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Torre del Cerrano Area Marina Protetta

ADRIATIC & IONIAN INITIATIVE

ADRIAPAN ADRIATIC PROTECTED AREAS NETWORK

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The Adriatic Sea as border made of water among different cultures is going to be cleaned from the new idea of the Adriatic Sea as a unitarian concentration of natural and economic resources to prevent in their own environment.
Protected Areas are special local administration created to take care to this delicate environment. On the last *IUCN World Conservation Conference*, Barcelona -Spain, October 2008 has been adopted the last definition of Protected Area, as: "*A **clearly defined geographical space**, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term **conservation of nature** with **associated ecosystem services** and **cultural values***".
Protected Areas could be the better places where carry on new local sustainable development forms. In fact, Protected Areas authorities are the only officially identified as public bodies that have both the mission: the **conservation of natural resources** and the **local economic development**. And, more, they are the only form of public administration that extends its own action, planning and programming, on both the different geographic areas: **sea** and **earth**. Those are two different habitats completely separate for all the other local public administration.
So Coastal and Marine Protected Areas (MPAs) could be the primary laboratories in where normal people, researchers, academic bodies and public administrations could be involved for training in sustainable form of development.
On July 8th, 2008, the **Carta di Cerrano** (*Cerrano Charter*) was drafted and circulated to all Italian interested parties for comments: "**AdriaPAN**" (*Adriatic Protected Areas Network*) was selected as the official title of the newly born network. Almost all Italian Marine and Coastal Protected Areas along the Adriatic coast have responded positively to this initiative and the Charter has been definitely undersigned on September 26th, 2008, during the meeting on purpose organized in *Delta Po Veneto Regional Park*. In Barcelona, Spain, on **October** the **6th, 2008,** during the *IV International Union for Conservation of Nature World Conservation Conference* it has been presented on the international stage.
The AdriaPAN aims at initiating a technical process in support of all MPAs managers in the region that will speed up the achievement of the goal - set during the World Summit on Sustainable Development (WSSD) of Johannesburg 2002 of halting marine and coastal biodiversity loss through the establishment of **networks of marine protected areas** by **2012**. This initiative responds also to the main international provisions related to the conservation of the marine environment, such as the ***Convention on Biological Diversity*** (CBD) and the ***European Commission's Directives.***
The number of MPAs who subscribed the Cerrano Charter is rising very quickly. Actually AdriaPAN count **42** MPAs member from all the Adriatic countries and received request of collaboration from more than **50** various organizations as Universities, Research Institutes, NGO, Associations, Local Agency, etc.
Within the PANforAMaR project financed by the Adriatic and Ionian Initiative- AII, has been organized the AdriaPAN international meeting "***Towards 2020: Adriatic sea, Ionian sea and the Aichi targets***", which has been held during June 2-3-4, 2014 in the "Torre del Cerrano" Marine Protected Area (Italy). The University of Camerino organized during the meeting a parallel session on June 3, under the strategic objective of "***Ecological networks***- *Establishing an ecological network of Marine and Coastal PAs in the Adriatic and Ionian Seas which is representative and interconnected*", to discuss in more depth the theme: "*Threatened Species and Habitats of Ionic-Adriatic Coasts*".
The final result, of such a session, is an important contribute to the research on these topics and it is a pleasure for the *Torre del Cerrano Marine Protected Area* to edit this special number of **Plant Sociology** with the best speech presented during that session.

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Il mare Adriatico da confine tra differenti culture si sta pian piano trasformando in un luogo di unione ricco di una straordinaria concentrazione di risorse naturali ed economiche da tutelare nel loro stesso ambiente.
Le aree protette sono speciali amministrazioni locali create appositamente per occuparsi di questo delicato ambiente. Nell'ultima *IUCN World Conservation Conference*, tenutasi a Barcellona, in Spagna, nell'ottobre del 2008 è stata adottata la definizione ultima di Area Protetta: "*Uno spazio **geografico chiaramente definito**, riconosciuto, dedicato e gestito, mediante sistemi legali o di comunque efficaci, per raggiungere la **conservazione**, sul lungo periodo, d**ella natura** con gli **associati servizi ecosistemici** e dei **valori culturali***".
Le aree protette possono essere i luoghi migliori dove sperimentare le nuove forme locali di sviluppo sostenibile. In effetti, le autorità di gestione delle Aree Protette sono gli unici organismi ufficialmente identificati come enti pubblici, che hanno tra le proprie finalità entrambe le missioni: la **conservazione delle risorse naturali** e lo **sviluppo economico locale**. E, di più, esse sono l'unica forma di pubblica amministrazione che estende la propria azione, la propria pianificazione e programmazione, alle diverse zone geografiche: **mare** e **terra**. Sono questi due diversi *habitat* considerati sempre in forma separata per tutti gli altri attori, locali e non, della pubblica amministrazione.
Così le aree protette marine e costiere (MPAs), potrebbero essere i primi laboratori in cui gli attori locali, i ricercatori, gli organismi accademici e le amministrazioni pubbliche possono essere coinvolti per sperimentare forme locali di sviluppo sostenibile.
Ai primi di giugno del 2008, nel corso di un seminario di formazione organizzato dalla Associazione Italiana dei Direttori e funzionari delle Aree Protette (AIDAP), è stata lanciata l'idea di creare una **rete di aree marine e costiere protette in Adriatico** e la sua fattibilità e la pertinenza sono state immediatamente valutate. Altre riunioni sono state organizzate poco dopo, al fine di definire gli **obiettivi** e il **contenuto** di tale iniziativa. Infine è stata creata una carta con idee e obiettivi condivisi denominata "**Carta di Cerrano**", in onore del luogo in cui tutto è iniziato.
L'8 luglio 2008, la **Carta di Cerrano** (*Cerrano Charter*) è stata definita e distribuita a tutte le parti italiane interessate per l'ultima verifica. "**AdriaPAN**" (*Adriatic Protected Areas Network*), è stato scelto come titolo ufficiale della rete appena. Quasi tutte le aree protette italiane, lungo la costa adriatica hanno risposto positivamente a questa iniziativa e la Carta è stata definitivamente sottoscritta il 26 settembre 2008, in occasione di un workshop appositamente creato presso il *Parco Regionale del Delta del Po Veneto*. A Barcellona, in Spagna, il **6 ottobre 2008**, durante il *IV World Conservation Conference dell'Unione Internazionale per la Conservazione della Natura*, c'è stata la presentazione sul palcoscenico internazionale.
L'obiettivo primario di *AdriaPAN* è quello di avviare un procedimento tecnico a sostegno di tutti i gestori di zone marine protette della regione, che permetterà di accelerare il conseguimento degli obiettivi, fissati nel corso del Vertice Mondiale sullo Sviluppo Sostenibile (WSSD) di Johannesburg nel 2002, di arrestare la perdita di biodiversità marina e costiera attraverso la creazione di **reti di aree marine protette** entro il **2012**. Questa iniziativa risponde anche alle principali disposizioni internazionali in materia di conservazione dell'ambiente marino, come la ***Convenzione sulla diversità biologica*** (CBD) e le ***Direttive*** dell'***Unione Europea***.
Il numero di aree protette costiere e marine che hanno sottoscritto la "Carta di Cerrano" sta aumentando molto rapidamente. Ad oggi AdriaPAN conta **42** membri delle zone marine protette da tutti i paesi dell'Adriatico e ha ricevuto richiesta di collaborazione da più di **50** diverse organizzazioni, come Università, Istituti di Ricerca, ONG, associazioni, Agenzie locali, ecc.
All'interno del progetto PANforAMaR, finanziato dalla Iniziativa Adriatico Ionica-IAI, è stato organizzato il Convegno internazionale AdriaPAN "***Verso il 2020: Adriatico e Ionio e gli obiettivi di Aichi***", che ha avuto luogo il 2-3-4 Giugno 2014 presso l'Area Marina Protetta Torre del Cerrano (Italia).
L'Università di Camerino ha organizzato durante il convegno una sessione parallela per il giorno 3 Giugno, inquadrata nell'obiettivo strategico "***Reti ecologiche**- Creare una rete ecologica rappresentativa e connessa, di Aree Protette marine e costiere in Adriatico e Ionio*", per discutere in dettaglio il seguente tema: "Specie e habitat minacciati della costa Adriatico-Ionica".
Il risultato finale, di questa sessione, è un importante contributo alla ricerca su tali temi ed è un piacere per l'*Area Marina Protetta Torre del Cerrano* pubblicare questo numero speciale di **Plant Sociology** con le migliori relazioni presentate durante tale sessione.

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On the themes of environment protection and sustainable use of sea resources the Mediterranean countries work all together since they have subscribed in 1995 the **Barcelona Protocol** concerning the biological diversity and specially **protected areas** and in Mediterranean Sea (*SPAMI-Special Protected Areas of Mediterranea Importance*).
The introduction, with the same protocol, of the ICZM (*Integrated Coastal Zone Management*), in all the Mediterranean countries, has been an important help to the integration of administrative and political forms of territorial planning. It could help integration within different cultures and, thanks to their similarity on international stage and their capacity to govern the deep sea as well as coastal territories, protected areas became the best laboratories where practice this new planning and programming form.
Biodiversity conservation and sustainable use of resources are the topics in which have already been involved more than hundreds of MPAs along all the Adriatic coasts, in Italy, Slovenia, Croatia, Bosnia-Herzegovina, Montenegro, Albania and Greece thanks to the activity of AdriaPAN, the Adriatic and Ionian Protected Areas Network.
AdriaPAN finds the own main strategies in the international programs of activities managed from MedPAN, the Mediterranean Marine Protected Areas Network.
The Parties to the **Convention on Biological Diversity** (CBD), held in **Nagoya** (Japan) in 2010, adopted the Strategic Plan for Biodiversity 2011-2020 aiming at inspiring broad-based action in support of biodiversity. The Strategic Plan includes a shared vision, a mission, strategic goals and 20 ambitious yet achievable targets, collectively known as the **Aichi Targets** (www.cbd.int/ sp/targets). The Strategic Plan serves as a flexible framework for the establishment of national and regional targets.

During the Mediterranean MPA Forum organized by **MedPAN**, RAC/SPA, the General Directorate of Natural Assets Protection (Turkey) and UNDP Turkey, held in **Antalya** (Turkey, November 25-28, 2012), the Mediterranean MPA community developed a **roadmap** calling for urgent actions and aiming at achieving the objectives set by international commitment by 2020 (www.medmpaforum2012.org/en/node/2313). In particular, **4 strategic objectives** were formulated as follows:

1 – Establishing an ecological network of MPAs which is representative and interconnected;
2 – Achieving effective, efficient and sustainable management and good MPAs governance in the Mediterranean area;
3 – Developing territorially-integrated governance of Mediterranean MPAs, thus promoting the sharing of environmental and socio-economic benefits;
4 – Increasing the allocation of financial resources in order to establish and maintain an ecological network of effectively managed MPAs.

Furthermore, during the **IMPAC3** (3rd International Marine Protected Areas Congress) held in 2013 at Marseille and in Corsica, the participants stressed their commitment to meeting the Aichi targets of the Convention on Biological Diversity – in particular, **Target 11** which calls for the **protection of at least 10 percent of the seas by 2020** - all in the **Ajaccio** Declaration (http://www.impac3.org/images/pdf/ Ajaccio/ajaccio_declaration_en_final.pdf).
During the 18th Ordinary Meeting of the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols
held in 2013 in Istanbul, Mediterranean countries, in the **Istanbul Declaration**, “committed to take all the necessary measures to make the Mediterranean an exemplary model in implementing activities effectively protecting the marine and coastal environment as well as contributing to sustainable development" in line with the Aïchi targets.

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Sui temi della tutela dell'ambiente e l'uso sostenibile delle risorse del mare tutti i paesi del Mediterraneo lavorano insieme da quando hanno sottoscritto nel 1995 il **Protocollo di Barcellona** relativo alla biodiversità e alle zone protette speciali del Mediterraneo (SPAMI-*Special Protected Areas of Mediterranea Importance*).
L'introduzione, con quello stesso protocollo, dell'ICZM (*Integrated Coastal Zone Management*) in tutti i paesi del Mediterraneo, è stato un aiuto importante per l'integrazione dei sistemi amministrativi e politici della pianificazione territoriale. Ciò potrebbe aiutare l'integrazione all'interno di culture diverse e, grazie alla loro somiglianza sulla scena internazionale e la loro capacità di governare sia il mare profondo che i territori costieri, le aree protette sono divenute i migliori laboratori dove praticare questa nuova pianificazione e forma di programmazione.
Conservazione della biodiversità e uso sostenibile delle risorse sono i temi in cui sono già stati coinvolti più di centinaia di aree protette lungo le coste dell'Adriatico, in Italia, Slovenia, Croazia, Bosnia-Erzegovina, Montenegro, Albania e Grecia grazie alle attività di AdriaPAN, la rete delle aree protette dell'Adriatico e dello Ionio.
AdriaPAN trova le proprie principali strategie nei programmi internazionali di attività gestiti dal MedPAN, la rete della Aree Marine Protette Mediterraneee.
Le parti della **Convenzione sulla Diversità Biologica** (CBD) , tenutasi a **Nagoya** (Giappone) nel 2010, ha adottato il Piano Strategico per la Biodiversità 2011-2020 che punta a ispirare una azione di sostegno della biodiversità. Il Piano Strategico prevede una visione condivisa, una missione, obiettivi strategici e 20 obiettivi ambiziosi ma realizzabili, comunemente noti come gli **obiettivi di Aichi** (www.cbd.int/sp/targets) . Il Piano Strategico serve come un quadro flessibile per la definizione di obiettivi nazionali e regionali.

Durante il Forum delle AMP del Mediterraneo organizzato da **MedPAN**, RAC/SPA, Direzione Generale Protezione Natura (Turkey) e UNDP Turkey, tenutosi ad **Antalya** (Turchia , 25-28 novembre 2012) , la comunità MPA Mediterraneo ha sviluppato una tabella di marcia che chiede azioni urgenti e finalizzata a realizzare gli obiettivi fissati dalla impegno internazionale entro il 2020 (www .medmpaforum2012.org/en/node/2313) . In particolare , 4 obiettivi strategici sono stati formulati come segue :
1 – La creazione di una rete ecologica di zone marine protette che sia rappresentativa ed ecologicamente connessa;
2 - Il raggiungimento di una gestione efficace , efficiente e sostenibile delle AMP nell'area del Mediterraneo ;
3 – Lo sviluppo di una governance integrata territorialmente di aree marine protette del Mediterraneo , favorendo così la condivisione dei benefici ambientali e socio-economici ;
4 – L'aumento dell'allocazione delle risorse finanziarie al fine di stabilire e mantenere una rete ecologica di zone marine protette efficacemente gestite.

Inoltre, durante **IMPAC3** (Terzo Congresso Internazionale delle Aree Marine Protette) tenutosi a Marsiglia e in Corsica nel 2013, i partecipanti hanno sottolineato il loro impegno a raggiungere gli obiettivi di Aichi della Convenzione sulla diversità biologica e, in particolare , il **Target 11** che prevede la **protezione di almeno il 10 per cento dei mari entro il 2020**, nella Dichiarazione di Ajaccio (http://www.impac3.org/images/pdf/ Ajaccio/ajaccio_declaration_en_final.pdf).
Durante la XVIII Assemblea Ordinaria delle Parti contraenti della Convenzione per la protezione dell'ambiente marino e del litorale del Mediterraneo e dei suoi protocolli tenutasi nel 2013 a Istanbul, i paesi mediterranei, nella **Dichiarazione di Istanbul**, si sono "impegnati a prendere tutte le misure necessarie per rendere il Mediterraneo un modello esemplare nella azione di proteggere efficacemente l'ambiente marino e costiero, nonché contribuire allo sviluppo sostenibile", in linea con l'Aichi obiettivi

Sui quattro punti sopra elencati si è sviluppato il programma del workshop AdriaPAN, il V° del progetto PANforAMaR, dal titolo: "Verso il 2020". Dove i seguenti contributi scientifici hanno avuto l'occasione di essere presentati.

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Notes on the vegetation diversity on the Adriatic and Ionian Italian coasts: the dunes and cliffs

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Abstract
After a brief introduction of the environmental conditions and some phytogeographic, climate and geomorphological notes, the Italian Adriatic and Ionian coastal vegetation is described briefly, considering that of the dunes and cliffs.

Key words: biodiversity, cliffs, Italian Adriatic/ Ionian coasts, phytosociology, sand dunes, syntaxonomy.

Introduction

Coasts represent one of the most complex of ecological systems. At the same time, they are one of the most fragile systems on our planet, in which the incessant actions of the wind and the sea reshape the morphology, and modify the ecosystem. Along with the undeniable beauty of the landscape, a significant level of coenological, species and biological diversity can be added to characterise this strip of land under tension between two very different environments, which makes the coast among the most interesting in terms of its natural and scientific profile.

The coastline represents a 'restricting environment' of great selectivity, in which there are very specialised forms of life. In the course of their evolutionary history, the plants that live among the dunes along the low and sandy coasts have adapted to the severe conditions through various morphological, anatomical and physiological strategies. These conditions are defined by the dryness and mobility of the sand, the lack of nutrients, the saline aerosol, the wind, and the strong irradiation. The coastal vegetation is highly specialised and azonal, and thus although consistent with the macroclimate, it is strictly correlated with the substrate.

In the context of these fragile coastal ecosystems, the plant species and communities have important roles as indicators of environmental quality, for which in the past they have often not been given their true value (Biondi, 1999; Biondi & Géhu, 1994).

Currently the beaches, dunes and interdunal and retrodunal wetlands, however, are among the most vulnerable and threatened of habitats on a global scale (Audisio, 2002). It is easy to understand, then, why in Italy the environments that have been shown to have the highest levels of extinct or endangered species (21%) are indeed these coastal and lagoon areas (Conti *et al*., 1992).

The Italian Coastline

The Italian peninsula juts out into the Mediterranean Sea, which it separates into the western and eastern basins. Italy has a coastline of over 7,500 km, which makes up about 80% of the administrative boundaries. It can be seen, therefore, that while forming the most diverse of mosaics, the coastal environments represent a significant part of the Italian landscape.

The morphology of the Italian coast consists of two fundamental aspects: the high rocky coast and the low sandy coast. Although both are represented for the two basins, the rocky coast is dominant along the Tyrrhenian coast, and the sandy coast is dominant along the Adriatic and Ionian coasts. The geomorphological panorama of the coasts is completed by a series of wetland areas (i.e., lagoons, stagnant pools and salty marshes), of which the most important are the north Adriatic lagoons and brackish pools, the Gargano lakes, the southern Lazio lakes, Orbetello lagoon, and the stagnant pools and marshes of Sicily and Sardinia.

The lithology is very diverse, and it includes recent sediments of the Quaternary, detritus deposits of the Pliocene (clay, marl, sand, conglomerates), sandy-marly and carbonacious formations of the Miocene and the Cretaceous, and granites and basalts.

From the climate point of view, the Tyrrhenian, Ionian and low-Adriatic areas are dominated by the oceanic, pluviseasonal Mediterranean bioclimate. The mid-Adriatic is affected by the sub-Mediterranean, oceanic, temperate bioclimate. Then, the high-Adriatic is under the influence of the oceanic temperate bioclimate that along the Veneto section assumes a steppes-

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like character (Rivas-Martinez *et al*., 2004a).

On a biogeographic basis, the territory is divided between the two Mediterranean regions (with the western and eastern Mediterranean subregions, the Italo-Tyrrhenian and Adriatic Provinces, and the sectors of the Italian western coast and Puglia) and EuroSiberian (with the Alpine-Caucasus subregion, the Apennine-Balkan Province, and the Padano and Apennine sectors) (Rivas-Martinez *et al*., 2004b).

The vegetation of the Adriatic and Ionian coasts

In a context that is particularly wide and varied, the vegetative component of the Italian coasts is equally diverse and rich, even if the degradation processes of anthropogenic origin have drastically reduced the parts that are still truly natural. The scientific literature on the Italian coastal vegetation is very rich. Limiting ourselves to the phytosociological studies, for the forerunners we can note in particular the examples of: Frei (1937), Pignatti (1952) and Pirola (1959) for Sicily; Béguinot (1941) and Pignatti (1953, 1960, 1966) for Veneto; Lausi & Poldini (1962) for Friuli-Venezia Giulia; Corbetta (1968, 1976) and Lorenzoni (1978) for Emilia-Romagna; Biondi *et al*., 1992 for Marche, Corbetta (1970) Chiesura Lorenzoni & Lorenzoni (1977) for Puglia.

In addition to numerous studies that have dealt with specific coastal segments, there are several contributions available that present the various scenarios, on a phytosociological basis, for the entire coastal perimeter, or at least for most of it. The first study in terms of a research campaign carried out along all of the Italian coastline was that of Géhu *et al*. (1984). Others followed, among which we can mention the overviews of Bartolo *et al*. (1989), Géhu & Biondi (1996a, 1996b), Biondi (1999, 2007), Corbetta *et al*. (1999), and Brullo *et al*. (1997, 2001).

Here, we provide a synthesis of the Adriatic–Ionian coastal vegetation in terms of its phytosociology that is limited to the cliff and dune phytocoenoses. Given the vastness of the subject, we report on the most representative aspects, drawn from the studies cited above and from those reported in the literature, with the exclusion of the Sicilian coast, which deserves specific treatment. For each category of vegetation, its habitat of origin is also given, according Annex I of the Habitats Directive 92/43 EEC.

The low sandy and gravelly coasts

Along the sandy coastline, the alternation of the dune ridges and intradunal depressions has resulted in a vegetation sequence that establishes the xerophilous phytocoenoses on the tops of the dunes and the halo-hygrophilous or hygrophilous phytocoenoses in the intradunal and retrodunal depressions.

Starting from the shoreline, the whole system is spread along the gradient of the intensity of the wind, from the unstructured and open communities that are more pioneering, continuing to the most structurally and floristically complex, such as the evergreen sclerophyllous shrubbery and woods.

This represents a particular topographic series that in the more typical and original forms can now be seen in only a few locations within the Mediterranean basin. The strong human disturbance and the coastal erosion have led to compression, mixing and loss of identity, and often also to the total disappearance of some or all of the plant communities. Even the submerged portion of the beach has an important role that reflects on the emerged environment and that therefore must be considered an integral part of the coastal system.

In this context, it is therefore possible to distinguish different habitats that follow on from each other, at times in the space of a few tens of metres, and that host complex units of the phytosociological landscape (Fig. 1). These units, which phytosociologists refer to with the term geoseries, can be schematically identified as the following ecological typologies: submerged, halo-nitrophilous of the beach; xerophilous of the dune ridges; and halo-hygrophilous and hygrophilous in the depressions (interdunal and retrodunal). Of these, the following illustrate the main representatives relating to the Adriatic–Ionian coasts, referring to the phytosociological rank of the alliance; the syntaxonomic scheme with the most significant associations is given in the Appendix.

The submerged beach

Habitat 1120* - *Posidonia* beds (*Posidonion oceanicae*)

This is the site of the phanerogamic seagrasses, which are mainly *Posidonia oceanica* (endemic to the Mediterranean), which has developed on the moving seabed between 1 m and 40 m in depth, and which determines the lower limit of the infralittoral zone (Bruno, 2001). These seagrasses constitute an effective barrier to wave motion, and thus effectively protect the shoreline from erosion and stabilise the sea bottom; moreover, for many species this represents their breeding site and it is one of the main sources of oxygenation of the environment. Other submerged phanerogamic seagrasses are *Cymodocea nodosa*, *Zostera noltii* and *Zostera marina*.

