulacoides* has also responded well to the shift in the coastline, as it has colonised many other areas where it was not found in previous sampling. Given its conservation value, this trend is undoubtedly very positive. However, it cannot be denied that this is a dynamic that needs to be further developed and better studied. This is because on the one hand, throughout the entire Adriatic sector, *H. portulacoides* does not enjoy good health, and on the other hand, it has found here what is probably an ideal habitat that has allowed it massive development. This has, however, had direct impact on other species (e.g., *S. perennans* subsp. *perennans*).

Erosion and evolution of the coastline

The overlapping of historical images has shown the continuous retreat of the coastline throughout the Natural Reserve (Fig. 8). In quantitative terms, this retreat was measured according to the 5th century 'Harbour Tower', and it has resulted in a loss of about 140 m since 1961, 100 m since 1976, 70 m since 1994, and 25 m since 2009. This translates into a speed of coastal erosion that in the first two recorded periods was



Fig. 7 - Evolution of the study area for the thinning of *Halimione portulacoides* that was carried out to favour the recovery of *Salicornia perennans* subsp. *perennans*.



Fig. 8 - Evolution of the coastline of the 'Sentina' Regional Natural Reserve.

around 2 m/year, which increased to 3 m/year from 1994 to 2009, and increased again between 2009 and 2013, when it rose to 5 m/year.

Conclusion

As noted above, there has been a change in the continuum of vegetation as a necessary movement inland from the shoreline. This alteration is due to the marine erosion, which has been particularly intense along this part of the coast. This erosion has been due to three main factors: (a) lack of sea barriers parallel to the line of this stretch of the coast; (b) presence of perpendicular groynes for the protection of the coast outside the Natural Reserve (especially for Martinsicuro); and (c) little material arriving from the Tronto River.

The combination of these three factors has resulted in the removal of the sand from along the coast. The displacement of the shoreline then occurs at the expense of the ground that becomes emersed, which is too

intense an effect to allow the time and opportunity for the vegetation of the coastal dunes to stabilise along even a small part of the coastline.

Within this dynamic, the mechanical strength of the wave motion has practically no opposition, especially during the more intense storms. This has resulted in: (i) undermining of the bases of the small spurs that host residual strips of dune vegetation (see Fig. 5); (ii) accumulation of material with graded grain sizes in those areas where a break has occurred in the dunes, either prior to or in conjunction with the break (e.g., the *Crypsis aculeata* areas south of the Tower); and (iii) the relative displacement of most areas, which while they do not change their geographical coordinates, they are positioned increasingly closer to the approaching coastline (e.g., for *Elytrigia juncea* subsp. *juncea* and *Spartina versicolor*), which can result in their disappearance (see Fig. 5).

At the same time, consideration needs to be given to the actions of the wind. In the absence of natural protective elements, such as the stabilising influence of plants on the dunes, the wind generates a movement of the sand, and consequently an accumulation of the finer material, which is sometimes very consistent.

Although from the maps *E. juncea* subsp. *juncea* and *S. versicolor* show potential for adaptation to these dynamics, the typical vegetation of the mobile embryonic dunes of *Echinophoro spinosae*-*Elymetum farcti*, which is a priority habitat (i.e., 2110), is in danger of extinction, due to the possible disappearance of its habitat. As evidence of this, the absence of *Ammophiletum* in the dunal vegetation confirms these intense alterations to the natural succession of the dune plant communities. In addition, with the disappearance of the dunes, other vegetation types and typical priority areas such as *Salicornia* communities, and *S. versicolor* and *J. maritimus* (i.e., in priority habitats 1310, 1320 and 1410) can be damaged.

In terms of the areas covered by *Salicornia* in the recent monitoring campaign, a reduction in the size of its population was recorded. In this regard, it can be noted that with the sampling methodology applied, the mapping of distributions can make a situation appear better than it is in reality. Indeed, even the presence of only one individual of a given species records the presence of that species within the sampling unit of 50 × 50 m. In this context, the current and previous observations made in the field have been essential. This trend is shown by the disappearance of *S. perennans* subsp. *perennans*, which is probably related to the intense changes that have characterised the last decade. Cultivated land that once occupied some of the areas of the Natural Reserve that are closer to the beach have been abandoned, which releases areas for natural evolution. In this context, there was an initial expansion of *S. perennans* subsp. *perennans*, although this species

subsequently suffered from the competition with *H. portulacoides*. The positive outcome of the intervention through the localised thinning of *H. portulacoides* described above gives support to this observation.

During the autumn periods of this monitoring, the areas covered by *H. portulacoides* were seen to have a large number of wading birds that belong to the family *Charadriidae*. This is probably due to the refuge that this particular structure provides, and the dense cover that *H. portulacoides* offers; hence the need for the correct management of the area. For the aggressiveness of the invasive *Cuscuta campestris*, its manual removal can be periodically implemented for the benefit of the native flora.

From these considerations, the delicacy inherent to the choice of the actions that the management of the Natural Reserve needs to carry out is evident. In this context, the cases of *R. palustris* and *R. peltatus* subsp. *baudotii* should also be considered, which both require greater care in the management of their sites. There is also the need to ascertain in advance what the actual effects of periodic mowing performed on the banks of the floodway ditches will have, and buffer zones around the cultivation areas need to be guaranteed.

From the foregoing, there are many problems that the management must deal with, and first of all of these is related to the coastal erosion. With the current rate of coastal retreat, there is a risk that the dunal and retrodunal environments that are already severely compromised might materially disappear in the near future. Thus along with the work being carried out under the Life+ Project (Restoration of Sentina Coastal Wetlands), there is the need to put into place short-term specific actions to reduce this ongoing coastal erosion.

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