The phytosociology of these seagrasses includes alliances *Zosterion marinae (Posidonia oceanica, Zostera* spp. and *Cymodocea nodosa* seagrasses). The algal alliances are *Peyssonnelion squamariae, Cystoseirion crinitae* and *Caulerpion*.

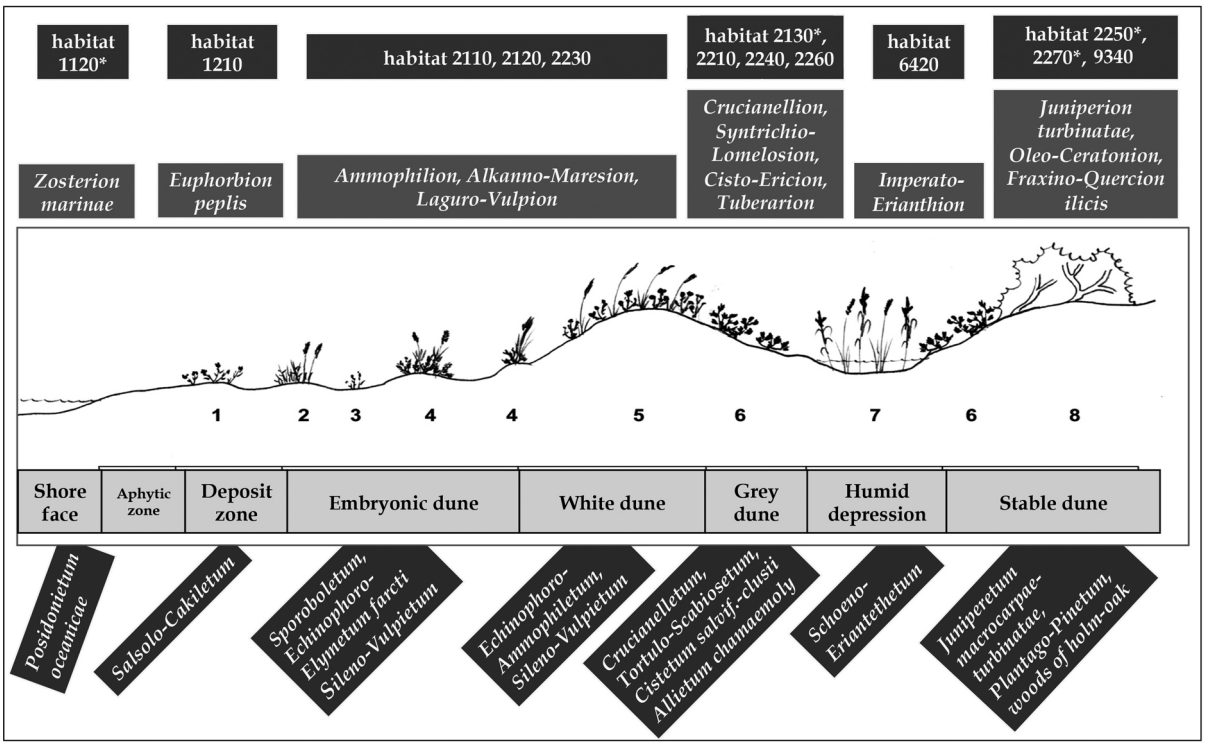

Fig. 1 - The dune system. It is characterized by the chain zonation of the plant communities arranged in strips parallel to the coast line, from the most pioneer to the most mature. (by E. Biondi, 2007, modified)

The halo-nitrophilous strip

Habitat 1210 – Annual vegetation of the drift lines

This is represented by the therophytic halo-nitrophilous vegetation that has colonised the sandy pebbled beach between the strip devoid of vegetation next to the shoreline and the psammophylic perennial phytocoenoses.

Alliance *Euphorbion peplis*. The most common associations are: *Salsolo kali-Cakiletum maritimae*, which is often found with the subassociation *xanthietosum italici* of particularly eutrophic soils, differentiated by *Xanthium italicum*; *Xantho italici-Cenchretum incerti* (favoured by the levelling of the dunes); *Raphano maritimi-Glaucietum flavi* (on gravel), with the last two especially along the central Adriatic. Another association known for gravel deposits rich in organic matter of the Adriatic coast of Puglia is *Atriplicetum hastato-tornabeni*.

The dune ridges

The dunes are the result of a continuous dynamic process that depends on the interactions between three factors: the wind, the sand and the vegetation (Pignatti, 2002). The wind moves the sand, while the vegetation constitutes a barrier that allows its accumulation, and thus the formation of the ridges of the dune. This can be eroded by the wind if it is too strong. In this way, an equilibrium is established between deposition and erosion, which determines the height of the dune.

The dune ridges are characterised from the chain connections of the plant communities that are found in strips parallel to the coastline, from the more pioneering to the more mature. Along the Adriatic–Ionian coast, the topographic sequence includes the following typologies:

HEMICRYPTOPHYTIC-GEOPHYTIC PERENNIAL VEGETATION

Habitat 2110 – Embryonic shifting dunes; habitat 2120 – Shifting dunes along the shoreline with *Ammophila arenaria*.

Alliance *Ammophilion australis*. This vegetation colonises the embryonic dunes and the higher more inland dunes (moving or white dunes), and it contributes to the stabilisation of the dunes through the plant rhizome. This is mainly represented by the associations *Sporoboletum arenarii* (embryonic tufts, with *Sporobolus virginicus*, suballiance *Sporobolenion arenarii*), *Echinophoro spinosae-Elymetum farcti* (embryonic dunes and dune ridges with little nutrition from the sand, with *Elymus farctus*, suballiance *Sporobolo arenarii-Elymenion farcti*), *Echinophoro spinosae-Ammophiletum australis* (high dunes that are still mobile, with *Ammophila arenaria* subsp. *australis*, suballiance *Medicagini marinae-Ammophilenion australis*). The association *Inulo crithmoidis-Elytrigietum junceae* (embryonic dunes differentiated by *Inula crithmoides*) is found in the north-western Adriatic (Veneto, Emilia-

Romagna). Similar aspects have also been reported for Abruzzo.

EPHERMERAL THEROPHYTIC VEGETATION

Habitat 2230 – *Malcolmietalia* dune grasslands

Alliance *Alkanno-Maresion nanae*, with the associations *Maresio nanae-Ononidetum variegatae, Anthemido-Centaureetum conocephalae, Anchuso hybridae-Plantaginetum albicantis,* and *Onobrychido-Malcolmietum ramosissimae*.

Alliance *Laguro ovati-Vulpion fasciculatae*, with the associations *Sileno coloratae-Vulpietum membranaceae, Ambrosio coronopifoliae-Lophochoetum pubescentis, Sileno coloratae-Ononidetum variegatae,* and *Sileno nicaeensis-Cutandietum maritimae*.

These associations form mosaics with the perennial vegetation. In positions further back, there are therophytic-geophytic meadows of the alliance *Tuberarion guttatae* (association *Allietum chamaemoly*, with groupings of *Romulea rollii*).

SMALL-SIZED CHAMAEPHYTIC AND SUFFRUTICOSE VEGETATION

Habitat 2210 – *Crucianellion maritimae* fixed beach dunes

Alliance *Crucianellion maritimae*. This colonises the inner slopes of the dune systems that are stabilised and well developed, on compact sand (grey dunes). In Italy, this habitat is very localised and is under regression, due to fewer suitable sites. Along the Adriatic–Ionian coasts, this vegetation is known only for Puglia, Calabria and Sicily. The associations belonging to the alliance include: *Crucianelletum maritimae, Helichryso italici-Ephedretum distachyae* (retrodunal areas on consolidated sand), *Loto commutati-Thymetum capitati* (more or less deep calcareous sand on slabs of limestone), *Helichryso italici-Sarcopoterietum spinosi* (on stony substrates).

Habitat 2260 – *Cisto-Lavanduletalia* dune sclerophyllous shrubs

Sometimes the inner slopes of the dunes also include primary garrigues from the classes *Cisto-Micromerietea* (alliance *Cisto cretici-Ericion manipuliflorae*, with the association *Coridothymo capitati-Anthyllidetum hermannianae*) and *Rosmarinetea officinalis* (alliance *Cisto eriocephali-Ericion multiflorae*, with the associations *Cistetum salvifolio-clusii, Erico multiflorae-Halimietum halimifolii,* and *Helianthemo jonii-Fumanetum thymifoliae*).

PERENNIAL VEGETATION OF THE TEMPERATE CLIMATE

Habitat 2130* - Fixed coastal dunes with herbaceous vegetation (grey dunes)

Alliance *Syntrichio ruraliformis-Lomelosion argenteae*. This alliance is endemic to the north Adriatic coast, and the structure of the phytocoenoses that belong to this alliance is determined by a thick carpet of briochamaephytes, and at times of lichens, among which there are hemicryptophytes, therophytes and camaephytes. This description corresponds to the association *Tortulo-Scabiosetum*, as described for the Veneto coast. An association that is similar, but described for the Ionian coast of Apulia, and therefore in a Mediterranean climate, is *Plantagini albicantis-Scabiosetum albae*.

SHRUB VEGETATION OF THE STABILISED DUNES, WITH A DOMINANCE OF JUNIPER (*Juniperus macrocarpa, J. phoenicea* subsp. *turbinata*)

Habitat 2250* – Coastal dunes with *Juniperus* spp.

Alliance *Juniperion turbinatae*, with the associations *Asparago acutifolii-Juniperetum macrocarpae, Helianthemo sessilifolii-Juniperetum macrocarpae,* and *Juniperetum macrocarpae-turbinatae*.

In the temperate bioclimate (north Adriatic), this strip comprises the juniper of *Juniperus communis* (alliance *Pruno-Rubion ulmifolii*, with the association *Junipero communis-Hippophaetum fluviatilis*).

FOREST VEGETATION

Habitat 2270* - Wooded dunes with *Pinus pinea* and/or *Pinus pinaster*; 9340 – *Quercus ilex* and *Quercus rotundifolia forests*

This occurs when the dune systems are highly developed more inland. This category includes the mixed woods of evergreen sclerophyllous and deciduous woods belonging to the alliance *Fraxino orni-Quercion ilicis*, with the associations of the holm oak woods (e.g., *Fraxino orni-Quercetum ilicis* and *Cyclamino hederifolii-Quercetum ilicis*), and to the alliance *Pistacio lentisci-Pinion halepensis*, with the associations of the pine woods of the Aleppo pine (on the sand: *Plantago albicantis-Pinetum halepensis*).

VEGETATION OF THE DEPRESSIONS BETWEEN THE DUNES

Habitat 6420 – Mediterranean tall humid grasslands of *Molinio-Holoschoenion*

This develops in the depressions that are more or less moist and are enriched in organic matter. It is represented by the association *Schoeno nigricantis-Erianthetum ravennae*. Its syntaxonomic collocation is within the alliance *Imperato cylindricae-Saccharion ravennae*. The same classification includes the associations *Calamagrostio epigejotis-Erianthetum ravennae* of Molise and Abruzzo, and *Imperato cylindricae-Schoenetum nigricantis* in Sardinia and Abruzzo.

The depressions sometimes also contain phytocoenoses belonging to the alliance *Scirpion compac-*

to-littoralis, with the associations *Scirpetum compacto-littoralis* (the coastal Scirpeto), *Puccinellio palustris-Scirpetum compacti* (at the edges of lagoons), *Scirpo compacti-Juncetum subulati* (thermophilous), and *Junco maritimi-Cladietum marisci*.

The cliffs

The rocky shores are home to many plant communities that are differentiated primarily on the basis of the more or less marked actions of the salt winds. The rocks closest to the sea, and therefore those more subjected to the actions of the marine aerosol, are colonised by halo-rupicolous pioneer vegetation, while the less exposed cliffs have been colonised by halotolerant communities (Fig. 2).

In the first case, the vegetation belongs to the alliance *Crithmo-Staticion* (order *Crithmo-Staticetalia*, class *Crithmo-Staticetea*, with a wide Mediterranean distribution), which includes several associations that are characterised not only by *Crithmum maritimum*, but also by several species of *Limonium*, many of which are endemic and sometimes punctiform (Habitat 1240 - vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* spp.).

The known associations of the Adriatic and Ionian coasts include the following:

- *Crithmetum maritimi* (on cliffs and rock walls reached by sea spray), Veneto;
- *Reichardio maritimae-Brassicetum robertianae* (on limestone cliffs), Monte Conero;
- *Crithmo maritimi-Limonietum virgat*i (on conglomerate cliffs and gravel deposits), southern Abruzzo;
- *Crithmo-Limonietum diomedeae* (on low limestone rocky coasts), endemic to Gargano and the Tremiti Islands;
- *Limonietum japigici* (on limestone rocky coasts), endemic to Salento;
- *Frankenio-Limonietum cancellati* (on rocky coasts of Torre Guaceto-Brindisi);
- *Limonio virgati-Plantaginetum grovesii* (on marly coastal cliffs), Alimini Lakes;
- *Limonietum calabri* (on granite and gneiss), endemic to Calabria;
- *Crithmo-Limonietum lacinii* (on calcarenitic substrates), endemic to Capo Colonna (Calabria).

The top parts of the cliffs are colonised by chasmophytic vegetation included in the class *Asplenietea trichomanis*, orders *Centaureo-Campanuletalia* and *Onosmetalia frutescentis* (Habitat 8210 - Calcareous rocky slopes with chasmophytic vegetation). The phytocoenoses of the Friuli coast belong to the alliance *Cantaureo-Campanulion*, seen for both sides of the Adriatic Sea with a predominant spread to the east, with the associations *Campanulo-Centaureetum kartschianae* (cliffs exposed to the sea spray) and

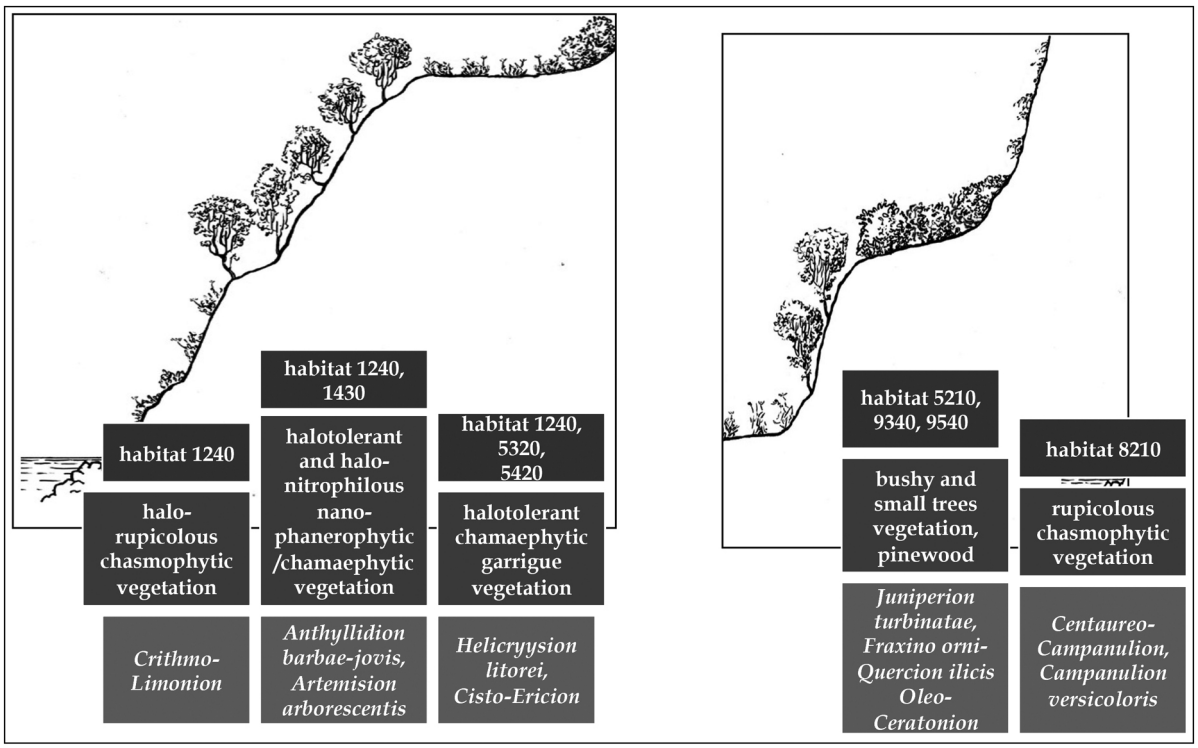

Fig. 2 - The cliffs. The rocks closest to the sea and most exposed to the sea aerosol are colonized by a pioneer halo-rocky vegetation, while in the less exposed cliffs halo-tolerant communities can be found. (by E. Biondi, 2007, modified)

Micromerio-Euphorbietum wulfenii (cliffs that have no direct marine influence). The Puglia phytocoenoses belong to the alliance *Campanulion versicoloris*, of the southern Balkan area, with the association *Campanulo-Aurinietum leucadeae* (the coast between Gallipoli and Otranto).

On the conglomerate-arenaceous cliffs of Punta Aderci in Abruzzo that are affected by dripping fresh water, there is a phytocoenosis of the alliance *Adiantion capilli-veneris* (order *Adiantetalia capilli-veneris,* class *Adiantetea*), within the association *Crithmo maritimi-Adiantetum capilli-veneris*.

Within the class *Crithmo-Staticetea* on the cliffs with less marine influence, there has developed chamaephytic and nanophanerophytic halotolerant vegetation of the alliance *Anthyllidion barbae-jovis* (order *Senecetalia cinerariae*), with the association *Anthyllido-Centaureetum diomedeae* (the high limestone cliffs of the Tremiti Islands) (Habitat 1240 - vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* spp.; 5320 - Low formations of *Euphorbia* close to cliffs).

The cliffs are also home to the halotolerant and nitrophilous shrub vegetation of the alliance *Artemision arborescentis* (order *Salsolo vermiculatae-Peganetalia harmalae,* class *Pegano harmalae-Salsoletea vermiculatae*), with the association *Suaedo verae-Atriplicetum halimi* (Gargano and the Tremiti Islands; the Santa Gilla stagnant pool, Sardinia; Ortona, Abruzzo) and the grouping of *Atriplex halimus* (Abruzzo) [Habitat 1430 - Halo-nitrophilous shrubs (Pegano-Salsoletea)].

The coastal cliff garrigues belong to the alliance *Cisto cretici-Ericion manipuliflorae* (associations *Saturejo cuneifoliae-Sarcopoterietum spinosi, Cisto monspeliensis-Sarcopoterietum spinosi,* and *Saturejo cuneifoliae-Ericetum manipuliflorae*) and *Cisto eriocephali-Ericion multiflorae* (associations *Asperulo aristatae-Fumanetum thymifoliae,* and *Cisto eriocephali-Rosmarinetum officinalis*). The alliance *Oleo-Ceratonion* is represented by the shrubbery of *Oleo-Euphorbietum dendroidis* (Monte Conero, Gargano, Tremiti Islands) and the alliance *Pistacio lentisci-Pinion halepensis* of the pine woods of *Pistacio-Pinetum halepensis* (Puglia, Tremiti Islands) and of *Erico arboreae-Pinetum halepensis* (north-eastern Calabria).

Syntaxonomic scheme

ZOSTERETEA MARINAE Pignatti 1953
ZOSTERETALIA Bèguinot 1941
Zosterion marinae Christiansen 1934
Zosteretum marinae (Van Goor 1921) Harmsen 1936
Zosteretum noltii Harmsen 1936
Cymonoceetum nodosae Giaccone & Pignatti 1967
POSIDONIETEA OCEANICAE Hartog 1976 ex Ge´hu in Bardat, Bioret, Botineau, Boullet, Delpech, Ge´hu, Haury, Lacoste, Rameau, Royer, Roux & Touffet 2004
POSIDONIETALIA OCEANICAE Hartog 1976
Posidonion oceanicae Br.-Bl., Roussine & Negre 1952
Posidonietum oceanicae (Funk 1927) Molinier 1958
Alliances of seaweeds:
Peyssonnelion squamariae Augier & Boudouresque 1975 emend. Giaccone 1994,
Cystoseirion crinitae Molinier 1958,
Caulerpion Giaccone& Di Martino 1997.

CAKILETEA MARITIMAE Tüxen & Preising ex Br.-Bl. & Tuxen 1952
EUPHORBIETALIA PEPLIS Tüxen 1950
Euphorbion peplis Tüxen 1950
Salsolo kali-Cakiletum maritimae Costa & Manzanet 1981 corr. Rivas-Martinez *et al*. 1992, con subass. *xanthietosum italici*;
Xantho italici-Cenchretum incerti Biondi, Brugiapaglia, Allegrezza & Ballelli 1992
Raphano maritimi-Glaucietum flavi Biondi, Brugiapaglia, Allegrezza & Ballelli 1992
Thero-Atriplicion Pignatti 1953
Atriplicetum hastato-tornabeni O.Bolòs 1962

AMMOPHILETEA AUSTRALIS Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946
AMMOPHILETALIA AUSTRALIS Br.-Bl. 1933
Ammophilion australis Br.-Bl. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez, Lousã, T.E. Díaz, Fernández-González & J.C. Costa 1990

Sporobolenion arenarii Géhu 1988
Sporoboletum arenarii (Arénes 1924) Géhu & Biondi 1994
Limonio virgati-Sporoboletum arenarii Biondi, Casavecchia & Guerra 2006 (Salento)
Sporobolo arenarii-Elymenion farcti Géhu 1987
Echinophoro spinosai-Elymetum farcti Géhu 1987
Medicagini marinae-Ammophilenion australis (Br.-Bl. 1921) Riv.-Mart. & Géhu 1980 em. Géhu & Biondi 1994
Echinophoro spinosae-Ammophiletum australis (Br.-Bl. 1933) Géhu, Rivas-Martinez & R. Tx. 1972 in Géhu *et al*. 1984

TUBERARIETEA GUTTATAE (Br.-Bl. in Br.-Bl., Roussine & Nègre 1952) Rivas Goday & Rivas-Martínez 1963 nom. mut. propos. in Rivas-Martínez *et al*. 2002
CUTANDIETALIA MARITIMAE Rivas-Martìnez, Dìez Garretas & Asensi 2002
Alkanno-Maresion nanae Rivas Goday ex Rivas Goday & Rivas-Martinez 1963 corr. Dìez-Garretas Asensi & Rivas-Martínez 2001
Maresio nanae-Ononidetum variegatae Géhu, Biondi, Géhu-Franck & Arnold-Apostolides 1986
Anchuso hybridae-Plantaginetum albicantis Corbetta & Pirone in Corbetta *et al*. 1992
Anthemido-Centaureetum conocephalae Brullo & Grillo 1985
Onobrychido-Malcolmietum ramosissimae Brullo, Scelsi & Spampinato 2000
Laguro ovati-Vulpion membranaceae Géhu & Biondi 1994
Sileno coloratae-Vulpietum membranaceae (Pignatti 1953) Géhu & Scoppola 1984
Ambrosio coronopifoliae-Lophochoetum pubescentis Biondi, Brugiapaglia, Allegrezza & Ballelli 1992
Sileno coloratae-Ononidetum variegatae Géhu 1986
Sileno nicaeensis-Cutandietum maritimae Géhu & Biondi 1994
Sileno conicae-Avellinietum michelii Sburlino, Buffa, Filesi, Gamper & Ghirelli 2013
TUBERARIETALIA GUTTATAE Br.-Bl. in Br.-Bl., Molinier & Wagner 1940 nom. mut. propos. Rivas-Martìnez *et al*. 2002
Tuberarion guttatae Br.-Bl. in Br.-Bl., Molinier & Wagner 1940 nom. mut. propos. Rivas-Martìnez, *et al*. 2002
Allietum chamaemoly Molinier 1954
Aggruppam. a *Romulea rollii*

HELICHRYSO-CRUCIANELLETEA MARITIMAE (Sissingh 1974) Géhu, Rivas-Martinez & Tüxen in Géhu 1975 em. Géhu & Biondi 1994
HELICHRYSO-CRUCIANELLETALIAMARITIMAE Géhu, Rivas-Martìnez & Tüxen 1973 em. Sissingh 1974
Crucianellion maritimae Rivas.Goday & Rivas-Martinez 1958
Loto commutati-Thymetum capitati Géhu, Biondi, Géhu-Franck & Marchiori 1984 (Salento)
Helichryso italici-Sarcopoterietum spinosi Géhu & Costa i n Géhu, Costa, Scoppola, Biondi, Marchiori, Peris, Franck, Caniglia & Veri 1984
Helichryso italici-Ephedretum distachyae Géhu, Biondi, Géhu-Franck & Taffetani 1987
Artemisio variabilis-Ephedretum distachyae Brullo, Giusso Del Galdo, Siracusa & Spampinato 2001
Plantagini albicantis-Scabiosetum albae Brullo, Giusso Del Galdo, Siracusa & Spampinato 2001
HELICHYSETALIA ITALICI Biondi & Géhu in Géhu & Biondi 1994
Helichrysion litorei Biondi 2007
Agropyro-Helichrysetum italici Bartolo, Brullo & Signorello 1983
Aggruppam. a *Helichrysum italicum* and *Reichardia picroides* var. *maritima*

KOELERIO-CORYNEPHORETEA Klika in Klika & Novák 1941
ARTEMISIO-KOELERIETALIA ALBESCENTIS Sissingh 1974
Syntrichio ruraliformis-Lomelosion argenteae Biondi, Sburlino & Theurillat in Sburlino, Buffa, Filesi, Gamper & Ghirelli 2013
Tortulo-Scabiosetum Pignatti 1952

FESTUCO-BROMETEA ERECTI Br.-Bl. & Tüxen ex Klika & Hadač 1944
SCORZONERO-CHRYSOPOGONETALIA Horvatić & Horvat in Horvatić 1958
Saturejion subspicatae (Horvat 1962) Horvatic 1973
Centaurenion dicroanthae (Pignatti 1962) Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1994
Teucrio capitati-Chrysopogonetum grylli Sburlino, Buffa, Filesie & Gamper 2008

CISTO CRETICI-MICROMERIETEA JULIANAE Oberdorfer 1954
CISTO CRETICI-ERICETALIA MANIPULIFLORAE Horvatić 1958
Cisto cretici-Ericion manipuliflorae Horvatić 1958
Coridothymo capitati-Anthyllidetum hermannianae Brullo, Minissale & Spampinato 1987
Aggruppam. a *Cistus creticus* ssp. *creticus* and *Fumana thymifolia*

ROSMARINETEA OFFICINALIS Rivas-Martinez, T.E. Diaz, F. Prieto, Loidi & Penas 2002
ROSMARINETALIA OFFICINALIS Br.-Bl. ex Molinier 1934
Cisto eriocephali-Ericion multiflorae Biondi 2000
Cistetum salvifolio-clusii Bartolo, Giardina, Minissale & Spampinato 1987
Erico multiflorae-Halimietum halimifolii Taffetani & Biondi 1992
Helianthemo jonii-Fumanetum thymifoliae Taffetani & Biondi 1992

QUERCETEA ILICIS Br.-Bl.
QUERCETALIA ILICIS Br.-Bl. ex Molinier 1934 in Br.-Bl., Roussine & Nègre 1952
Fraxino orni-Quercion ilicis Biondi, Casavecchia & Gigante ex Biondi, Casavecchia & Gigante in Biondi, Allegrezza, Casavecchia, Galdenzi, Gigante & Pesaresi 2013
Fraxino orni-Quercetum ilicis Horvati (1956) 1958
Cyclamino hederifolii-Quercetum ilicis Biondi *et al*. ex Biondi, Casavecchia & Gigante in Biondi, Allegrezza, Casavecchia, Galdenzi, Gigante & Pesaresi 2013
PISTACIO LENTISCI-RHAMNETALIA ALATERNI Rivas-Martinez 1975
Oleo-Ceratonion siliquae Br.-Bl. ex Guinochet & Drouineau 1944 em. Rivas-Martinez 1975
Oleo-Euphorbietum dendroidis Trinajsti 1974
Myrto-Pistacietum lentisci (Molinier 1954 em. O.Bolòs 1962) Rivas-Martinez 1975
Juniperion turbinatae Rivas-Martinez 1975 corr. 1987
Asparago acutifolii-Juniperetum macrocarpae O. Bolòs 1964
Helianthemo sessilifolii-Juniperetum macrocarpae Brullo. Giusso Del Galdo, Siracusa & Spampinato 2001
Juniperetum macrocarpae-turbinatae Pedrotti & Cortini-Pedrotti ex Pedrotti *et al*. 1982
PINETALIA HALEPENSIS Biondi, Blasi, Galdenszi, Pesaresi & Vagge Biondi, Blasi, Galdenzi, Pesaresi & Vagge in Biondi *et al*. 2014
Pistacio lentisci-Pinion halepensis Biondi, Blasi, Galdenzi, Pesaresi & Vagge Biondi, Blasi, Galdenzi, Pesaresi & Vagge in Biondi *et al*. 2014
Plantago albicantis-Pinetum halepensis Bartolo, Brullo, Minissale & Spampinato 1985
Pistacio-Pinetum halepensis De Marco, Veri & Caneva 1984

RHAMNO-PRUNETEA Rivas-Goday & Borja ex Tüxen 1962
PYRO SPINOSAE-RUBETALIA ULMIFOLII Biondi, Blasi & Casavacchia in Biondi *et al*. 2014
Pruno-Rubion ulmifolii O. Bolòs 1954
Junipero communis-Hippophaetum fluviatilis Géhu & Scoppola in Géhu *et al*. 1984

MOLINIO-ARRHENATHERETEA Tüxen 1937
SACCHARETALIA RAVENNAE Biondi, Blasi & Casavecchia in Biondi *et al*. 2014
Imperato cylindricae-Saccharion ravennae Br.-Bl. & O.Bolòs 1958
Schoeno nigricantis-Erianthetum ravennae Pignatti 1953
Calamagrostio epigejotis-Erianthetum ravennae Taffetani & Biondi 1992
Imperato cylindricae-Schoenetum nigricantis Arrigoni 1996

PHRAGMITI-MAGNOCARICETEA Klika 1941
SCIRPETALIA COMPACTI Hejny in Holub, Hejny, Morav. & Neuh. 1967 em. Rivas-Martinez 1980
Scirpion compacti Dahl & Hadaĉ 1941 corr. Rivas-Martìnez, Costa, Castroviejo & E. Valdés 1980
Scirpetum compacto-littoralis (Br.-Bl. (1931) 1952 em. Riv.Mart. *et al*. 1980
Puccinellio palustris-Scirpetum compacti (Pignatti 1953) Géhu & Scoppola 1984
Scirpo compacti-Juncetum subulati Géhu *et al*. 1992
Junco maritimi-Cladietum marisci Géhu & Biondi 1988

CRITHMO-STATICETEA Br.-Bl. in Br.-Bl., Roussine & Nègre 1952

CRITHMO-STATICETALIA Molinier 1934 em. Biondi 2007
Crithmo-Staticion Molinier 1934
Crithmetum maritimi Béguinot 1941
Reichardio maritimae-Brassicetum robertianae Biondi 1982
Crithmo maritimi-Limonietum virgati Pirone 1995
Crithmo-Limonietum diomedeae Bartolo, Brullo & Signorello 1989
Limonietum japigici Curti & Lorenzoni 1968
Frankenio-Limonietum cancellati Mariotti 1992
Limonio virgati-Plantaginetum grovesii Bartolo, Brullo & Signorello 1989
Limonietum calabri Bartolo, Brullo & Signorello 1989
Crithmo-Limonietum lacinii Bartolo, Brullo & Signorello 1989
Crithmo maritimi-Inuletum crithmoidis Biondi, Casavecchia & Guerra 2006
SENECIONETALIA CINERARIAE Biondi 2007
Antthyllidion barbae-jovis Brullo & De Marco 1989
Anthyllido-Centaureetum diomedeae Brullo & De Marco 1989

PEGANO HARMALAE-SALSOLETEA VERMICULATAE Br.-Bl. & O. Bolòs 1958
SALSOLO VERMICULATAE-PEGANETALIA HARMALAE Br.-Bl. & O. Bolòs 1954
Artemision arborescentis Géhu & Biondi 1986
Suaedo verae-Atriplicetum halimi Biondi 1988
Aggruppam. a *Atriplex halimus*
STELLARIETEA MEDIAE Tüxen, Lohmeyer & Preising ex Von Rochow 1951
STELLARIENEA MEDIAE
THERO-BROMETALIA (Rivas Goday & Rivas-Martìnez ex Esteve 1973) O. Bolòs 1975
Echio plantaginei-Galactition tomentosae O. Bolòs & Molinier 1969
Verbasco garganici-Euphorbietum terracinae Biondi, Casavecchia & Biscotti 2007

STELLARIETEA MEDIAE Tüxen, Lohmeyer & Preising ex Von Rochow 1951
STELLARIENEA MEDIAE
THERO-BROMETALIA (Rivas Goday & Rivas-Martìnez ex Esteve 1973) O. Bolòs 1975
Echio plantaginei-Galactition tomentosae O. Bolòs & Molinier 1969
Verbasco garganici-Euphorbietum terracinae Biondi, Casavecchia & Biscotti 2007

ASPLENIETEA TRICHOMANIS (Br.-Bl. in Meier & Br.-Bl. 1934) Oberd. 1977
CENTAUREO KARTSCHIANAE-CAMPANULETALIA PYRAMIDALIS Trinajstic ex Di Pietro & Wagensommer 2008
Centaureo-Campanulion Horvatić 1934
Campanulo-Centaureetum kartschianae Lausi & Poldini 1962
Campanulo-Aurinietum leucadeae Bioanco, Brullo, Pignatti & Pignatti 1988
Campanulo versicoloris-Dianthion japigici Di Pietro & Wagensommer 2008

ADIANTETEA Br.-Bl. in Br.-Bl., Roussine & Nègre 1952
ADIANTETALIA CAPILLI-VENERIS Br.-Bl. ex Horvatic 1934
Adiantion capilli-veneris Br.-Bl. ex Horvati 1934
Crithmo maritimi-Adiantetum capilli-veneris Géhu *et al*. 1987

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The state of Ionian-Adriatic coastal habitats: the database of "Carta della Natura" System of Italy

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Abstract
Aim of this work is to provide a national scale synthesis of useful data for conservation status assessment of Italian Adriatic - Ionian coastal habitats. Basing on the data provided by the Carta della Natura information system it has been possible to consider about 70% of the Ionian and Adriatic coastlines. Initially all the patches included in a buffer of 500 meters from the coastline has been extracted from regional habitat maps and for each habitat type has been calculated: total and mean surface area, number of biotopes. After that the study focus on threatened coastal habitats, considering the classification used by the Carta della Natura system.
Taking into account the Ecological Value index, about 90% of Natural habitat biotopes fall into "high" and "very high" classes. Comparing these data with "Environmental Fragility" classes distribution it is possible to highlight a set of habitat types at higher risk of degradation. Representative coastal habitats are included in this set. Risky conditions are due to high Ecological Value and Environmental Fragility indexes, involving factors such as fragmentation, rarity, suitability to host threatened species, and to important anthropogenic pressures. Many biotopes at risky conditions are already included in protected areas. For this reason particularly attention should be given to the success of management tools.

Key words: Anthropogenic Pressure, Directive 92/43/EEC, Ecological Sensitivity, Ecological Value, Environmental Fragility, Habitat, Map of Habitats

Introduction

Carta della Natura is an informative system following the Italian Law on Protected Natural Areas (no. 394/1991), aiming at assessing quality and fragility status of natural environment in Italy. It has, therefore, two main objectives: the knowledge (by mapping environmental homogeneous units) and the assessment (by the use of indicators and indexes to estimate quality and fragility values) of the Italian landscapes and habitats.

Basic information layers (Maps of Habitats) are produced according to the European criteria for habitats classification and the assessment layers are realized through the use of widely shared indexes and indicators. Outputs of information system are different thematic maps of Ecological Value, Ecological Sensitivity and Anthropogenic Pressure, and Environmental Fragility.

Data from Carta della Natura information system are particularly useful in case of environmental evaluations, landscape planning at regional scale, designation of ecological network or green infrastructures planning, and whenever a shared base of quantitative and qualitative data are required.

Materials and methods

The basis of the work is represented by the Carta della Natura information system, consisting of a set of map layers (ISPRA, 2009a). Map of Habitats identified units as described in the CORINE Biotopes System (C.E.C., 1991; ISPRA, 2009b).

Spatial scale at 1:50,000 imposes accuracy limits (mapped only patches > of 1 hectare) and may produce loss of biotopes of limited extent, but allows the necessary synthesis to represent habitats of entire regions and to highlight the most significant ones at national scale.

The assessment process aims to create assessment maps that determine, for each environmental unit, the following indexes: Ecological Value, Ecological Sensitivity, Anthropogenic Pressure and Environmental Fragility. The last one is a result of a combination of Ecological Sensitivity and Anthropogenic Pressure Indexes (ISPRA, 2009a) . The maps are related to administrative regional boundary and are the results of application of specific algorithms on selected indicators. Ecological Value means the measure of a biotope quality from the environmental point of view, defined by law as "natural value". It is calculated using specific indicators.

Environmental Fragility measures the state of vulnerability of the environmental unit from the natural and environmental point of view. It is proportional both to the predisposition of suffering damage and to the disturbance due to human activities.

Considering a biotope Ecological Sensitivity as its

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intrinsic predisposition to the degradation risk and Anthropogenic Pressure as disturbance caused by human activities, the amount of the Environmental Fragility of a biotope is the result of the combination of these two indexes.

ISPRA created a specific application for the indicators and indexes calculation, able to ensure consistency in file management and algorithms application (ISPRA, 2009a).

Calculating process is structured in subsequent phases:

1) Normalization of indicator values: this phase is necessary because indicators that contribute to the calculation of each synthetic index value are extremely heterogeneous. Through normalization they may be compared and processed in the same algorithm.

2) Calculating the value of three indexes: Ecological Value, Ecological Sensitivity and Anthropogenic Pressure, processing jointly standardized indicators through the application of the TOPSIS method, known as the "Ideal Point" (Hwang&Yoon1981). The choice of the TOPSIS method, based on experimental texts, allows a more articulated distribution of the resulting values and therefore a better defined class rank value.

3) Subdivision of indices values into five classes: 'very low', 'low', 'medium', 'high' and 'very high'.

4) Identification of Environmental Fragility: implemented using a double entry matrix (with ecological sensitivity and anthropogenic pressure).

The calculation of each indicator requires a sets of data: some indicators use existing valid data recognized at national and/or European level, while others refer the polygon geometry, such as perimeter or area. Suitable databases are from official publication sources.

Since the assessment objective phase is to highlight the natural aspect, no indicators and indexes for biotopes of completely artificial environments, such as urban areas, industrial areas and quarries are calculated. Study area is identified within a buffer of 500 meters from the coastline, including all types of habitats: natural, semi-natural and anthropogenic. This buffer extends for about 2000 km along Friuli Venezia Giulia, Veneto, Abruzzo, Molise, Puglia, Basilicata and Sicily coastline, and it is interrupted in correspondence of the Regions Emilia Romagna, Marche and Calabria, due to the progress of the Carta della Natura (Fig.1). It represents approximately 70% of the entire Adriatic-Ionic Italian coast.

Studied area extends over 190,430 hectares and represents a selection of coastal habitats maps realized at Regional level. The study particular highlights the context of coastal ecosystems, by analyzing interactions with other natural habitats, but also giving a special attention to the effect of semi-natural and artificial habitats about them.

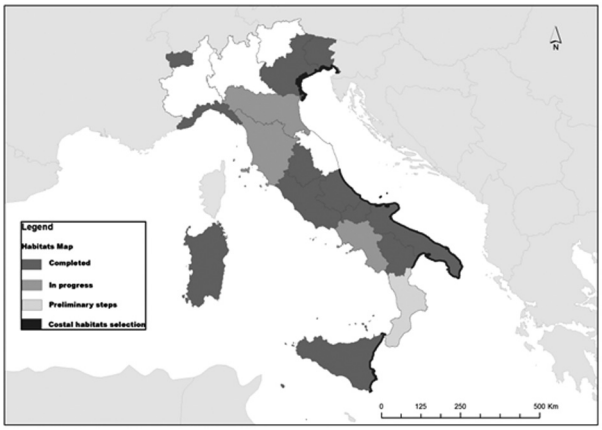

Fig. 1 - Progress on regional Carta della Natura Information System and study area.

Biotopes analysis allowed to highlight: habitat types, differentiating semi-natural and anthropogenic habitats from the natural ones and which are typical of coastal environment; size, number of biotopes and their coverage percentage, analyzing all habitats types, and separately coastal and other natural habitat; the risk of degradation of natural habitats of each biotope considering Ecological Values and Environmental Fragility indexes.

Results

Distribution analysis show the presence of 82 different Habitats types along Ionian-Adriatic coast, including 65 natural types and 17 among man-made and semi-natural types .

Man-made and semi-natural habitats, account for a significant portion of the study area, of about 35%, despite of the numerical inferiority compared to the natural habitat types. Natural habitats are distributed on 65% of the studied area (about 124,000 hectares), about 56% belong to 18 different types of coastal ecosystems (CEC,1991; ISPRA, 2009b).

Figure 2 shows for each habitat, average and total surface area and number of biotopes.

It indicates also correspondence with Annex 1 of the Habitats Directive (European Commission, 2013) highlighting the priority ones. Surface area provides a measure of each habitat representativeness (Figs. 2 and 3). This is an important data for assessment of conservation status of habitat types, as recommended in guidelines for assessment and reporting under Article 17 of the Habitats Directive (Evans & Arvela, 2011).

Combining total surface area with the number of biotopes of an habitat type, it is possible to obtain indication about its fragmentation, that is the inverse of average surface (Figs. 2 and 4): the lower the ratio of surface area and number of biotopes of each habitat,

CODE	HABITAT	TOTAL SURFACE (Ha)	N° biotopes	SURFACE AVERAGE (Ha)	DIRECTIVE 92/43/CEE (annex 1)	Priority interest (*)
21	Lagoons	73.994	93	796	X	*
14	Mud flats and sand flats	8.637	76	114	X	
15.1	Salt pioneer swards	4.662	311	15	X	
16.1	Sand beaches	4.193	210	20		
16.29	Wooded dunes	4.168	52	80	X	*
53.1	Reed beds	3.842	216	18		
15.5	Mediterranean salt meadows	1.802	137	13	X	
34.81	Mediterranean subnitrophilous grass communities	1.770	294	6		
34.6	Mediterranean tall-grass steppes	1.632	135	12	X	*
34.5	Mediterranean xeric grasslands	1.619	93	17	X	*
23	Standing brackish and salt water	1.603	24	67		
16.28	Dune sclerophyllous scrubs	1.595	54	30	X	
42.84	Aleppo pine (Pinus halepensis) forests	1.573	24	66	X	
18.22	Mediterranean sea cliff communities	1.555	138	11	X	
32.4	Western meso-Mediterranean calcicolous garrigues	1.432	144	10		
16.21	Shifting dunes	1.395	131	11	X	
24.1	River course	1.345	40	34	X	
42.83	Stone pine (Pinus pinea) forests	805	30	27	X	
15.6	Saltmarsh scrubs	795	70	11	X	
16.27	Dune juniper thickets and woods	724	67	11	X	*
16.3	Humid dune-slacks	490	25	20	X	
32.211	Oleo-lentisc (Olea, Pistacia) brush	433	35	12		
15.21	Flat-leaved cordgrass swards	400	47	9	X	
15.81	Sea-lavender (Limonium) salt steppes	392	55	7	X	*
44.61	Mediterranean riparian poplar (Populus alba) forests	359	84	4	X	
31.8A	Tyrrhenian sub-Mediterranean deciduous thickets	322	41	8		
41.731	Northern Italian Quercus pubescens woods	294	33	9		
41.732	Southern Italian and Sicilian Quercus pubescens woods	267	90	3		
45.1	Olive-carob forests	236	2	118	X	
42.1B	Fir reforestation	232	31	7		
45.31A	Southern Italian holm-oak forests	175	34	5	X	
31.81	Medio-European rich-soil thickets	132	21	6		
45.318	Northern and central Italian holm-oak forests	121	7	17	X	
17.1	Unvegetated shingle beaches	99	27	4		
62.11	Western eu-Mediterranean and oro-Iberian calcareous cliffs	89	16	6	X	
45.319	Illyrian holm-oak woodland	78	2	39	X	
16.22	Grey dunes	71	13	5	X	
34.75	Eastern sub-Mediterranean dry grasslands	68	20	3	X	
32.22	Tree-spurge (Euphorbia dendroides) formations	63	9	7	X	
44.81	Oleander, chaste tree and tamarix galleries	62	11	6	X	
44.44	Po oak-ash-alder forests	57	6	9	X	
22.1	Fresh waters	50	9	6		
32.219	Wood clubrush (Scirpus sylvaticus) meadows	50	2	25		
24.225	Mediterranean gravel beds	39	19	2	X	
32.3	Meso-Mediterranean silicicolous maquis	38	3	13		
53.2	Large sedge communities	38	5	8		
32.23	Diss (Ampelodesmos mauritanica)-dominated garrigues	36	7	5	X	
24.53	Mediterranean river mud communities	35	11	3	X	
19	Islets and rock stacks	34	10	3	X	
32.11	Evergreen oak matorral	24	7	3		
37.31	Purple moorgrass (Molinia caerulea) meadows and related communities	16	3	5	X	
37.4	Mediterranean tall humid grasslands	14	3	5	X	
44.12	Lowland, collinar and Mediterraneo-montane willow brush	12	8	2	X	
33.6	Italian Sarcopoterium spinosum phryganas	12	4	3	X	
44.63	Mediterranean riparian ash (Fraxinus angustifolia) woods	12	1	12	X	
34.323	Middle European Brachypodium-dominated semi-dry grasslands	9	2	5	X	
38.2	Lowland hay meadows	7	2	4	X	
44.62	Mediterranean riparian elm (Ulmus minor) forests	6	1	6	X	
44.513	Western Mediterranean alder galleries	5	1	5	X	*
32.212	Thermo-Mediterranean heath-garrigues	3	3	1		
44.713	Sicilian plane tree canyons	3	1	3	X	
31.844	Tyrrhenian broom (Cytisus) fields	3	1	3		
32.217	Coastal Helichrysum garrigues	3	2	1	X	
44.13	White willow (Salix alba) gallery forests	2	2	1	X	
32.215	Calicotome brush	1	2	1		

Fig. 2 - Summary of some characteristic parameters of natural habitat (coastal habitat types in gray) in study area. Data from: Carta della Natura information system

the higher the habitat fragmentation.

Analysing natural habitats, we can notice that “Lagoons” (Corine Biotopes code 21), the most widespread habitat (74,000 hectares), have a low level of fragmentation, since it is divided in a number of patches relatively low (93). Similarly, habitats with minor extensions, as "Wooded dunes" (Corine Biotopes code 16.29) are relatively fragmented.

On the contrary other typical coastal habitats, such as "Mediterranean cliff communities" (Corine Biotopes code 18.22), "Shifting dunes" (Corine Biotopes code 16.21) "Grey dunes" (Corine Biotopes code 16.22) and “Dune juniper thickets and woods” (Corine Biotopes code 16.27), are characterized by high fragmentation, with small total surface area and several patches.

It is important to notice the rarity of some habitat types, which have few polygons and very small extensions: “Coastal *Helicrysum* garrigues" (Corine Biotopes code 32.217), "Italian *Sarcopoterium Spinosum phrygana*" (Corine Biotopes code 33.6), "Sea lavender salt steppes” (Corine Biotopes code 15.81), “Illyrian holm oak forests” (Corine Biotopes code 45.319) and “Northern and central holm oak forests” (Corine Biotopes code 45. 318), or some riparian habitat types that are locate in small flaps at the mouths of rivers. All this data are scale-dependent and results depend on the spatial definition of habitats mapping. For this reason it is important to focalize attention on the results on a large scale more than on specific ecological consideration.

Using data extracted from regional Carta della Natura databases and relating to Ecological Value classes,

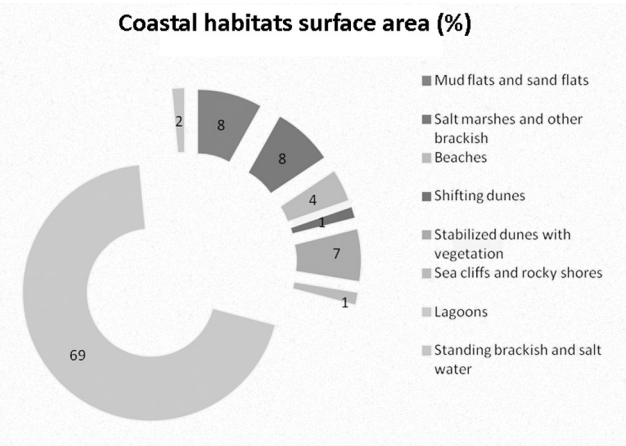

Fig. 3 - Percent of surface area of coastal habitat types.

natural habitats and coastal habitats classes of values have been compared, also as percentage values of surface area occupied by classes (Fig.5).

Higher Ecological Values classes most represented in the coastal habitats group are due to their peculiarities: some of them are included in Annex I of Directive 92/43 CEE and are suitable for many different species of flora and fauna, many of which are threatened; they are mostly rare habitat types particularly in the coastal area.

Their value is also already recognized since 67% of the area examined in this paper is subjected to various levels of security and protection (protected areas, Natura 2000 network sites, Ramsar areas).

In addition to the Ecological Value, the Environmental Fragility has been considered, which provides a measure of the actual state of the risk acting on environmental unit (Fig. 6).

In order to highlight the most threatened biotopes the combination of Value and Fragility has been studied. This analysis is extremely useful to perform actions on environmental conservation and planning, and allows to identify habitats containing high value natural resources exposed to greater risk of deterioration or loss.

The diagram in Fig.7 shows the distribution of habitats types in relation to Ecological Value (x-axis) and Environmental Fragility (y-axis). Position of each habitat type in the graph is the average of the values of the classes of Environmental Fragility and Ecological Value calculated on the total of biotopes belonging to the habitat, assigning numerical values from 1 to 5 classes, from "very low" to "very high". Habitat types on which a 'maximum attention' is required are those that fall in the upper right section, because they are at “very high” Ecological Value and “very high” Fragility.

All coastal habitats (highlighted codes Fig. 7) are assigned in "very high" sections for Ecological Value. The only exception are for beaches (16.1 and 17.1) and for "non-marine brackish and salt water" (23) habitats type.

It should also be noted that coastal habitats in higher Fragility classes are all included in Annex 1 of the Di-

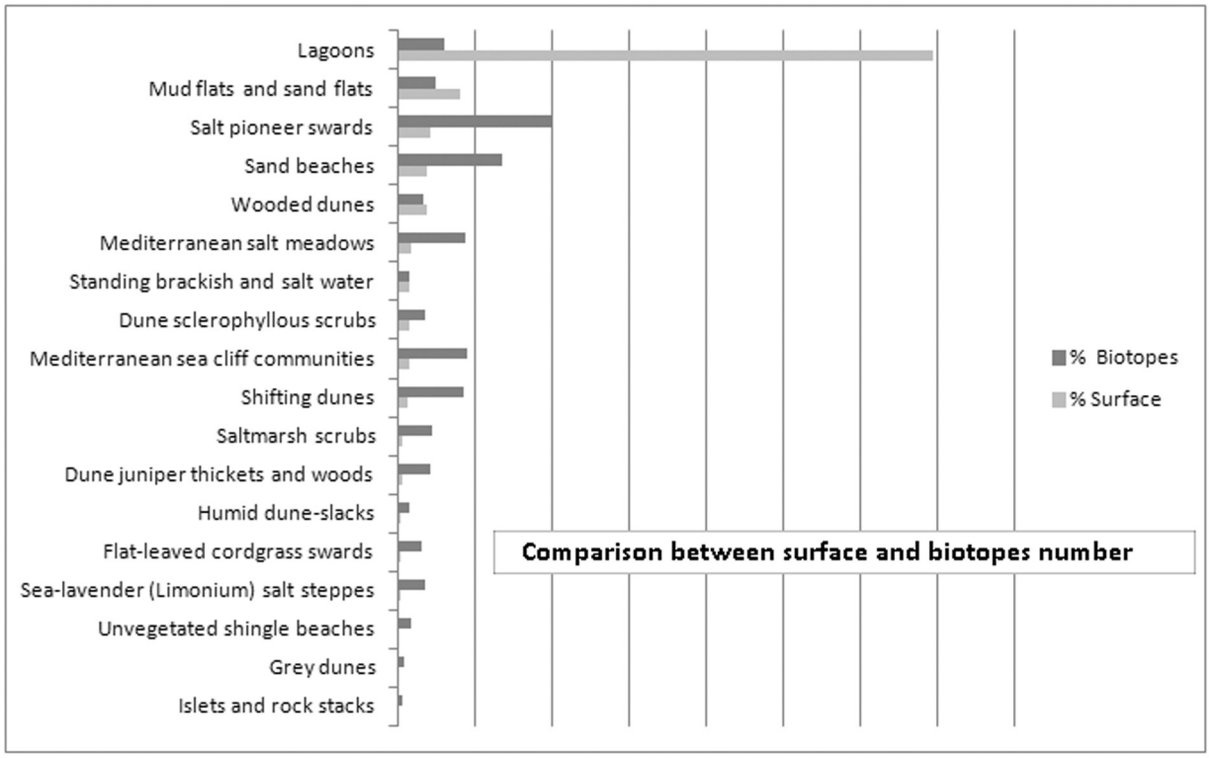

Fig. 4 - Percent of surface area and biotopes number of each coastal habitat type.

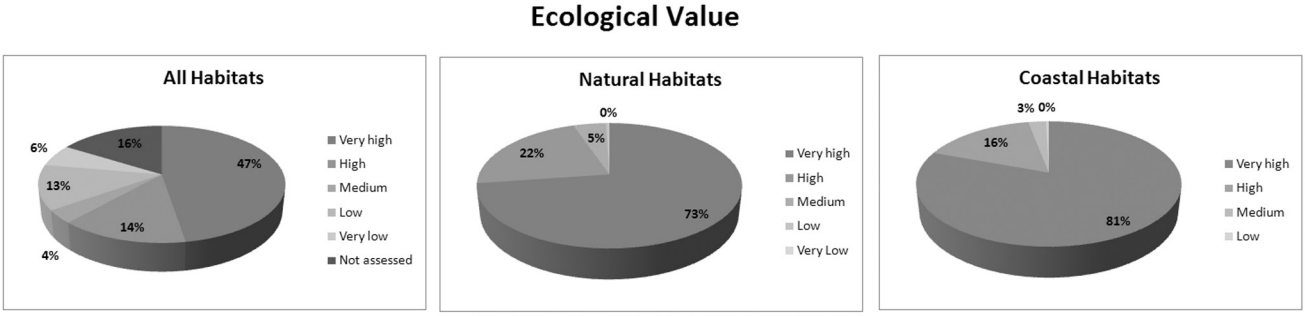

Fig. 5 - Ecological Values classes distribution considering all habitats, natural habitats and coastal habitats. Percent values refer to surface area.

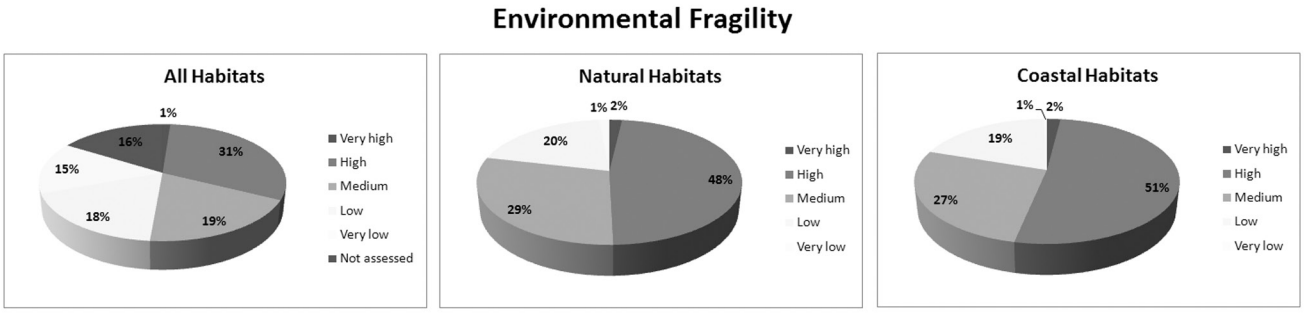

Fig. 6 - Environmental Fragility classes distribution considering habitats, natural habitats and coastal habitats. Percent values refer to surface area.

rective 92/43 CEE as habitats of priority interest.

Habitat types "Dune juniper thickets and woods" (Corine Biotopes code 16.27) and "Sea lavender salt steppes" (Corine Biotopes code 15.81) are at maximum risk because Ecological Value and Environmental Fragility are both "very high".

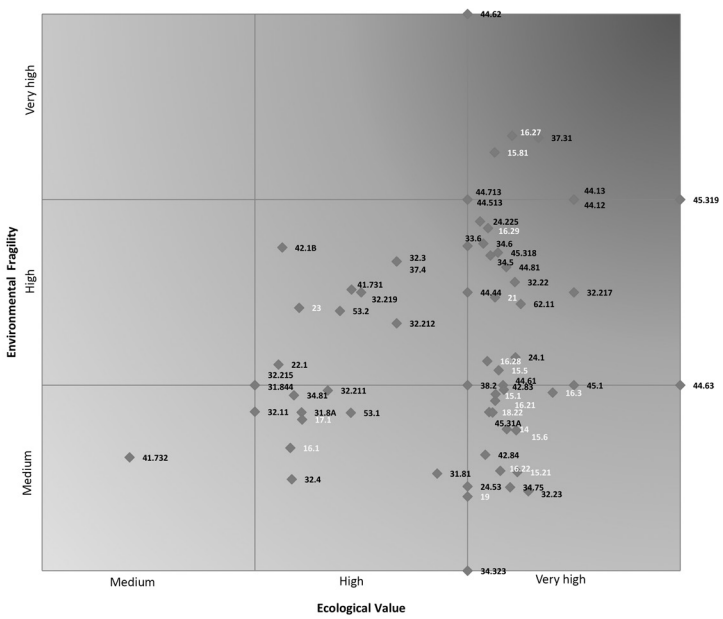

Fig. 7 - Relationship between Ecological Value and Environmental Fragility classes of habitat types (Corine Biotopes codes).

Environmental Fragility play a very important role because almost all coastal habitat types are at "very high" Ecological Value. It depend on the indicators that consider: DH priority interest, small average size of biotopes, high level of fragmentation.

As an example we can observe that the coastal habitats which falling within the less vulnerable class, "Wooded dunes" (Corine Biotopes code 16.29) and "Lagoons" (Corine Biotopes code 21), have a lower fragility because they have significantly greater average size and equally low fragmentation level (Fig. 3).

Conclusion

This work shows the potential of the Carta della Natura information system wich is a tool, shared at national level, that allows territorial and ecological large-scale analysis.This study confirm critical condition of coastal environment, which status needs to enhance conservation measures. Great presence of anthropogenic habitats reduce connectivity of natural ones and in particular on the coasts, and fragmentation is an important threat who can lead to complete loss of natural heritage that they represent.

Event thought high extent of surface area investigated is located within protected areas, assessment shows that fragility of coastal habitats

stands at high classes value: for the purposes of conservation attention should be given to the effective of management tools.

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Syntaxonomic considerations of the Mediterranean vegetation dominated by perennial psammophilous graminaceous plants

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Abstract
The vegetation dominated by perennial psammophilous grasses along the Mediterranean coasts is reviewed and updated according to the new concepts, with particular reference to the European grasses. First, the class of the dune psammophilous vegetation that is already indicated in the Vegetation Prodrome of Italy with the name of *Ammophiletea* is updated to *Euphorbio paraliae-Ammophiletea australis*. Thus, the dune vegetation of the central and northern Atlantic is distinguished in syntaxonomic terms from that of the similar Mediterranean and south-Atlantic formations. This separation is carried out at the order level, by recognizing the order *Elymetalia arenarii* for the north-European Atlantic coasts and the order *Ammophiletalia australis* for the Mediterranean and thermo-Atlantic coasts. For the Mediterranean area is also recognized the order *Elymetalia gigantei*, for the Pontic zone and specifically for the Black Sea coasts and the Marmara Sea areas.
The main aim of this revision is therefore recognition of the syntaxa that make up the hierarchical scheme proposed for the Mediterranean Basin, with the definition of the alliance *Ammophilion australis* for the vegetation of the white dunes, the alliance *Agropyrion juncei* for that of the embryonic dunes and the alliance *Elymion gigantei* for that of the Pontic dunes. In terms of the alliance *Ammophilion australis*, the suballiance *Ammophilenion australis* is recognized for the European thermo-Atlantic and Mediterranean coastal areas except for the coasts of north Africa and the new suballiance *Silene succulentae-Ammophilenion australis* is described for the Mediterranean part of north Africa. For the alliance *Agropyrion farcti* that defines the vegetation that shows the richest biodiversity of the whole system, four suballiances are recognized. Of these, two are 'structural system', even if they are well characterised in ecological and floristic terms, and two are biogeographic. The first two of the suballiances are *Sporobolenion arenarii*, which includes the first perennial vegetation of the first parts of embryonic dunes directly reached by seawater, and *Elymo farcti-Otanthenion maritimi* suball. nova, which includes the vegetation of the inner parts of the embryonic dunes characterised by reduced mobility of the sandy substrate. Defined in chorological terms, the two suballiances within the Mediterranean Basin are: the suballiance *Agropyrenion farcti*, which includes the European psammophilous communities from the Iberian Peninsula to the Balkan one up to the Pontic Region except for the Crete and Cyprus Islands; and the suballiance *Sileno succulentae-Elymenion farcti* suball. nova, which includes the communities of the north African Mediterranean coast. Finally, within the order *Elymetalia gigantei*, the alliance *Elymion gigantei* is recognized for the psammophilous vegetation of the Pontic dunes.

Keywords: Atlantic coasts, coastal vegetation, embryonic dunes, Mediterranean coasts, mobile dunes, syntaxonomy.

Introduction

The sandy coasts are characterised by particular vegetation formations that are in chain succession along a gradient defined by ecological factors, such as the salinity, the winds, and the particular quality of the substrate, especially in terms of its mobility and extreme dryness (Biondi, 2007). Stabilisation of the sandy substrate occurs through the annual and, in particular, perennial psammophytes. These are characterised by their hypogean structure, which together with their above-ground structure can retain the sand, thus promoting the progressive growth of the dunes.

In more detail, along the Mediterranean and thermo-Atlantic coasts, the *Sporobolus pungens* (Schreb.) Kunth and *Elymus farctus* (Viv.) Runemark ex Melderis formations promote the building of the first sand accumulations, or drifts (the embryonic dunes) that then grow to increased heights (as the mobile dunes). This is due to the presence of the geophyte *Ammophila arenaria* (L.) Link subsp. *australis* (Mabille) Lainz [= *Ammophila arenaria* (L.) Link subsp. *arundinacea* H. Lindb.] in the inner part of the dune system (Braun-Blanquet, 1933; Géhu, 1986, 1998; Géhu & Géhu-Franck, 1986, 1988; Géhu *et al*., 1990; Rivas-Martínez *et al*., 2002, 2011; Géhu & Biondi, 1994; Biondi, 1999; Biondi *et al*., 2001; Brullo *et al*., 2001; Biondi & Bagella, 2005). These communities are included in a single vegetation class and organised into the relevant subordinate syntaxonomic ranks according to the different criteria.

The aim of this article is to update the syntaxonomic scheme already published in the Vegetation Prodrome of Italy according to the concepts which are presented here.

On the basis of this vision the class of vegetation that characterises the plant communities of the Atlantic and Mediterranean dunes that is currently proposed according to different definitions is here recognized, and the syntaxonomic scheme of this class, for each hierarchical level and in relation to the Mediterranean Basin is completed. The following proposed syntaxonomic scheme follows the interpretation of Géhu (1986), which is adapted according to the views of the

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authors. Some syntaxa are reproposed here according to the rules of the International Code of Phytosociological Nomenclature (ICPN, Weber *et al*., 2000).

Analysis of the syntaxonomical approaches

In the latest syntaxonomic schemes (Bardat *et al*., 2004; Rivas-Martínez *et al*., 2011; Schaminée *et al*., 1995-1999; Rodwell, 1991-2000; Pott, 1995; Costa *et al*., 2012; Bioret *et al*., 2013; Biondi *et al*., 2014), the class that includes the coastal dune vegetation of the northern Atlantic and the thermo-Atlantic and Mediterranean is proposed with different definitions. Moreover, the classification of the vegetation in biogeographical and ecological terms is defined at the level of alliance and suballiance, according to the views of the authors.

In particular, in their Prodrome des végétations de France ('Prodrome of the French Vegetation') Bardat *et al*. (2004) followed the interpretation of Géhu & Géhu-Franck (1988), according to the class *Euphorbio paraliae-Ammophiletea australis*. Within this, the order *Ammophiletalia australis* Br.-Bl. 1933 and two alliances were recognized: *Ammophilion arenariae* (Tüxen in Braun-Blanq. & Tüxen, 1952) Géhu 1986, for the Atlantic dune vegetation; and *Ammophilion australis* Br.-Bl. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez, Lousã, Diáz, Fernández-González & Costa 1990, for the Mediterranean and Mediterranean-Atlantic dune vegetation. The distinction at the alliance level between the specifically Atlantic and Mediterranean communities was introduced by Géhu (1986), and this showed how the Mediterranean communities form a group that is well distingushed from the pre-Pontic and Atlantic units, in that it is well characterised floristically (Géhu & Géhu-Franck, 1988). Within each alliance, the chain succession of the perennial formations that make up the dune system are defined at the suballiance level. This applies to both the Atlantic sector and the Mediterranean sector, where three suballiances are therefore defined: one that groups the halo-nitrophilous psammophilous vegetation of the parts of the embryonic dunes that are still influenced by the tides; one for the communities that make up the embryonic dunes; and one for the communities that colonise the mobile dunes. Bardat *et al*. (2004) followed the interpretation of Géhu (1986) and Géhu & Géhu-Franck (1988).

The syntaxonomic schemes proposed by Rivas-Martínez *et al*. (2002, 2011) included the perennial dune vegetation initially in the class *Ammophiletea* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946. Later they were included in the newly proposed class *Euphorbio paraliae-Ammophiletea australis* Géhu & Rivas-Martínez in Rivas-Martínez *et al*. 2011, on the basis that the class published by Géhu & Géhu-Franck (1988) was invalid according to Articles 5 and 8 of the ICPN. Within this class, Rivas-Martínez *et al*. (2011) defined the order *Ammophiletalia australis* Br.-Bl. 1933, with three alliances that include the psammophilous communities according to their ecological particularities. They recognized an alliance that includes the different communities of the embryonic dunes, *Honckenyo peploidis-Elytrigion boreoatlanticae* Tüxen in Br.-Bl. & Tüxen 1952 nom. inv. et nom. mut. in Rivas-Martínez *et al*. 2002. This alliance includes two suballiances, which are respectively characterised by the two geovicariant species of the genus *Elymus* (= *Elytrigia*): one of the Temperate and Mediterranean macrobioclimate with an Atlantic distribution, *Honckenyo peploidis-Elytrigienion boreoatlanticae* (Tüxen in Br.-Bl & Tüxen 1952) Rivas-Martínez 2011; and the other of the Mediterranean macrobioclimate with eastern Mediterranean distribution that reaches west to the north African coasts, *Elytrigienion junceae* Rivas-Martínez, Costa, Castroviejo & Valdés 1980. The second alliance defined by Rivas-Martínez *et al*. (2011) includes the vegetation that colonises the mobile dunes, the alliance *Ammophilion australis* Br.-Bl. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez, Lousã, Díaz, Fernández-González & Costa 1990. For this alliance, Rivas-Martínez *et al*. (2002, 2011) also defined two suballiances: *Ammophilenion australis* Rivas-Martínez & Géhu in Rivas-Martínez, Lousã, Díaz, Fernández-González & Costa 1990, for the communities dominated by *Ammophila australis* that develop along the Mediterranean coasts and reach up to the European Atlantic coasts as far as Galicia; and *Ammophilenion arenariae* (Tüxen ex Br.-Bl. & Tüxen 1952) Rivas-Martínez, Costa, Castroviejo & Valdés 1980, for the vegetation of the mobile dunes found along the Cantabrian coasts, up to the southern Baltic (Rivas-Martínez *et al*., 1980). Finally, there is the third alliance defined by Rivas-Martínez *et al*. (2011), *Sporobolion arenarii* (Géhu & Géhu-Franck ex Géhu & Biondi 1994) Rivas-Martínez & Cantó 2002, which includes the halo-nitrophilous communities of the Mediterranean salt-flat coastal dunes. On this basis, the ecological dimension, expressed as the alliance, has priority, while the biogeographical aspect is relegated to the subordinate level.

The classification proposed in the Vegetation Prodrome of Italy (Biondi *et al*., 2014) is obviously defined only for the Mediterranean communities. Within the vegetation class *Ammophiletea* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946, the order *Ammophiletalia australis* Br.-Bl. 1933 is recognized with two alliances that differentiate the communities of the mobile dunes: *Ammophilion australis* Br.-Bl. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez, Lousã, Diáz, Fernández-González & Costa 1990, for those of the embryonic dunes; and *Agropyro-Minuartion*

peploidis Tx. in Br.-Bl. & Tx. 1952. This latter alliance refers in effect to the formations of the embryonic dunes of the Atlantic coast, and in Biondi *et al*. (2014) it was used on a provisional basis.

Results

The classifications considered here highlight the different definitions in syntaxonomic terms, for which there is proposed a classification system of the plant communities that is consistent with what is stated in the presentation of the Vegetation Prodrome of Italy (Biondi *et al*., 2014). For some aspects, this follows the update of the concept of the plant associations (Biondi, 2011).

As far as the class is concerned, the proposal of Rivas-Martinez *et al*. (2011) is adopted, with the class *Euphorbio paraliae-Ammophiletea australis* Géhu & Rivas-Martínez in Rivas-Martínez *et al*. 2011 (including the *Honckenyo-Elymetea arenarii* Tüxen 1966) accepted here to include the vegetation of both the north Atlantic dune systems and those of the Mediterranean and thermo-Atlantic. On this basis, therefore, the subordinate syntaxa are recognized and defined according to specific assumptions.

In more detail, the order is assigned the role of the fundamental rank that includes the phytocoenoses according to the biogeographical macro-units of Region and Subregion (Rivas-Martínez, 2007). Indeed, this view allows the better definition and clustering of the plant communities into the lower hierarchical levels. In this way, the alliance can represent the hierarchical level on the basis of the ecological characteristics of the community, while the suballiance can represent the rank for which both the biogeographical and ecological features are more detailed.

On the basis of this, with reference to the Mediterranean dune vegetation, the order *Ammophiletalia australis* Br.-Bl. 1933, as it has been interpreted to date (Bardat *et al*. 2004; Rivas-Martinez *et al*., 2011), should be considered as *nomen ambiguum* because of the use of the subspecies epithet "*australis*", which must follow the interpretation of Braun-Blanquet (1933) that defines a Mediterranean order with thermo-Atlantic penetration. Instead, in the different classifications analysed, this order includes both Mediterranean and Atlantic communities, and also the north European ones.

Therefore, three distinct orders are proposed: the order *Elymetalia arenarii* Br.-Bl. & Tüxen 1943, for the perennial psammophilous vegetation of the Atlantic and north European dunes and two orders for the Mediterranea area, the order *Ammophiletalia australis* Br.-Bl. 1933, which includes the perennial dune communities of the Mediterranean and south Atlantic coasts and the order *Elymetalia gigantei* Vicherek 1971 for the Black Sea coasts and the Marmara Sea areas. Within the order *Ammophiletalia australis*, two alliances are recognized: *Ammophilion australis*, for the mobile dune and *Agropyrion juncei*, for the embryonic dune. The classification here defined at the level of alliance has already been recognized for a long time in the literature and is therefore kept unchanged. However, it is considered more suitable to cluster mainly the vegetation of the alliance *Agropyrion juncei* at the lower hierarchical level, as it is characterised by higher specific and phytocoenotic biodiversity. In contrast, these aspects are not found in the mobile dune communities, where in their more stable parts *Ammophila arenaria* gives origin to dense structures where the other psammophilous species of a smaller size cannot survive, which is also linked to the accumulation of the sand.

The vegetation of the Mediterranean mobile dunes has been included in the alliance *Ammophilion australis* Br.-Bl. 1933 em. Géhu & Géhu-Franck 1988, which was reported by Géhu & Géhu-Franck (1988), and not in the alliance *Ammophilion australis* Br.-B. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez *et al*. 1990, which is instead currently used in the recent classifications analysed. Indeed, as was defined in Rivas-Martínez *et al*. (1990), this latter syntaxon includes both the Mediterranean vegetation (*Ammophilenion arundinaceae*) and the Atlantic vegetation (*Ammophilenion arenariae*). The syntaxon reported by Géhu & Géhu-Franck (1988) included only the thermo-Atlantic and Mediterranean communities and for this reason it is the most suitable for the classification proposed here. Within this alliance two suballiances are recognized: the suballiance *Ammophilenion australis*, for the European thermo-Atlantic and Mediterranean coastal areas, except for the north African coasts, and the new suballiance *Sileno succulentae-Ammophilenion australis*, for the north African Mediterranean coast.

The vegetation that forms the embryonic dunes is included in the alliance *Agropyrion juncei* (R.Tüxen 1945 in Br.-Bl. & R.Tüxen 1952) Géhu, Rivas-Martínez & R. Tüxen 1972 in Géhu *et al*. 1984, within which four suballiances are recognized that include and subdivide the communities in ecological and biogeographical terms. The suballiance *typicum* is *Sporobolenion arenarii* Géhu ex Biondi & Galdenzi suball. nova *hoc loco*. This syntaxon was not published in a valid form (according to Articles 5 and 8) by Géhu (1986), although it is proposed again here, in accordance with the ICPN rules, through the definition of the holotypus: the association *Sporobolo arenarii-Agropyretum juncei* (Br.-Bl. 1933, Géhu, Rivas-Martínez & R. Tüxen 1972) Géhu in Géhu, Costa, Scoppola, Biondi, Marchiori, Peris, Franck, Caniglia & Veri 1984, which was also the holotypus of the alliance *Agropyrion juncei*. The communities with *Sporobolus arenarius* included

in this suballiance define the structure of the embryonic dunes, making up the vegetation of the first parts of the sand dune systems that are still influenced by the waves, for all of the sandy coasts of the Mediterranean.

The suballiance *Elymo farcti-Otanthenion maritimi* suball. nova hoc loco also covers a structural role, as it is found in the Mediterranean sand dune systems where it develops on the highest parts of the embryonic dunes, which for the larger systems tend to be more stable. This is due to the high levels of *Otanthus maritimus*, which characterises this new syntaxon. The other two suballiances included in the alliance *Agropyrion juncei* define instead the synchorology of the embryonic dunes and are among their geosynvicariants: the suballiance *Agropyrenion juncei* Rivas-Martínez, Costa, Castroviejo & Valdés 1980, which includes the European psammophilous communities from the Iberian Peninsula to the Balkan one up to the Pontic Region except for the Crete and Cyprus Islands; and the suballiance *Sileno succulentae-Elymenion farcti* suball. nova *hoc loco*, of the embryonic dune vegetation along the north African coast. The former suballiance includes the association *Echinophoro spinosae-Elymetum farcti*, wich was described and reported by Géhu (1986) in an invalid way (Article 3f; Géhu, 1986). According to the ICPN rules, this syntaxon is here validated through the indication of the holotypus (holotypus: relevé 14 in Table 2 for Géhu *et al*., 1987).

Finally, the order *Elymetalia gigantei* with the alliance *Elymion gigantei* Morariu 1957 are recognized for the sandy coasts of the Pontic sector and specifically for the Black Sea coasts and the Marmara Sea areas (Géhu & Uslu, 1989; Tzonev *et al*., 2005, 2009; Kavgaci, 2007; Făgaras, 2013).

Syntaxonomical scheme

For the syntaxonomic scheme, for each syntaxon and succession, the information and the rules are followed as already applied in the Vegetation Prodrome of Italy (Biondi *et al*., 2014).

Cl.: ***EUPHORBIO PARALIAE-AMMOPHILETEA AUSTRALIS*** Géhu & Rivas-Martínez in Rivas-Martínez, Asensi, Díaz-Garretas, Molero, Valle, Cano, Costa & Díaz 2011

[*Euphorbio-Ammophiletea arundinacea*e Géhu & Géhu-Franck 1988 (art. 5, 8), *Ammophiletea arenariae sensu*. auct. non Br.-Bl. & Tüxen ex Westhoff, Dijk, Passchier & Sissingh 1946, quod est: *Honckenyo-Elymetea arenariae* Tüxen 1966].

Holotypus: *Ammophiletalia australis* Br.-Bl. 1933

Diagnostic species: *Ammophila arenaria* (L.) Link subsp. *australis* (Mabille) Lainz [= *A. arenaria* (L.) Link subsp. *arundinacea* H. Lindb., *A. littoralis* (Beauv.) Rothm., *Arundo arenaria* L.], *Anthemis maritime* L., *Cyperus capitatus* Vand. [= *C. kalli* (Forssk.) Murb., *C. kallii* (Forssk.) Murb., *C. mucronatus* (L.) Mabille, non Steud. 1854, nom. illeg.], *Euphorbia paralias* L., *Lotus creticus* L., *Medicago marina* L., *Pancratium maritimum* L. and *Polygonum maritimum* L..

Short description: Psammophilous perennial vegetation from the coastal sandy and fine-pebbly dunes, with a Mediterranean, thermo-Atlantic and Macaronesian coastal distribution, which is important in the dune construction and stabilisation processes.

Ord.: *AMMOPHILETALIA AUSTRALIS* Br.-Bl. 1933

[*Ammophiletalia* Br.-Bl. 1931 (Article 2b), *Elymetalia arenarii* Br.-Bl. & Tüxen 1943 (art. 8), *Elymo-Ammophiletalia arenariae* Géhu-Franck 1969, *Euphorbio-Ammophiletalia* Géhu & Géhu-Franck 1969 (syntax. syn.)].

Holotypus: *Ammophilion australis* Braun-Blanquet 1933 em. Géhu & Géhu-Franck 1988.

Diagnostic species: *Ammophila arenaria* subsp. *australis*, *Echinophora spinosa* L. and *Sporobolus arenarius* (Gouan) Duval-Jouve [= *S. pungens* (Schreber) Kunth, no *S. virginicus* Kunth].

Short description: Perennial herbaceous vegetation typical of the forward beach areas and the embryonic and mobile dunes, distributed in the Mediterranean coastal areas, with extensions into the European thermo-Atlantic areas.

All.: **Ammophilion australis** Braun-Blanquet 1933 em. Géhu & Géhu-Franck 1988

[*Ammophilion littori-arenariae* Br.-Bl. 1921 (art. 43), *Ammophilion* Br.-Bl. 1931 nom. nud. (art. 2b, 8), *Ammophilion* Br.-Bl. 1933 nom. ambig. (art. 36) p.p., *Ammophilion borealis* Tüxen in Br.-Bl. & Tüxen 1952 (syntax. syn.), *Euphorbio-Ammophilion arenariae* Géhu & Géhu-Franck 1969 (syntax. syn.), *Ammophilion arundinacea*e Br.-Bl. 1921 corr. Rivas-Martínez, Costa, Castroviejo & Valdés Berm. 1980 (art. 43) p.p., *Ammophilion arundinacea*e Braun-Blanquet 1933 em. Géhu & Géhu-Franck 1988 (art. 43), *Ammophilion australis* Braun-Blanq. 1921 corr. Rivas Mart., M.J.Costa & Izco in Rivas Mart., Lousã, T.E.Diáz, Fern.-Gonz. & J.C.Costa 1990 p.p. (syntax. syn.)].

Holotypus: *Medicagini marinae-Ammophiletum australis* Br.-Bl. 1933

Diagnostic species: *Ammophila arenaria* subsp. *australis*, *Echinophora spinosa, Euphorbia paralias, Pancratium maritimum* and *Launaea resedifolia* (L.) Kuntze [= *Podospermum laciniatum* (L.) DC. subsp. *decumbens* (Guss.) Gemeinholzer & Greuter].

Short description: Psammophilous perennial herbaceous communities that colonise the mobile dunes in the Mediterranean and European thermo-Atlantic coastal areas.

Suball.: ***Ammophilenion australis*** (Br.-Bl. 1921) Rivas-Martínez & Géhu in Rivas-Martínez, Lousã, Díaz, Fernández-González & Costa 1990
[*Ammophilenion arundinacea*e Rivas-Martínez, Costa, Castroviejo & E. Valdés 1980 (art. 27a, 28), *Medicagini-Ammophilenion arundinacea*e (Braun-Blanq. 1921) Géhu & Biondi 1994 nom. illeg.(art. 29, 43)]
Holotypus: The same as the alliance.
Diagnostic species: The same as the alliance.
Short description: Psammophilous perennial herbaceous communities that colonise the mobile dunes in the European thermo-Atlantic and Mediterranean coastal areas except for the north African coast.

Suball.: ***Sileno succulentae-Ammophilenion australis*** suball. nova *hoc loco*
Holotypus: *Sileno succulenthae-Ammophiletum arundinacea*e (Burollet 1927) Géhu et Géhu- Franck 1986 [Syn. *Ammophiletum arundinacea*e Br-Bl. (1921) 1933 race géographyque sud orientale à Silene succulent Vander Berghn 1977] in Géhu & Gèhu-Franck (1986)
Diagnostic species: *Ammophila arenaria* subsp. *australis*, *Silene succulent* Forssk., *Ipomaea stolonifera* (Cyr.) Gmelin, *Lotus polyphyllos* Clarke, *L. creticus* and *Zygophyllum album* L..
Short description: Psammophilous perennial herbaceous communities that colonise the mobile dunes in the north African coast.

All.: **Agropyrion juncei** (R.Tüxen 1945 in Br.-Bl. & R.Tüxen 1952) Géhu, Rivas-Martínez & R. Tüxen 1972 in Géhu, Costa, Scoppola, Biondi, Marchiori, Peris, Franck, Caniglia & Veri 1984
[*Sporobolion arenarii* (Géhu & Géhu-Franck ex Géhu & Biondi 1994) Rivas-Martínez & Cantó in Rivas-Martínez *et al*. 2002 (syntax. syn.)].
Holotypus: *Sporobolo arenarii-Agropyretum juncei* (Br.-Bl. 1933, Géhu, Rivas-Martínez & R. Tüxen 1972) Géhu in Géhu, Costa, Scoppola, Biondi, Marchiori, Peris, Franck, Caniglia & Veri 1984.
Diagnostic species: *Elymus farctus* (Viv.) Runemark ex Melderis subsp. *farctus* [= *Agropyron junceum* (L.) Beauv, *Agropyron junceum* (L.) Beauv. subsp. *mediterraneum* Simonet & Guinochet *sensu* Pignatti, *Elytrigia juncea* (L.) Nevski, *E. mediterranea* (Simonet) Prokudin], *Sporobolus arenarius*, *Echinophora spinosa, Otanthus maritimus* (L.) Hoffmanns. & Link [= *Diotis candidissima* Desf., nom. illeg., *Diotis maritima* (L.) Cass., *Filago maritima* L.], *Calystegia soldanella* (L.) R.Br., *Medicago marina, Anthemis maritima, Cyperus capitatus* and *Silene succulenta* subsp. *corsica* (DC.) Nyman.
Short description: Psammophilous perennial herbaceous communities that colonise the embryonic dunes in the Mediterranean and European thermo-Atlantic coastal areas.

Suball.: ***Sporobolenion arenarii*** Géhu ex Biondi & Galdenzi suball. nova hoc loco
[*Sporobolenion arenarii* Géhu 1986 nom. inval. (art. 5, 8), *Sporobolenion arenarii* Géhu & Géhu-Franck ex Géhu & Biondi 1994 non Rothmaler 1943 (art. 27a), Incl.: *Sporobolion arenarii* (Géhu & Géhu-Franck ex Géhu & Biondi 1994) Rivas-Martínez & Cantó 2002].
Holotypus: The same as the alliance.
Diagnostic species: *Sporobolus arenarius*, *Polygonum maritimum, Ipomoea stolonifera*.
Short description: Halo-nitrophilous perennial herbaceous communities that occur in the first parts of the meso- and thermo-Mediterranean sand dune systems that are characterised by *Sporobolus arenarius*, which colonises the lower parts of the embryonic dunes that are regularly reached by the sea.

Suball.: ***Elymo farcti-Otanthenion maritimi*** suball. nova *hoc loco*.
Holotypus: *Elymo farcti-Otanthetum maritimi* ass. nova
Diagnostic species: *Otanthus maritimus, Pancratium maritimum, Medicago marina, Euphorbia paralias, Ipomoea stolonifera* and *Silene succulenta* subsp. *corsica*.
Short description: Psammophilous plant communities that are physiognomically dominated by *Otanthus maritimus*, which occur on the inner parts of the embryonic dunes that are characterised by reduced mobility of the sandy substrate.

Ass.: *Elymo farcti-Otanthetum maritimi* Géhu ex Biondi & Galdenzi ass. nova *hoc loco*
[*Echinophoro spinosae-Elymetum farcti* Géhu ex Biondi & Galdenzi 2014 subass. *otanthetosum* Géhu e Biondi 1994 (corresp. name)].
Holotypus: Relevé 44 in Table 4 of Géhu & Biondi 1994.
Diagnostic species: *Otanthus maritimus*.
Short description: Communities that occur on the inner parts of the embryonic dunes where the plants have reduced the mobility of the dunes. Under these conditions, *Otanthus maritimus* dominates over other psammophilous species, which are consequently less numerous.

Suball.: ***Agropyrenion farcti*** Rivas-Martínez, Costa, Castroviejo & Valdés 1980
[Incl: *Echinophoro spinosae-Elymetum farcti* Géhu 1986 nom. inval. (art. 3f)]
Holotypus: *Cypero mucronati-Elytrigietum junceae* Br.-Bl. 1933.
Diagnostic species: *Elymus farctus, Lotus creticus, L. cytisoides, Cyperus mucronatus, Echinophora spino-*

sa, Calystegia soldanella.
Short description: Psammophilous embryonic dune communities that occur in European Mediterranean area from the Iberian Peninsula to the Balkan Peninsula up to the Pontic Region except for the Crete and Cyprus Islands.

Ass.: *Echinophoro spinosae-Elymetum farcti* Géhu ex Biondi & Galdenzi ass. nova hoc loco.
Validated name: *Echinophoro spinosae-Elymetum farcti* Géhu 1986 nom. inval. (art. 3f).
Holotypus: Relevé 14 in Table 2 of Géhu *et al*., 1987.
Diagnostic species: *Echinophora spinosa* and *Elymus farctus*.
Short description: Communities of the central Mediterranean embryonic dunes. association is distributed over a wide area of Mediterraneeo European, from the central to the eastern area until the Pontic ex the islands of Crete and Cyprus.

Suball.: ***Sileno succulentae-Elymenion farcti*** suball. nova *hoc loco*.
Holotypus: *Sileno succulentae-Elymetum farcti* (Burollet 1927) Géhu & Géhu-Franck 1986.
Diagnostic species: *Silene succulenta* Forssk. subsp. *succulenta, Lotus polyphyllus* E.D.Clarke, *Zygophyllum album* and *Alhagi graecorum* Boiss.
Short description: Psammophilous communities that occur on embryonic dunes along the coasts of central and eastern Mediterranean south region, from the Crete and Cyprus islands up to the coasts of Tunis, Egypt and Sinai (Géhu *et al*. 1984; Géhu, Costa & Uslu, 1992; Géhu & Géhu-Franck, 1986, 1992; Géhu *et al*., 1992).

Order: ***ELYMETALIA GIGANTEI*** Vicherek 1971
Short description: Psammofilous perennial grass of the Pontic sectors and specifically of the Black Sea coast and the Marmara Sea areas.

All.: **Elymion gigantei** Morariu 1957
Diagnostic species: *Leymus racemosus* subsp. *sabulosus* (M. Bieb.) Tzvelev, *Convolvolus persicus* L., *Argusia sibirica* (L.) Dandy Show, *Lagedium tataricum* (L.) Soják, *Centaurea arenaria* Bieb., *Elymus farctus* subsp. *bessarabicus* (Savul. & Rayss) Melderis, *Silene thymifolia* Sm., *Medicago marina, Stachys maritime Gouan, Eryngium maritimum* and *Cynanchum acutum* L..
Short description: Psammophilous communities of the Pontic dunes.

Order: ***ELYMETALIA ARENARII*** Br.-Bl. & Tüxen 1943
[*Elymetalia arenarii* Fröde 1958 (art. 31), *Elymo-Ammophiletalia arenariae* Géhu-Franck 1969 (syntax. syn.)].
Holotypus: *Honckenyo latifoliae-Elymion arenarii* (Christiansen 1927) Géhu & Géhu-Franck 1988.
Diagnostic species: *Ammophila arenaria* (L.) Link subsp. *arenaria*.
Short description: Perennial herbaceous vegetation that is typical of the forward beach areas and of embryonic and mobile dunes, and is distributed in the north-European Atlantic coastal areas.

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The 3rd Italian Report under art.17 of the Habitats Directive for plants: main outcomes with a focus on Adriatic coastal species

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Abstract
The Article 17 of the Habitats Directive (HD) requires that every six years Member States of the European Union report on implementation of the directive, including the assessment of the conservation status of the species and habitats of community interest recorded in the whole national territory. The 3rd Italian National Report (reporting period 2007-2012) was completed in 2013. A summary of data requested, assessment methodology and main outcomes for plant species is presented. The results show a negative status for half of the Italian plant taxa listed under HD. Critical conditions of species living in coastal areas, particularly vulnerable to human pressures, are confirmed, with unfavourable conservation status in 85% of cases. In addition for these species inadequate future prospects and decreasing trend can be expected. In this paper a survey of the status of the HD Adriatic coastal species (*Stipa veneta* Moraldo, *Centaurea kartschiana* Scop., *Salicornia veneta* Pignatti & Lausi, *Kosteletzkya pentacarpos* (L.) Ledeb.) is presented.

Key words: flora of community interest, conservation status, Directive 92/43/EEC.

Introduction

The Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora, known as the Habitats Directive (HD), aims to maintain or restore natural habitats and wild species listed on the Annexes I, II, IV and V at a favourable conservation status. For some of the habitat types and species Europe has a priority interest, meaning a particular responsibility for their protection in view of the proportion of their natural range which falls within the European territory of the Member States.

In order to evaluate the effectiveness of measures taken by Member States under HD, Article 11 requires to monitor the habitats and species, while Article 17 requires to report about status and trends referring to the whole territory of each Member State, not only to the Natura 2000 Network. A National Report must be sent to the European Commission and made accessible to the public every six year. The HD also demands that the European Commission then produce a consolidated EU Composite Report based on the national reports. With the aim to facilitate aggregation and comparisons between Member States, assessment and reporting must follow standard methodology and format.

The 3rd Italian National Report (reporting period 2007-2012) was completed in December 2013 through a collaborative work between the Ministry of the Environment, the Institute for Environmental Protection and Research, Regions, Autonomous Provinces, the main national scientific societies and several experts. The Report (Genovesi *et al*., 2014) and all data are accessible on the ISPRA website (www.sinanet.isprambiente.it/Reporting_Dir_Habitat). Database and assessments produced by all Member States are freely available at the Central Data Repository (http://bd.eionet.europa.eu/activities/Reporting/Article_17).

In the present work a survey on the 3rd Italian reporting process for plant species is presented. Data requested, methodology and some results are briefly analyzed. A special focus on the Adriatic littoral species protected under HD is proposed, with particular attention to distribution, habitat preference, threats and conservation status.

Materials and methods

The standard methodology for reporting under Article 17 attempts to ensure that Member States produce comparable results, in order to enable a better compilation and analysis of the data received at EU-level. Accurate information regarding the standard methodology can be found in the European guidelines (Evans & Arvela, 2011). A summary of the Italian reporting process for plant species is here briefly presented. More detailed information on the sources, methods and results, can be found in the specific chapter in the Italian national report (Ercole & Giacanelli, 2014).

The reporting format requires a separate analysis and assessment for each species in each biogeographical

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region of presence. Distribution and range maps have to be developed at national scale using a standard 10x10 km grid (projection ETRS LAEA 5210). For the estimation of the range a specific tool is provided by the European Commission; ranges of plants were calculated using different gap values in accordance to their various geographical and ecological features.

The reporting on plant taxa was based on the most up-dated information available, consisting in both published and unpublished sources such as checklists, atlas, etc., as well as specialized literature. Data from Regions and Autonomous Provinces were also gathered, with the technical coordination of ISPRA. An additional source of information derived from the project for the Red List of the Italian flora, carried out by the Italian Botanical Society (Rossi *et al*., 2013a; 2013b). Moreover, for a set of 44 species, a significant contribution came from regional flora experts who were involved in the work.

The methodology requires a large amount of information (quantitative data and/or estimates) on specific parameters (range, populations, habitat for the species, threats) and the evaluation of Favourable Reference Values (FRV). It is required to identify threshold values (FRRange and FRPopulation) to determine if the parameter is in a favourable or unfavourable status. Determining these values is not easy. At present quantitative data for FRV are still lacking and the comparison between FRV and current situation was made, as allowed by the guidelines, on the basis of the experts judgment.

With regard to population, an estimation of the number of individuals is primarily requested, even if alternative units are allowed. In this reporting for 29 plant species the number of individuals could be provided; number of localities were chosen as alternative unit for 22 taxa and number of grid cells in the remnant cases. The parameter "habitat for the species", as defined in Art.1 of HD ("an environment defined by specific abiotic or biotic factors, in which the species lives at any stage of its biological cycle") is one of the four parameters used to assess conservation status. The reporting format asks for the area occupied in kmq, information that is currently lacking for plant taxa; thus only the fields concerning habitat quality and trend were filled. It should be remind that the reporting system does not require any indication about ecology and habitat type. For each species pressures (factors acting now or have been acting in the last 6 years) and threats (future/foreseeable impacts affecting the long term viability of the species) selected from a hierarchical list were provided.

The conservation status (CS) takes into account the state of range, population, habitat for the species and future perspectives, evaluated considering the likely future status and trends, dependent on threats (negative influence) and, on the other hand, on conservation measures (potential positive influence). The CS must be expressed through one of the following categories: favourable (the species can be expected to prosper without any change to existing management or policies); unfavourable-inadequate (a change in management or policy is required to return the species to favourable conditions, but there is no danger of extinction in the foreseeable future); unfavourable-bad (for species in serious danger of becoming extinct, at least regionally); unknown.

With the aim to focus attention on the Adriatic coasts the list of plant species reported for Italy was first analyzed to identify the typically coastal taxa. Selected species must have distribution restricted (or largely so) to coastal ecosystems, particularly dunes, salt marshes and coastal lagoons, cliffs and rocky slopes under salt spray. Within this subset, attention was then focused on species of the Adriatic coasts. A synthesis of habitat preference, major impacts and CS was elaborated on the basis of reporting results and other published sources.

Results

The 3rd Report for flora was conducted for 107 taxa (96 vascular, 10 bryophytes, 1 lichen). In fact, of the 113 plants of the official list for Italy, 4 were recently signed as Not-Present in our territory (A*splenium hemionitis* L., Centranthus trinervis (Viv.) Bég., *Colchicum corsicum* Baker, *Myosotis rehsteineri* Wartm.) and 2 as extinct, *Aldrovanda vesiculosa* L. and *Caldesia parnassifolia* (Bassi ex L.) Parl., respectively RE(Ex) and CR(PEx) (Rossi *et al*., 2013a). Distribution patterns vary from wide, to very narrow and punctiform: 49 species are restricted to only 1 of the Italian Regions, 11 of which occur in only 1 grid cell. 50% of all CS-assessments resulted unfavourable (inadequate or bad) and the percentage grows to 65% if only species on Annex II are considered. These percentages are also reflected in the future perspectives.

Among the Italian HD plant taxa, 27 (26 vascular, 1 bryophyte) grow in coastal ecosystems, such as sand dunes, salt marshes and lagoons, garrigues and thermomediterranean scrublands, coastal cliffs. Some of these species have their optimal habitat and main distribution in coastal areas, but can also grow in inland sites (e.g. *Campanula sabatia* De Not. and *Dianthus rupicola* Biv.). Most of them refer to the Mediterranean Bioregion (see figure 1), with the highest number (19 species) in Sicilia, Sardegna and small islands (Egadi, Eolie, Pelagie, Maddalena Archipelago, Asinara, San Pietro). Peninsular coasts facing Tyrrenian Sea host 1 species in Liguria and 3 along the southern Tyrrenian coastline. Only 4 species refer to Continental Bioregion, growing along the northern part of Adriatic

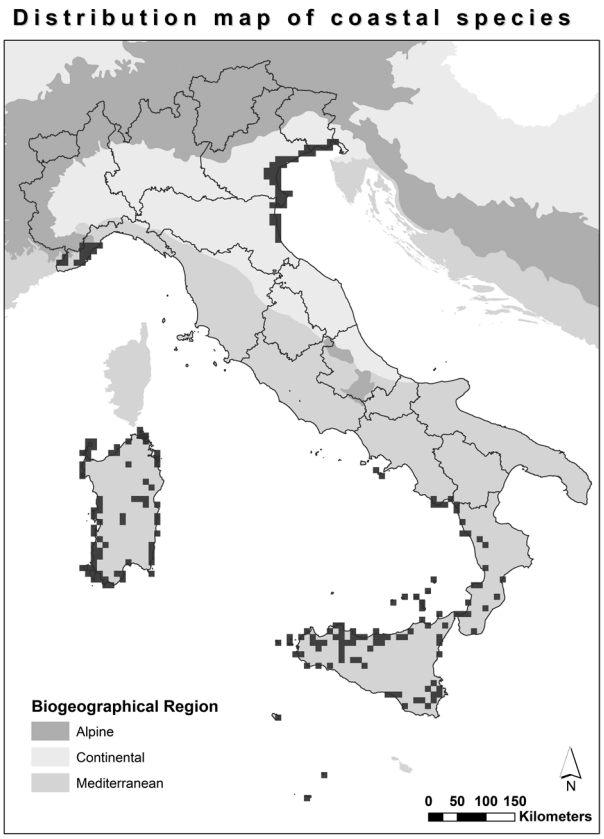

Fig. 1 - Distribution of the 27 plant taxa of community interest (Ann. II, IV, V Dir. 92/43/CEE) living in coastal ecosystems (10x10Km grid cells).

Sea, from Emilia Romagna to Friuli Venezia Giulia.

HD species of coastal ecosystems show a particularly high rate of endemism (78%): 17 species are exclusive of our territory, 3 Sardo-Corsican endemic and 1 species is restricted to Linosa Island (Sicily) and Malta (Peruzzi *et al*., 2014). Many of them have very localized and punctiform distribution. CS-assessments for coastal species resulted unfavourable in 23 cases (85%), 20 of which inadequate and 3 bad. Even more a future decreasing of the CS seems to be predictable for 19 of them.

The situation is not better also considering the only 4 Adriatic coastal species. These four species of Annex II grow in different habitat: *Stipa veneta* Moraldo is an endemic species of priority interest typical of grey dunes of Veneto and Friuli Venezia Giulia; *Centaurea kartschiana* Scop. is a restricted endemite of the coastal cliffs near Trieste; *Salicornia veneta* Pignatti & Lausi, species of priority interest, and *Kosteletzkya pentacarpos* (L.) Ledeb. live in lagoons and salt marshes, the latter with a broader distribution also outside the Italian boundaries.

In the following, a survey of the status of these species is presented.

Stipa veneta grows in the grassland open communities of the grey dunes referring to the association *Teucrio capitati-Chrysopogonetum grylli* Sburlino, Buffa, Filesi et Gamper 2008 (order *Scorzonero-Chrysopogonetalia* Horvatić et Horvat in Horvatić 1958) (Sburlino *et al*., 2008, 2013). It is endemic to northeast Italy (Veneto and Friuli Venezia Giulia coasts), where it occurs in few, severely fragmented locations (Fig. 2). The CS of *Stipa veneta*, assessed in the context of the reporting, is unfavourable-bad, mainly due to limited population size and bad status of its habitat. The trends of range, population and habitat for the species are decreasing, especially because of the degradation of the sandy coastal habitats in the northern Adriatic and the strong contraction of the distribution area. However, natural fires of the wood helped this species to expand one of its population to over thousands of individuals (Lignano-Udine). *Stipa veneta* is threatened by habitat loss and degradation, tourism, invasive non-native species, but also by species composition change (succession).

Centaurea kartschiana is a very local endemic, restricted to limestone coastal cliffs between Duino and Aurisina near Trieste (Fig. 3), growing in the communities of the association *Campanulo-Centaureetum kartschianae* Lausi et Poldini 1962. Its habitat occupies few meter between the shore and cliffs with subalophilous species and the sunny rocky vegetations with *Euphorbia wulfenii* Hoppe. *Centaurea kartschiana* lives in an endemic-rich habitat, which has been proposed as an independent habitat for the inclusion in HD Annex I (Poldini *et al*., 2007). The distribution map in figure 3 shows the extremely narrow distribution of the species (only 1 grid cell 10x10Km), reported in few locations with an estimated population of 200-250 individuals (Aa.Vv., 2010).

The current CS of *Centaurea kartschiana*, assessed in the frame of Article 17 methodology, is unfavourable-inadequate, but with a stable trend. The species grows on cliffs and rocks and is mainly threatened by

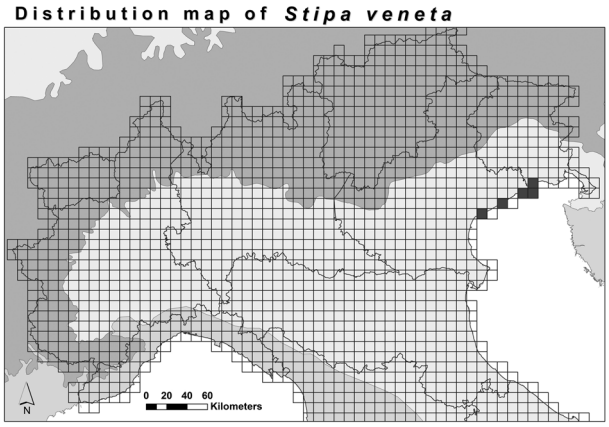

Fig. 2 - *Stipa veneta* Moraldo, endemic species of priority interest (Adriatic coasts: VEN, FVG).

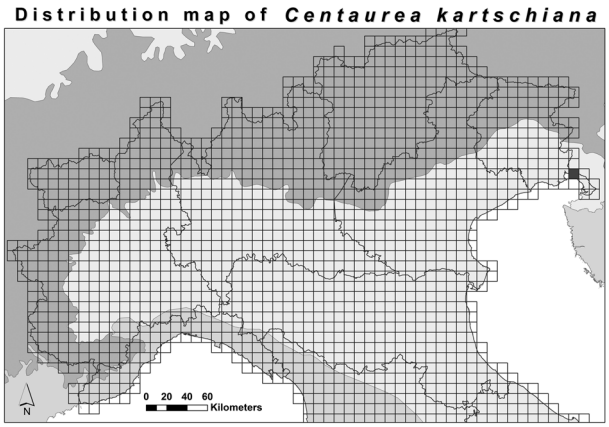

Fig. 3 - *Centaurea kartschiana* Scop., endemic species (Adriatic coasts: FVG).

impacts from leisure activities and tourism. Nevertheless it seems to be able to colonize also disturbed habitats showing an apophytic behavior.

Salicornia veneta, described for the Venice lagoon (Lausi, 1969), is a doubt species inside the group of *Salicornia procumbens* Sm. in Sowerby subsp. *procumbens* (Šajna *et al*., 2013). Previously recorded also for Slovenia and Croatia, the species was in the last years excluded from both of the countries (Kaligarič *et al*., 2008; Šajna *et al*., 2013). In Italy *Salicornia veneta* is manly distributed from Emilia Romagna to Friuli-Venezia Giulia (interesting 40 grid cells of the Continental Bioregion, Fig. 4) with a disjunction of one locality (1 grid cell in the Mediterranean Bioregion) in centre-western Sardinia in S'Ena Arrubia lagoon (Conti *et al*., 2005; Arrigoni, 2006; Filigheddu *et al*., 2000).

Lausi (1969) in the original description of the species noted that "seems ecologically restricted on the muddy and lower parts of the clayey banks of the lagoon called barene". In addition the species can live in wet brackish environments, on muddy beaches and salt marshes, without long desiccation period, and often in contact with *Spartina maritima* swords. The species gives name to the association *Salicornietum venetae* Pignatti 1966. The assessment of *Salicornia veneta* resulted in a favourable CS with stable trend. Main future threats can derive from drainage activities and modifications of water quality and salinity.

Kosteletzkya pentacarpos lives in the coastal lagoons, brackish and fresh water marches, on the banks of streams and other wetlands. The global area of distribution of the species goes from eastern Spain to SW-Russia (Nogueira & Paiva, 1993). In Italy the species is currently present in six sites along the coast of Veneto (Cavallino-Treporti, Venice, Po-Valle Cannelle, Caorle lagoon) and in one site recently discovered in Emilia Romagna (Po di Volano, Ferrara) with a population of 15 individuals (Ercole *et al*., 2013); all sites fall within 5 grid cells 10x10Km (Fig. 5).

The results of the 3rd report for *Kosteletzkya pentacarpos* indicate an inadequate CS in Continental Region with inadequate future prospects and decreasing trends. The report has also highlighted the extinction of the species from the Italian Mediterranean Region, because it has been no longer found in Toscana, Lazio, Campania and Puglia (Tomei & Pistolesi, 1980; Tomei *et al*., 1985; Tomei & Guazzi, 1993; Motti & Ricciardi,

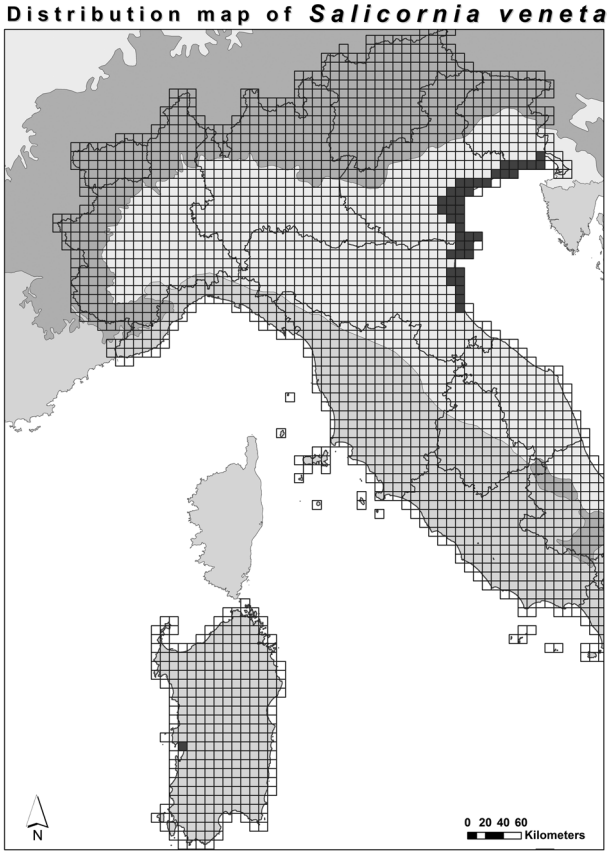

Fig. 4 - *Salicornia veneta* Pignatti & Lausi, species of priority interest (Adriatic coasts from EMR to FVG; SAR).

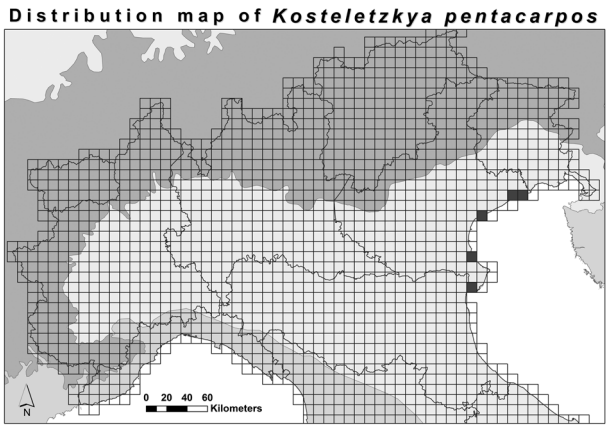

Fig. 5 - *Kosteletzkya pentacarpos* (L.) Ledeb. (Adriatic coasts: EMR, VEN).

2005; Ercole *et al*., 2013). In fact many populations of *Kosteletzkya pentacarpos* reported in '800 and in the first decades of the '900 (Bientina di Pietrasanta, Piana Pontina, Fogliano, Monaci, Caprolace, Fusaro and Licola lakes) disappeared. Afterwards, in the past few decades, it has not been found even in the more recent sites of presence (Mesola woods, Fondi and Lesina lakes). The species is threatened mostly by land reclamation and drying out, management of vegetation and invasion of alien species. Agricultural intensification, abstractions from groundwater and pollution of surface waters are also regarded as threats.

Conclusion

The 3rd Italian Report under Article 17 of the Habitats Directive reveals rather negative assessment for our flora of community interest. The overall results indicate a negative conservation status for about half of all plants and the situation is worse for coastal species, 85% of which are in inadequate or bad conditions.

In Italy the high number of HD plant species, combined with the particularly elevated rate of endemism (about 50%) underlines a special responsibility of our country in terms of protection of plant biodiversity of the European Union. Coastal species, with a rate of endemism of 78%, are particularly significant in this regard.

Despite advances in terms of knowledge during the last decades, a certain heterogeneity in different areas of our territory remains and there are still information gaps and lack of data for some parameters requested by the Directive (i.e. number of individuals, short and long-term trends). Future research activities and monitoring programs would be essential to fill these gaps and to address some key aspects of the reporting method such as favourable reference values and habitat for the species.

The severe level of pressures affecting our country (habitat fragmentation, inadequate agricultural and forestry practices, urbanization, drainage and other ecosystem modifications caused by man) stresses as well the application of strict conservation measures and the importance of ensuring adequate monitoring activities, focusing on the species and habitats in most critical conditions, like those of coastal ecosystems.

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PLANT SOCIOLOGY

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 Marzialetti 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

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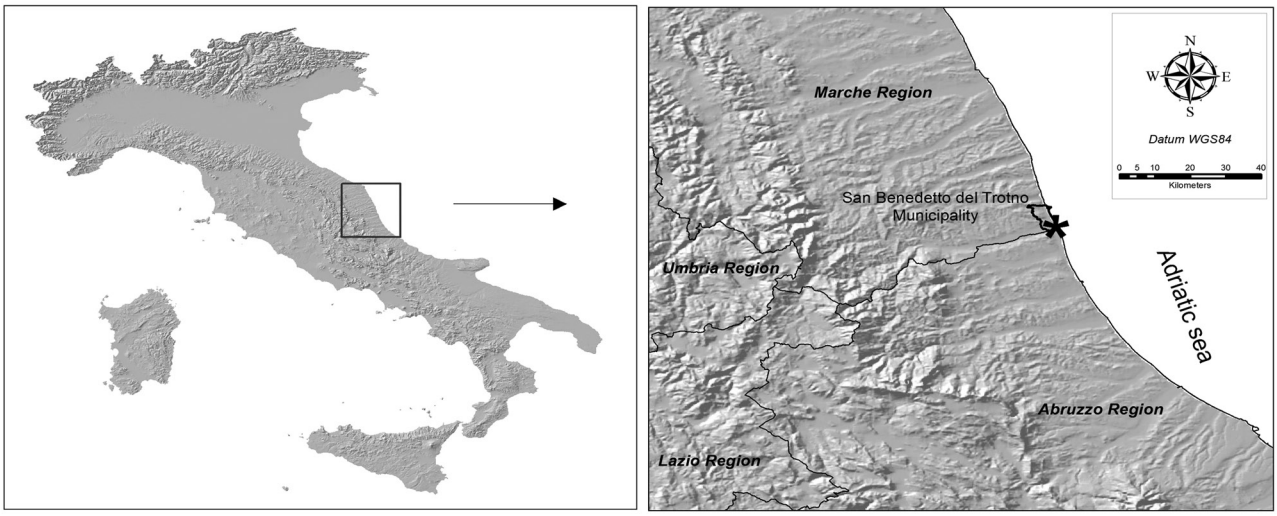

Fig. 1 - Map showing the study area: the 'Sentina' Regional Natural Reserve.

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

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 corrispond to the information on the presence of the plant species considered.

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. 3 - Detail of the territory of the 'Sentina' Regional Natural Reserve illustrating the presence of *Artemisia caerulescens* subsp. *caerulescens* **(+)** and the corrisponding 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).

CRYPSIS 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.

CRYPSIS 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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The Kentish plover (*Charadrius alexandrinus*) and the preservation of the dune environment on the coast of Senigallia and Montemarciano (Central Italy): activities carried out and future

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Abstract
In the Marche region (Central Italy) the Kentish plover (*Charadrius alexandrinus*) is considered as a breeding, migratory and irregular wintering species. In Senigallia it breeds in three different areas: Cesano e Cesanella (North litoral) and Marzocca (South litoral). Since 2009 is regularly carried out the monitoring of Kentish plover along the coast of Senigallia and Montemarciano, where since 2011 there are some breeding pairs. In collaboration with local governments over the last four years have taken some conservation strategies for the protection of the breeding population that also affect the dune habitat protection. In the study period there was an increase in the number of breeding pairs and a strong increase in the number of young fledged (96.6%). The trend shows that we moved from 10-12 pairs in 2009 to 21-22 in 2012 and 2013. Compared to 2008 (8 nests) there was an increase of 72.4% of the nests found. In many cases along the coast south of Marzocca, have been selected as a place of deposition, the roofs of bathing.

Key words: *Charadrius alexandrinus*, dune environment, Montemarciano, preservation, Senigallia.

Introduction

In Marche region (Central Italy) the Kentish plover (*Charadrius alexandrinus*) is considered as a breeding, migratory and irregular wintering species (Giacchini 2003, 2007). Actually it is resident all year around only along the seacoasts of Senigallia and Fermo, where the largest number of pairs breeds (Fusari *et al*., 2011, Morganti *et al*., 2009). In Senigallia it breeds in three different areas: Cesano e Cesanella (North litoral) and Marzocca (South litoral), that are characterized by the presence of sparse psammophilous vegetation, materials drift to the beach by sea storms and ditches and remittances of boats (Morganti *et al*. 2009) (Figure 1,2,3). In addition to this area, in 2012 we found breeding pairs also in an abandoned industrial area (called Veco) (Mencarelli *et al*., 2013).

Materials and methods

Since 2009 is regularly carried out the monitoring of Kentish plover along the coast of Senigallia and Montemarciano, where since 2011 there are some breeding pairs. The study area includes coasts characterized by formation of herbaceous annual vegetation of drift lines (vegetation terofitica-alonitrofila), as *Cakile maritima* and *Salsola kali* (*Salsolo kali-Cakiletum maritimae* community) and perennial psammophilous species of embryonic dunes as *Calystegia soldanella, Echinophora spinosa, Elymus farctus, Eryngium maritimum, Medicago marina, Pancratium maritimum, Spartina versicolor* (*Echinophoro spinosae-Elymetum farcti* community). There are also present *Euphorbia peplis* and *Cutandia maritima*. There are also non-native species *Xanthium italicum, Cenchrus incertus, Ambrosia coronopifolia* and *Oenothera* sp. pl.. Along the lines more established are found therophytes species as *Silene colorata, Vulpia membranacea* and *Lagurus ovatus* (*Sileno coloratae-Vulpietum membranaceae* community). The vegetation of sandy soil with gravel and pebbles, is characterized by the presence of

Fig. 1 - Example of vegetation in the study area.

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Fig. 2 - A Kentish plover breeds on the dunes with psammophilous vegetation.

Fig. 3 - Nest with eggs of Kentish plover.

Glaucium flavum and *Raphanus raphanistrum* subsp. *maritimus* (*Raphano maritime-Glaucetum maritime* community) in Marzocca and Marina di Montemarciano coasts (Biondi *et al.,* 1992; Biondi & Baldoni, 1996).

In collaboration with local governments over the last four years have taken some conservation strategies for the protection of the breeding population that also affect the dune habitat protection, summarized as follows: maintenance of vegetation through selective cutting of non-native species and weeds using a brush cutter; raising awareness through permanent billboards in proximity of nests, seminars and educational activities; fencing and protection of nests with cages closed at the top to prevent predation by Hooded Crow (Morici *et al.*, 2010). In 2010 was activated the project about ringing Kentish plover, with the coordination of ISPRA, which allowed to increase the wealth of information on the species and the local population.

Results

In the study period there was an increase in the number of breeding pairs and a strong increase in the number of young fledged (96.6%). The trend shows that we moved from 10-12 pairs in 2009 to 21-22 in 2012 and 2013. Compared to 2008 (8 nests) there was an increase of 72.4% of the nests found.

Thanks to the application of the selective cutting of vegetation and fencing of nests over the years has increased the number of eggs hatched regularly. As already reported in literature (Pietrelli & Biondi, 2012) even in the monitored sites, it was observed a decrease of depositions replacement: from 16 in 2011 we moved to 6 in 2012 and 7 in 2013.

It is still notable the difference between the number of chicks born and chicks fledged, undoubtedly due to the limits of the protection actions aimed to protecting the nest on the ground and not the chicks. It is notable that in 2012 and 2013 with the increase in the number of chicks born would have expected a higher rate of fledging, instead expectation not found: the causes of the high mortality of chicks are therefore attributable to the strong human disturbance, especially in the north coast of Senigallia, and predation by Hooded Crow and *Larus* sp. (Scarton *et al.*, 2004; Morici *et al.*, Pietrelli & Biondi, 2012). To reduce the vulnerability of chicks should take other measures, more restrictive, while the activities of bathing and recreation in general.

Along the north coast, even if there is an increase in the number of pairs and nests addition to the initiation of protective measures, there is a progressive tendency to abandon in favor of the port area, probably due to of excessive human disturbance. In fact, over the past four years has been a fall in the number of nests in the area of the north coast of Senigallia and an increase in Marzocca: in 2010, 18 nests were counted in Senigallia and 7 in Marzocca, 13 in 2011 against 26 in 2012 8 vs. 26, 5 vs. 17 in 2013 (Table 1).

In many cases along the coast south of Marzocca, have been selected as a place of deposition, the roofs of bathing: 6 in 2011, 2 in 2012 and 4 in 2013.

In the current season we were able to observe how the chicks, hatched from nests on the roofs, are able to descend to the ground: just come out from the egg, the parents make many flights from the roof to the ground, emitting a lot of calls, pushing the chicks to come to ground making jumps to 3 meters (Figure 4, 5, 6).

Discussion

The abandonment of the mechanical cleaning of the beach and use the brush cutter for cutting of vegetation, has allowed us to protect all nests present on embryonic dune. This technique, although difficult to implement because it requires wide consultation between public administration and management , has led to excellent results failing to protect both species of dune psammophilous both nests. Signaling of nests through billboards in addition to fences and metal ca-

4

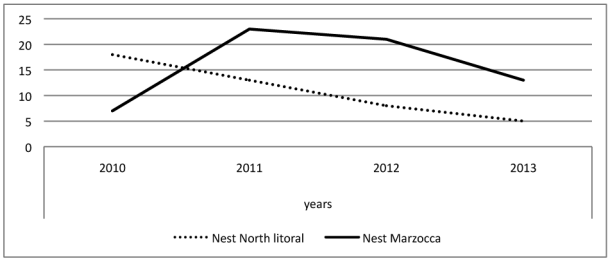
5

6

Figs. 4, 5, 6 - chicks come down on the ground.

ges had a positive impact on the success of hatching, However, many people, curious about the structures present along the beach, tend to get closer to fences disturbing, in this way, individuals in hatching that, in addition to spend a lot of energy in performing the display of distraction, leaving the eggs unattended and exposed to temperatures significantly affecting, in some cases, the embryo development (Amat & Masero, 2004; AlRashidi *et al*., 2010). Unfortunately, at times, we have witnessed the abandonment of the nest. The spatial distribution of nests seems to indicate a tendency to a progressive abandonment of the nesting area of Cesano-Cesanella, to the areas located to the south (Marzocca and Montemarciano). This could be

Tab. 1 - Trend in the number of nests in the north coast and Marzocca.



a result of increased human pressure, especially on hot days in April-May. Another possible cause of the abandonment of the site could relate to the height of the dune vegetation going to affect deposition in the period from May to June, when they develop some sort of tall grasses. This element, the subject of future research, might suggest the need to further increase targeted cuts of vegetation along stretches of beach affected by the presence of Kentish plover.

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EU habitats monitoring along the coastal dunes of the LTER sites of Abruzzo and Molise (Italy)

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Abstract
The Italian LTER network is an integrated and shared system for ecosystem monitoring (Long Term Ecological Research-Italy). The research sites of Abruzzo and Molise are part of the LTER site 20 " Coastal sand dunes in central Italy" (www.lteritalia.it) and include 5 S.C.I. along the central Italy Adriatic coastline. The paper aims to carry out a short review of the main results recently achieved through the dune vegetation monitoring in these LTER sites and proposes a synthesis on the species composition (focal and alien species occurrence) and the spatial distribution of dune EU habitats. We recorded 17 EU dune habitats, 4 of them are priority habitats (2250*, 2270*, 3170*, 1510*). Results suggest that many EU habitats are still locally widespread, with the exception of wet slacks and evergreen woods, occurring only in residual small patches. Moreover all EU habitats host several invasive alien species and only in salt marshes they are almost absent, because of the occurrence of extreme salinity. This natural heritage is therefore vulnerable and further efforts should be made to reduce the impacts of human pressure, through increased awareness of environmental issues and the education on ecosystem services provided by the natural landscape of coastal dunes.

Key words: coastal dune, EU habitats, species composition, alien species, spatial distribution.

Introduction

The Italian LTER network is an integrated and shared system for ecosystem monitoring (Long Term Ecological Research-Italy), which joined the LTER-Europe Network in 2007, including more than 300 research sites. These sites provide ecological data and information on long-term trends of terrestrial, freshwater and marine ecosystem quality at the European scale, working for the harmonization of survey protocols of bio-ecological data, allowing an effective data comparison across Europe, improving cooperation and synergy between/amongst different actors, interest groups, networks, etc., and providing education, exchange of know-how, communication and institutional integration (Bertoni, 2012; Stoll *et al*. 2014).

The research sites of Abruzzo and Molise are part of the LTER site 20 " Coastal sand dunes in central Italy" (www.lteritalia.it) which include 6 S.C.I. along the central Italy coastline and comprise highly fragile ecosystems as several threats affect them, mainly due to direct or indirect human pressure.

As around the other Mediterranean coasts, also along Italian Adriatic coastline, human activities in coastal areas have intensified over the course of the twentieth century (Feola *et al*. 2011; Romano & Zullo, 2014). Outbound tourism, the expansion of urban areas, and the spread of agriculture and afforestation activities have strongly modified coastal landscapes (Malavasi *et al*., 2013). Moreover, climatic change affects coastal areas and may be also an important driver of the vegetation composition and plant community structure (UNEP-MAP-RAC/SPA, 2010; Prisco *et al*. 2013). Indeed, in central Italy, throughout the last fifty years, the mean temperature increased by 0,8°C and precipitations lowered by 20% (Brunetti *et al*., 2006).

Along Italian Adriatic coast, several studies underlined that human pressure modifies the structure and the composition of dune plant communities in several sites causing: 1) Change in species composition (increase of ruderal and alien species), 2) Increase of community fragmentation, 3) Loss of vegetation zonation, 4) Local/regional extinction of dune habitats (Acosta *et al*. 2007, 2008, 2009; Biondi, 1999; Buffa *et al*.,2007; Carboni *et al*. 2009; Carranza *et al*., 2008; Cicarelli, 2014; Drius *et al*., 2013; Frattaroli *et al*., 2007; Géhu & Biondi, 1994; Géhu *et al*. 1984; Genovesi *et al*., 2014; La Posta *et al*. 2008; Pirone *et al*., 2001; Stanisci *et al*., 2007; Stanisci & Conti 1990; Taffetani, 2011).

This paper aims to carry out a short review of the main results recently achieved through the monitoring of dune EU habitats at the LTER sites along Italian Adriatic coastal ecosystems. Moreover, the paper proposes a synthesis of the species composition (focal and

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alien species occurrence) and the spatial distribution of dune EU habitats occurring in the study area and subjected to long term ecological monitoring.

Materials and methods

Study area

Vegetation monitoring is performed in five Sites of European Community Interest (S.C.I.) in Abruzzo and Molise regions along Adriatic coastline (Tab. 1). The four southern S.C.I. are composed by Holocene dunes in contact with alluvial terraces or pelitic-clay hills, while the northern S.C.I. is characterised by very young sand dunes, accumulated over the last century at the foot of conglomeratic cliffs (Giorgi *et al*., 1984; Iannantuono *et al*., 2004).

As concerns climate, mean yearly temperature is 15,6 °C and total rainfall amounts to 642,7 mm [Vasto (CH) -period 1974-1998; Termoli (CB) – period 1960-1990]. Thermo-types are between meso-Mediterranean and thermo-Mediterranean and ombro-types between the dry and the humid-subhumid. (Frattaroli *et al*., 2007).

Data

The identification of dune EU habitats was achieved by sampling plant communities through the phytosociological approach and a stratified random sampling on the basis of land cover map (Carranza *et al*., 2008). Recently (2005-2013) 96 phytosociological reléves and 120 plots (4x4 m) were carried out and georeferenced along the Molise and Southern Abruzzo coastline (Acosta *et al*. 2009; Del Vecchio *et al*., 2013; Frattaroli *et al*., 2007; Prisco *et al*. 2012).

The conservation status of sand dune EU habitats is investigated at plant community level and at landscape level. The first one has been evaluated through the analysis of species composition, focusing on two main ecological groups: focal species (FS) and alien species (AS). The focal species were identified and selected according to the list of diagnostic and characteristic species reported in the "Italian Interpretation Manual of the 92/43/EEC Directive habitats" (Biondi *et al*., 2007, 2009), while alien species refer to the Italian checklist (Celesti-Grapow *et al*., 2010).

Moreover, we used belt transects for the analysis of vegetation zonation along the beach-inland direction, which can be considered a further indicator of the conservation status of the whole sand dune ecosystem, as it was assessed in previous papers (Acosta *et al*., 2000; Iannantuono *et al*., 2004). We yearly perform the vegetation sampling of 4 vegetation transects. This data set is currently being processed.

At landscape level, EU habitats distribution was investigated through vegetation mapping in GIS environment at the scale 1:5.000 and the spatial composition analysis was applied (total cover area, total number of patches) (Acosta *et al*., 2009; Carranza *et al*., 2008; de Chiro *et al*. in press). Furthermore, a multitemporal analysis of Molise coastal landscape in the last fifty years was performed (Malavasi *et al*., 2013).

Results and discussion

We recorded 17 EU dune habitats in the studied area; 4 of them are priority habitats (2250*, 2270*, 3170*, 1510*) (Tab. 2).

The set of diagnostic plant species is well represented in each recorded habitat, with the exception of 1430 and 9340, which occupy small residual areas and are floristically poor.

All habitats host several invasive alien species and only in salt marshes they are almost absent, because of the occurrence of extreme salinity.

The most widespread alien species along the embryo- and foredunes are: *Ambrosia coronopifolia, Oenothera biennis, Erigeron canadensis, Cenchrus incertus, Xanthium italicum*. They are favored by human disturbance such as trampling and artificial flattening of dunes. On the fixed dunes *Acacia saligna, O. biennis, E. canadensis, Eleagnos angustifolia, Pittosporum tobira* are common. On the other hand, in back dune marsh habitats *Amorpha fruticosa, E. canadensis, E. sumatrensis, Aster squamatus, Setaria viridis* could be found.

Analyses were carried out for the evaluation of the effects of invasive alien species on the species composition and conservation status of the most invaded EU habitats in the study area, such as *Pinus* sp.pl. woods (2270*), coastal Mediterranean maquis (2250*, 2260), wet slacks (1410, 3170*) and annual grasslands (2230) (de Chiro *et al*., in press; Del Vecchio *et al*., 2013; Di Franco *et al*., 2012; Stanisci *et al*., 2010).

We investigated the effect of *Acacia saligna* on spe-

Tab. 1 - Sites of European Community Interest (S.C.I.) in Abruzzo and Molise regions along Adriatic coastline.

Abruzzo region:
S.C.I. IT7140108 "Punta Aderci-Punta della Penna"(Chieti province); lat. 42° 10' 0" N; long.14° 42' 40" E; area: 317 ha. The site is included in the Riserva Regionale Punta Aderci.
S.C.I. IT7140109 "Marina di Vasto" (Chieti province); lat. 42° 05' 10" N; long.14° 44' 25" E; area: 57 ha.
Molise region:
S.C.I. IT7228221 "Foce Trigno-Marina di Petacciato" (Campobasso province); lat. 42° 2' 32" N; long. 14° 50' 1"E; area: 747 ha.
S.C.I. IT7222216 "Foce Biferno-Litorale di Campomarino" (Campobasso province); lat.41° 57' 58" N; long.15° 2' 28" E; area: 817 ha.
S.C. I. IT7222217 "Foce Saccione-Bonifica Ramitelli" (Campobasso province); lat. 41° 55" 42' N; long.15° 5' 56" E; area: 870 ha.

Tab. 2 - Summary of the 17 coastal EU habitats (* = priority habitat) recorded in the LTER sites of Abruzzo and Molise coastline. For each habitat was reported information regarding focal species, alien species and syntaxonomical attribution. Species names have been updated according to the recent checklist of the Italian Flora (Conti et al. 2005) and syntaxa names refer to Italian EU habitats (Biondi *et al*. 2009).

Habitat	Focal species	Alien species	Syntaxonomical attribution
1210 Annual vegetation of drift lines	*Cakile maritima, Salsola kali, Chamaesyce peplis*	*Xanthium orientale* subsp. *italicum*	*Salsolo kali-Cakiletum maritimae* Costa e Manzanet 1981 nom. mut. propos. in Rivas-Martínez et al. 2002
2110 Embryonic shifting dunes	*Elymus farctus, Eryngium maritimum, Echinophora spinosa, Otanthus maritimus, Sporobolus virginicus, Cyperus capitatus*	*Xanthium orientale* subsp. *italicum, Ambrosia coronopifolia,Oenothera biennis, Erigeron canadensis*	*Echinophoro spinosae-Elymetum farct* Géhu 1987, *Sporoboletum arenarii* (Arénes 1924) Géhu & Biondi 1994
2120 Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)	*Ammophila arenaria, Eryngium maritimum, Echinophora spinosa, Euphorbia paralias, Anthemis maritima, Medicago marina, Lotus creticus*	*Xanthium orientale* subsp. *italicum, Ambrosia coronopifolia,Oenothera biennis, Erigeron canadensis*	*Echinophoro spinosae-Ammophiletum australis* (Br.-Bl. 1933) Géhu, Rivas-Martinez & R. Tx. 1972 in Géhu et al. 1984
2220 Coastal dunes grassland communities with *Euphorbia terracina*	*Euphorbia terracina, Verbascum garganicum, Artemisia campestris* subsp. *variabilis*	*Oenothera biennis, Cenchrus incertus, Ambrosia coronopifolia, Erigeron canadensis, Xanthium orientale* subsp. *italicum*	*Verbasco garganici-Euphorbietum terracinae* Biondi, Casavecchia & Biscotti 2007
2230 *Malcolmietalia* dune grasslands	*Malcolmia ramosissima, Vulpia fasciculata, Silene colorata subsp. canescens, Medicago litoralis , Ononis variegata, Pseudorlaya pumila, Cutandia maritima, Phleum arenarium, , Polycarpon diphyllum, Lophocloa pubescens.*	*Oenothera biennis, Cenchrus incertus, Ambrosia coronopifolia, Erigeron canadensis, Xanthium orientale* subsp. *italicum*	*Sileno coloratae-Vulpietum membranaceae* (Pign. 1953) Géhu & Scoppola 1984, *Sileno coloratae-Ononidetum variegatae* Géhu & Géhu-Franck 1986, *Ambrosio coronopifoliae-Lophocloetum pubescentis* Biondi, Brugiapaglia, Allegrezza & Ballelli 1992
2240 *Brachypodietalia* dune grasslands with annuals	*Trachynia distachya, Lagurus ovatus, Anchusa hybrid, Bromus gussonei.*	*Acacia saligna, Oenothera biennis Cenchrus incertus,* *Erigeron canadensis, E.sumatrensis, Xanthium orientale* subsp. *italicum*	*Trachynion distachyae* Rivas-Martinez 1978
2250* Coastal dunes with *Juniperus* spp.	*Juniperus macrocarpa, Asparagus acutifolius, Pistacia lentiscus, Phillyrea angustifolia, Prasium majus, , Lonicera implexa, Clematis flammula.*	*Acacia saligna, Erigeron canadensis, Oenothera biennis*	*Asparago acutifolii-Juniperetum macrocarpae* (R. et R. Molinier 1955) De Bolos 1962 razza tipo Géhu, Costa & Biondi 1990
2260 *Cisto-Lavanduletalia* dune sclerophyllous scrubs	*Cistus creticus, Cistus salviifolius, Erica multiflora, Rosmarinus officinalis,, Pistacia lentiscus, Halimium halimifolium, Helichrysum italicum, Rosmarinus officinalis*	*Acacia saligna, Erigeron canadensis, Oenothera biennis*	*Erico multiflorae-Halimietum* *halimifolii* Taffetani & Biondi 1989, *Cisto eriocephali-Rosmarinetum officinalis* Biondi 1999, *Helianthemo jonii-Fumanetum thymifoliae* Taffetani & Biondi 1989
2270* Wooded dunes with *Pinus pinea* and/or *Pinus pinaster*	*Pinus pinea, P. pinaster, P. halepensis, Juniperus. macrocarpa, Asparagus acutifolius, Pistacia lentiscus, Phillyrea angustifolia, Rhamnus alaternus, Daphne gnidium, Osyris alba, Rubia peregrina, Smilax aspera, Clematis flammula*	*Acacia saligna, Eucalyptus camaldulensis, Eucaliptus globulus,Pittosporum tobira*	*Pinetalia halepensis* Biondi et al.2014
6420 Mediterranean tall humid herb grasslands of the *Molinio-Holoschoenion*	*Erianthus ravennae,Schoenus nigricans, Juncus maritimus, J. acutus*	*Erigeron canadensis, E. sumatrensis, Oenothera biennis, Amorpha fruticosa, Eleagnus angustifolia*	*Eriantho ravennae-Schoenetum nigricantis* (Pignatti 1953) Géhu 1984, *Holoschoenetum romani* Br.-Bl. (1931) 1952
3170* Mediterranean temporary ponds	*Juncus bufonius, Lythrum tribracteatum, Isolepis cernua, Serapias vomeracea*	*Erigeron canadensis, Aster squamatus*	*Lythrion tribracteati* Rivas Goday & Rivas-Martínez ex Rivas Goday 1970
1310 *Salicornia* and other annuals colonizing mud and sand	*Salicornia patula, Suaeda vera, Puccinellia convoluta*	*Aster squamatus*	*Salicornion patulae* Géhu & Géhu-Franck 1984
1410 Mediterranean salt meadows (*Juncetalia maritimi*)	*Juncus maritimus, J. acutus, Carex extensa, Plantago crassifolia, Artemisia caerulescens, Elymus athericus, Limbarda crithmoides*	*Erigeron bonariensis,* *Erigeron canadensis,* *Aster squamatus, Setaria viridis*	*Schoeno nigricantis-Plantaginetum crassifoliae* Br.-Bl. (1931) 1952, *Plantagini crassifoliae-Caricetum extensae* Géhu et Biondi 1988
1420 Mediterranean and thermo-Atlantic halophilous scrubs *(Sarcocornetiea fruticosi)*	*Arthrocnemum fruticosum, Halimione portulacoides, Inula crithmoides, Suaeda vera, Aeluropus litoralis*		*Salicornion fruticosae* Br.-Bl. 1933

cies composition of coastal dunes, as this species is the main invader of Mediterranean scrub (habitats 2250* and 2260) and coastal *Pinus* dune wood (habitat 2270*) along the Molise coast (Del Vecchio *et al*., 2013). We compared species richness in invaded and non-invaded plots with rarefaction curves and analyzed the frequency of focal and ruderal species, identified according to Pignatti (2005). Although we did not find significant effects of *Acacia saligna* on total species richness, we observed significant results when species belonging to particular guilds were considered. In the invaded plots of the *Pinus* dune wood (habitat 2270*) we found an increase in ruderal grass species (*Bromus madritensis, Geranium purpureum, Oryzop-*

sis miliacea, Parietaria officinalis), with a significant decrease in focal species. Since *Acacia saligna* has been introduced relatively recently (approximately 1950), it is possible that our findings represent only an early stage of the invasion process, whereas other effects could be observed at a later stage.

As concerns the EU habitats of wet slack, we detected a relationship between the abundance of invasive alien species and species richness (Di Franco *et al.*, 2012). The 1410 and 3170* are the most invaded habitats in back dune slacks and, here, the most widespread species are *Erigeron canadensis* and *Aster squamatus*. The frequency of these aliens is higher in plots characterized by high species richness, as it was previously assessed in other habitat types (Acosta *et al.*, 2008, 2009; Gaertner *et al.* 2009).

Moreover, dune annual grasslands (2230) in the study area often are heavily invaded by *Oenothera biennis, Erigeron canadensis* and *Xanthium italicum* (Acosta *et al.*, 2008; de Chiro *et al.*, in press; Frattaroli *et al.*, 2007). As recorded in Carboni *et al.* (2011), transition dune is probably the most invaded sector of sand dune vegetation zonation, and such high level of invasion can be partially explained because of greater propagule pressure along this section of the dune profile. In order to explain the successful colonization of these species, we investigated the plant traits of a set of native and invasive alien species along Molise coast (Stanisci *et al.*, 2010). The results highlight that large leaf area, the reproductive period in late summer, a biennial/annual life cycle and thick, long roots are most common plant traits of the investigated invasive species.

Regarding vegetation transects in the LTER-Italy sites (conducted since 2001) we have carried out some preliminary analyses. We have observed changes in habitat distribution and plant species composition and these changes seemed to be mainly related to coastal erosion/accretion processes.

At landscape level (Tab. 3), it is worth nothing that the foredune habitats with open and herbaceous vegetation (drift line: 1210), embryonic shifting dunes: 2110 and shifting dunes: 2120) are well represented amounting to about 90 hectares in total. Transition dune and fixed dune habitats have a more restricted distribution with *Juniperus* sp. formations (2250*) present only in one S.C.I (Ramitelli) and the mosaic of dune grasslands (2220, 2230, 2240) and *Cistus* sp. formations (2260) circumscribed to the Molise coast. *Quercus ilex* forests (9340) are very rare, with two small residual patches in Ramitelli area. On the other hand, most of the analyzed area is characterized by *Pinus* spp backdune forests (2270*) which covers almost 100 ha distributed on 17 patches. Finally, habitats of wet slacks are present in fine grained mosaics (1310-1410-1420-1430-1510*-6420), distributed in small patches near the Biferno river mouth.

Conclusion

Coastal dune natural vegetation has been severely damaged and reduced along the whole Adriatic coast in the last 50 years. Nonetheless, our studies in Abruzzo and Molise regions suggest that many EU Directive 92/43 habitat types are still locally widespread, with the exception of wet slacks and evergreen wood habi-

Tab. 3 - Landscape features of the 17 coastal EU habitats (* = priority habitat) monitored in LTER sites of Abruzzo and Molise regions For each habitat was reported information regarding cover area and total number of patches in each SCI and globally in the study area.

	SCI										TOTAL NP	TOTAL AREA (ha)
	PUNTA ADERCI		MARINA DI VASTO		TRIGNO		BIFERNO		RAMITELLI			
HABITAT	AREA (ha)	NP	AREA (ha)	NP	AREA (ha)	NP	AREA (ha)	NP	AREA (ha)	NP		
1210-2110	3.9	22	2.5	25	13.8	31	7.5	16	8.8	5	99	36.5
1410-420	0.1	1	6.1	11	.	.	.	.	.	.	12	6.1
2120-2230	2	1	3.1	19	10	19	1.2	4	9.4	4	47	25.7
2230	1.2	2	6.2	14	.	.	.	.	.	.	16	7.4
2270*	.	.	2	2	47.4	6	41.6	6	3.5	1	15	94.5
3170*	.	.	0.01	1	.	.	.	.	.	.	1	0.01
1310-1410-1420-1430-1510*-3170*-6420	.	.	.	.	.	.	12.6	9	0.4	1	10	13
2220-2230-2240-2260	.	.	.	.	15	19	2.7	6	29.8	23	48	47.5
2250*	.	.	.	.	.	.	.	.	18.5	17	17	18.5
9340	.	.	.	.	.	.	.	.	0.4	2	2	0.4

tats occurring only in residual small patches. Moreover all habitats host several invasive alien species and only in salt marshes they are almost absent, because of the occurrence of extreme salinity. This natural heritage is therefore vulnerable and further efforts should be made to reduce the impacts of human pressure, through increased awareness of environmental issues and the education on ecosystem services provided by the natural landscape of coastal dunes.

For facing and mitigating the effects of human pressures on priority habitats, a project Life plus is ongoing with the participation of local decision makers (Campomarino and Petacciato municipalities). The project LIFE NAT/IT/000262 Maestrale provides concrete action for for the removal of some local *Acacia saligna* stands, contrasting trampling effects and enlarging wet habitats (http://lifemaestrale.eu/).

The information derived from these studies could be also useful to evaluate the response of coastal dune habitats to different global change scenarios and to estimate future possible range shifts for long-term conservation efforts. However, studies which combine both plant and animal biodiversity and the associated ecological services are still needed and could help to identify the most effective strategies for sustainable management, in order to prevent the high economic costs derived from the loss of the coastal dunes.

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Contribution to the knowledge of the coastal vegetation of Abruzzo (central Adriatic)

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Abstract
We report here on very rare associations (7) of the Abruzzo coast that are unusual for this Region (16). Moreover, we propose a new association of the alliance *Crucianellion maritimae*.

Key words: Abruzzo coast, Central Italy, vegetation.

Introduction

The rocky, halo-hygrophilous, halophilic and psammophylic aspects of the vegetation of the coast of Abruzzo are well known and have been documented in several studies (Pirone, 1983, 1985, 1988, 1995, 1997, 2005; Géhu *et al*., 1984; Stanisci & Conti, 1990; Pirone *et al*., 2001, 2003; Ciaschetti *et al*., 2004). This section of the Adriatic coast has also been discussed in terms of the environmental quality and degradation (Tammaro & Pirone, 1979, 1981; Pirone, 1982, 1997; Acosta *et al*., 2007; Frattaroli *et al*., 2007), which have shown the state of heightened disturbance suffered by various stretches of this coast.

Over the last few years, especially in the context of a recent monitoring of the presence of plant communities along the Abruzzo coast (Pirone *et al*., 2014), several phytocoenosis have been reported, including:

a) those already known for Abruzzo, but very rare and now found in new localities;
b) those not yet known for Abruzzo;
c) those here proposed for the first time.

Given their importance in phytogeographic and conservation terms, together with their role in integrating the cognitive framework of the coastal vegetation, we provide here a brief overview.

New localities of rare plant communities already reported for Abruzzo

SPOROBOLETUM ARENARII (Arènes 1924) Géhu & Biondi 1994
Syntaxonomy: *Ammophiletea australis* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946, *Ammophiletalia australis* Br.-Bl. 1933, *Ammophilion australis* Br.-Bl. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez, Lousã, T.E. Díaz, Fernández-González & J.C. Costa 1990, *Sporobolenion arenarii* Géhu 1988.

This association had only been reported for Vasto Marina (Pirone *et al*., 2001), and has now been recorded near Torre di Cerrano (Pineto - TE).
Relevé: Locality: Torre di Cerrano; date: 22 April 2006; vegetation cover: 35%; surface area: 20 m^2. *Sporobolus virginicus* (3), *Elymus farctus* ssp. *farctus* (1), *Medicago marina* (1), *Echinophora spinosa* (+), *Eryngium maritimum* (+), *Ambrosia coronopifolia* (1), *Silene colorata* (+), *Vulpia fasciculata* (+), *Salsola tragus* (+), *Xanthium orientale* ssp. *italicum* (+).

ECHINOPHORO SPINOSAE - AMMOPHILETUM ARUNDINACEAE
Syntaxonomy: *Ammophiletea australis* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946, *Ammophiletalia australis* Br.-Bl. 1933, *Ammophilion australis* Br.-Bl. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez, Lousã, T.E. Díaz, Fernández-González & J.C. Costa 1990, *Ammophilenion australis* Br.-Bl. (1931) 1932 em. J.M. & J. Géhu 1988.

This association was known for Torre di Cerrano, the mouth of the River Osento (Torino di Sangro), and for Punta Penna and Vasto Marina (Pirone, 1985, 1997; Stanisci & Conti, 1990; Pirone *et al*., 2001). It has now also been recorded for Casalbordino and San Salvo.
Relevé: Location: coast of San Salvo; date: 29 March 2014; vegetation cover: 70%; surface area: 40 m^2. *Ammophila arenaria* ssp. *australis* (4), *Elymus farctus* ssp. *farctus* (2), *Echynophora spinosa* (1), *Eryngium maritimum* (+), *Anthemis maritima* (1), *Lotus creticus* (3), *Silene colorata* (1), *Rostraria litorea* (2), *Artemisia campestris* subsp. *glutinosa* (+), *Xanthium orienta-*

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le ssp. *italicum* (2), *Cynodon dactylon* (1), *Oenothera suaveolens* (+), *Cenchrus incertus* (2).

ROMULEA ROLLII community
Syntaxonomy: *Tuberarietea guttatae* (Br.-Bl. in Br.-Bl., Roussine & Nègre 1952) Rivas Goday & Rivas-Martínez 1963 nom. mut. propos. in Rivas-Martínez *et al*. 2002, *Trachynetalia distachyae* Rivas-Martinez 1978, *Trachynion distachyae* Rivas-Martinez 1978].

Phytocoenosis dominated by *Romulea rollii* were reported for the Pineta D'Annunziana in Pescara (Pirone *et al*., 2001). This community has now also been recorded along the coast of Pineto, near the locality named Corfù.
Relevé: Location: coast of Pineto near Corfù; date: 31 March 2006; vegetation cover: 60%; surface area: 9 m^2. *Romulea rollii* (3), *Vulpia fasciculata* (2), *Cerastium pumilum* (2), *Silene colorata* (1), *Bromus diandrus* ssp. *maximus* (1), *Salvia verbenaca* (+), *Lagurus ovatus* (1), *Lotus creticus* (1), *Sonchus bulbosus* ssp. *bulbosus* (1), *Erodium laciniatum* (+), *Euphorbia terracina* (+).

SCHOENO NIGRICANTIS - PLANTAGINETUM CRASSIFOLIAE Br.-Bl. (1931) 1952
Syntaxonomy: *Juncetea maritimi* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952, *Juncetalia maritimi* Br.-Bl. ex Horvatic 1934, *Plantaginion crassifoliae* Br.-Bl in Br.-Bl., Roussine & Nègre 1952.

This association was reported for the coast of Vasto (Pirone, 1995). It has now also been recorded for San Salvo.
Relevé: Location: coast of San Salvo; date: 7 February 2014; vegetation cover: 80%; surface area: 20 m^2. *Plantago crassifolia* (4), *Schoenus nigricans* (2), *Aster tripolium* (+), *Juncus littoralis* (+), *Asparagus tenuifolius* (+), *Blackstonia perfoliata* ssp. *perfoliata* (+), *Dittrichia viscosa* (1), *Centaurium pulchellum* ssp. *pulchellum* (1), *Scirpoides holoschoenus* (1), *Agrostis stolonifera* (+), *Juncus articulatus* (+), *Rostraria litorea* (+).

PLANTAGINI CRASSIFOLIAE-CARICETUM EXTENSAE Géhu & Biondi 1988
Syntaxonomy: *Juncetea maritimi* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952, *Juncetalia maritimi* Br.-Bl. ex Horvatic 1934, *Juncion maritimi* Br.-Bl. ex Horvatic 1934, *Puccinellio festuciformis-Caricenion extensae* Géhu & Biondi 1995).

It was reported for Vasto Marina, Faro di Vasto, Villa Rosa di Martinsicuro, and between Pineto and Scerne (Pirone, 1995). It is no longer present at Faro di Vasto and Villa Rosa di Martinsicuro. The association was also recorded in San Salvo in March 2014, but a subsequent clearing of the area resulted in its disappearance.

SCHOENO NIGRICANTIS-ERIANTHETUM RAVENNAE (Pign. 1953)
Syntaxonomy: Géhu 1984 (*Molinio-Arrhenatheretea* Tüxen 1937, *Saccharetalia ravennae* Biondi, Blasi & Casavecchia in Biondi *et al*. 2014, *Imperato cylindricae-Saccharion ravennae* Br.-Bl. & O.Bolòs 1958).

The association was known for Montesilvano, San Silvestro and Pineta D'Annunziana in Pescara, and Vasto Marina (Stanisci & Conti, 1990; Pirone, 1995). It is now no longer present in Montesilvano and San Silvestro, but it has now been recorded for San Salvo.
Relevé: Location: coast of San Salvo; date: 7 February 2014; vegetation cover: 95%; surface area: 50 m^2. *Schoenus nigricans* (4), *Erianthus ravennae* (2), *Juncus littoralis* (+), *Dittrichia viscosa* (1), *Pulicaria dysenterica* (1), *Holcus lanatus* (1), *Agrostis stolonifera* (1), *Elymus athericus* (1), *Scirpoides holoschoenus* (+), *Potentilla reptans* (+), *Centaurium pulchellum* (+), *Phragmites australis* ssp. *australis* (1), *Equisetum ramosissimum* (+).

SCIRPETUM COMPACTO-LITTORALIS (Br.-Bl. (1931) 1952 em. Rivas-Martinez *et al*. 1980
Syntaxonomy: *Phragmito australis-Magnocaricetea elatae* Klika in Klika & Novak 1941; *Scirpetalia compacti* Hejny in Holub, Hejny, Moravec & Neuhäusl 1967 corr. Rivas-Martinez, Costa, Castroviejo & E.Valdés 1980, *Scirpion compacti* Dahl & Hadač 1941 corr. Rivas-Martinez, Costa, Castroviejo & E.Valdés 1980.

This association was reported for the mouth of River Vomano, Martinsicuro, the mouth of River Saline, and Punta Aderci and Vasto Marina (Pirone, 1995), and it is now confirmed for Punta Aderci and Vasto Marina. Moreover, it has now also been recorded between Pineto and Scerne, Ortona (CH) between the mouths of Rivers Foro and Arielli, south of the mouth of River Sangro, the mouth of River Sinello, and the coast of San Salvo.
Relevé: Location: coast of San Salvo; date: 7 February 2014; vegetation cover: 100%; surface area: 25 m^2. *Bolboschoenus maritimus* (5), *Phragmites australis* ssp. *australis* (1), *Lythrum salicaria* (+), *Lycopus europaeus* ssp. *europaeus* (+), *Samolus valerandi* (1), *Schoenoplectus tabernaemontani* (+), *Juncus littoralis* (+), *Tripolium pannonicum* (+), *Rumex crispus* (+).

New plant communities for Abruzzo

VERBASCO GARGANICI - EUPHORBIETUM TERRACINAE Biondi, Casavecchia & Biscotti 2007
Syntaxonomy: *Stellarietea mediae* Tuxen, Lohmeyer & Preising ex von Rochow 1951; *Thero-Brometalia* (Rivas.Goday & Rivas-Martinez ex Esteve 1973) O.Bolòs 1975; *Echio Plantaginei-Galactition tomentosae* O. Bolòs & Molinier 1969.

It is a vegetation of the interdunal and retrodunal are-

as that have been disturbed, abandoned and sometimes profoundly altered by human activities, which was described for Puglia by Biondi *et al*. (2007). In Abruzzo, it has now been recorded for several coastal areas.
Relevé: Location: Torre di Cerrano; date: 7 April 2014; vegetation cover: 85%; surface area: 25 m^2. *Euphorbia terracina* (3), *Verbascum niveum* ssp. *garganicum* (2), *Bromus diandrus* ssp. *diandrus* (2), *Bromus diandrus* ssp. *maximus* (1), *Ambrosia coronopifolia* (2), *Lagurus ovatus* (2), *Vulpia fasciculata* (1), *Silene colorata* (1), *Reseda alba* (+), *Erodium laciniatum* (1), *Lotus creticus* (1), *Echinophora spinosa* (+), *Rostraria litorea* (1), *Coniza bonariensis* (+), *Cynodon dactylon* (+), *Avena barbata* (1), *Raphanus raphanistrum* ssp. *landra* (+), *Cenchrus incertus* (+), *Elymus farctus* ssp. *farctus* (+), *Cyperus capitatus* (+).

XANTHIO ITALICI-CENCHRETUM INCERTI Biondi, Brugiapaglia, Allegrezza & Ballelli 1992
Syntaxonomy: *Tuberarietea guttatae* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952) Rivas Goday & Rivas-Martínez 1963 nom. mut. propos. in Rivas-Martínez *et al*. 2002; *Malcolmietalia* Rivas-Goday 1958; *Laguro ovati-Vulpion membranaceae* Géhu & Biondi 1994.

Plant communities dominated by *Cenchrus incertus*, which is exotic and invasive, and is a native to tropical and subtropical America. These coenosis substitute the typical vegetation following alterations to the dune systems. It was described for the Marche coast (Biondi *et al*., 1992), and it has now been found in many places along the coast of Abruzzo. It is included in the *Laguro ovati-Vulpion membranaceae* alliance.
Relevé: Location: Torre di Cerrano; date: 7 April 2014; vegetation cover: 70%; surface area: 25 m^2. *Cenchrus incertus* (4), *Xanthium orientale* ssp. *italicum* (+), *Rostraria litorea* (1), *Ambrosia coronopifolia* (1), *Silene colorata* (+), *Vulpia fasciculata* (1), *Lagurus ovatus* (1), *Erodium laciniatum* (+), *Pseudorlaya pumila* (1), *Lotus creticus* (1), *Bromus rigidus* ssp. *maximus* (1), *Echinophora spinosa* (+), *Cynodon dactylon* (+), *Elymus farctus* ssp. *farctus* (+), *Medicago marina* (+).

RAPHANO MARITIMI-GLAUCIETUM FLAVI Biondi, Brugiapaglia, Allegrezza & Ballelli 1992
Syntaxonomy: *Cakiletea maritimae* Tüxen & Preising ex Br.-Bl. & Tüxen 1952, *Euphorbietalia peplis* Tüxen 1950, *Euphorbion peplis* Tüxen 1950.

This is a nitrophilous association of the coastal deposits of gravel, which was described for Marche by Biondi *et al*. (1992). It has now been recorded for some areas along the Chieti and Teramo coasts of Abruzzo, and also as the variant with *Crithmum maritimum*, as in the relevé reported here.
Relevé: Location: coast of Torino di Sangro; date: 19 May 2014; vegetation cover: 40%; surface area: 100 m^2. *Glaucium flavum* (2), *Raphanus raphanistrum* ssp. *landra* (1), *Beta vulgaris* ssp. *maritima* (+), *Crithmum maritimum* (3), *Anthemis maritima* (2), *Dittrichia viscosa* (2), *Bromus diandrus* ssp. *maximus* (1), *Lotus corniculatus* ssp. *corniculatus* (+), *Catapodium rigidum* ssp. *rigidum* (1), *Sonchus oleraceus* (+), *Echynophora spinosa* (+), *Parapholis incurva* (1), *Elymus farctus* ssp. *farctus* (+), *Xanthium orientale* ssp. *italicum* (+), *Reichardia picroides* (1), *Avena barbata* (+), *Lagurus ovatus* (+), *Crepis sancta* (+), *Cynodon dactylon* (+), *Verbascum sinuatum* (+), *Lotus creticus* (1), *Hainardia cylindrica* (+).

CALAMAGROSTIO EPIGEJOTIS-ERIANTHETUM RAVENNAE Taffetani & Biondi 1992
Syntaxonomy: *Molinio-Arrhenatheretea* Tuxen 1937, *Saccharetalia ravennae* Biondi, Blasi & Casavecchia in Biondi *et al*. 2014, *Imperato cylindricae-Saccharion ravennae* Br.-Bl. & O.Bolòs 1958.

This association can be found in the dune depressions that are periodically flooded. It was described for Molise (Taffetani & Biondi, 1992), and it has now also been recorded in Abruzzo, along the coast of San Salvo.
Relevé: Location: coast of San Salvo; date: 7 February 2014; vegetation cover: 100%; surface area: 40 m^2. *Calamagrostis epigejos* (5), *Erianthus ravennae* (1), *Phragmites australis* ssp. *australis* (2), *Imperata cylindrica* (1), *Scirpoides holoschoenus* (+), *Schoenus nigricans* (1), *Dorycnium rectum* (1), *Asparagus tenuifolius* (1), *Agrostis stolonifera* (+), *Holcus lanatus* (2), *Carex extensa* (+), *Lotus tenuis* (+), *Elytrigia atherica* (+), *Oenothera suaveolens* (+), *Rumex crispus* (+), *and Dittrichia viscosa* (+).

IMPERATO CYLINDRICAE-SCHOENETUM NIGRICANTIS Arrigoni 1996
Syntaxonomy: *Molinio-Arrhenatheretea* Tuxen 1937, *Saccharetalia ravennae* Biondi, Blasi & Casavecchia in Biondi *et al*. 2014, *Imperato cylindricae-Saccharion ravennae* Br.-Bl. & O.Bolòs 1958.

This is a hygrophilous vegetation on sandy substrates that has been reported in the damp depressions with groundwater. It was described for Sardinia (Arrigoni, 1996), and has now also been recorded in Abruzzo along the coast of San Salvo and for Vasto Marina.
Relevé: Location: coast of San Salvo; date: 7 February 2014; vegetation cover: 90%; surface area: 30 m^2. *Imperata cylindrica* (4), *Schoenus nigricans* (2), *Phragmites australis* ssp. *australis* (2), *Erianthus ravennae* (+), *Holcus lanatus* (+), *Pulicaria dysenterica* (+), *Equisetum ramosissimum* (+), *Juncus littoralis* (+), *Dittrichia viscosa* (1), *Rostraria litorea* (1), *Xanthium orientale* ssp. *italicum* (1), *Linum bienne* (+), *Briza maxima* (+), *Mentha aquatica* (+), *Daucus carota* (+), *Blackstonia perfoliata* ssp. *perfoliata* (+), *Epilobium hirsutum* (+).

JUNCO MARITIMI-CLADIETUM MARISCI Géhu & Biondi 1988

***Syntaxonomy**: Phragmiti-Magnocaricetea* Klika 1941; *Scirpetalia compacti* Hejny in Holub, Hejny, Morav. & Neuh. 1967 em. Rivas-Martinez 1980, *Scirpion compacto-littoralis* Rivas-Martinez 1980).

The salt-marsh sedges association was described for the Alimini Lakes in Puglia, and also reported for Portonovo in Marche (Géhu & Biondi, 1988, 1996). In Abruzzo, it has now only been recorded for the retrodunal environments of San Salvo.

Relevé: Location: coast of San Salvo; date: 7 February 2014; vegetation cover: 100%; surface area: 30 m^2. *Cladium mariscus* (5), *Juncus maritimus* (2), *Juncus acutus* ssp. *acutus* (1), *Sonchus maritimus* ssp. *maritimus* (+), *Schoenus nigricans* (+), *Juncus subnodulosus* (1), *Phragmites australis* (1), *Mentha aquatica* (1), *Agrostis stolonifera* (+), *Juncus articulatus* (+), *Calystegia sepium* ssp. *sepium* (1), *Xanthium orientale* ssp. *italicum* (+).

CARICETUM DIVISAE Br.-Bl. in Br.-Bl., Roussin & Nègre 1952

Syntaxonomy: *Juncetea maritimi* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952, *Juncetalia maritimi* Br.-Bl. ex Horvatic 1934, *Juncion maritimi* Br.-Bl. ex Horvatic 1934, *Juncenion maritimi* Géhu & Biondi 1995.

It is a vegetation of few species reported for small depressions, on weakly saline soils that are flooded in winter. In Italy, it has been reported for Sardinia and Sicily (Valsecchi & Diana Corrias, 1973; Biondi, 1999; Biondi & Bagella, 2005), and this association has now also been recorded for the retrodunal areas of San Salvo.

Relevé: Location: coast of San Salvo; Date: 7 February 2014; vegetation cover: 100%; surface area: 25 m^2. *Carex divisa* (5), *Juncus maritimus* (1), *Sonchus maritimus* ssp. *maritimus* (+), *Schoenus nigricans* (+), *Agrostis stolonifera* (1), *Dittrichia viscosa* (+), *Holcus lanatus* (1), *Equisetum ramosissimum* (1), *Phragmites australis* ssp. *australis* (+), *Rumex crispus* (+), *and Juncus articulatus* (+).

JUNCETUM MARITIMI-ACUTI Horvatic 1934

Syntaxonomy: *Juncetea maritimi* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952, *Juncetalia maritimi* Br.-Bl. ex Horvatic 1934, *Juncion maritimi* Br.-Bl. ex Horvatic 1934, *Juncenion maritimi* Géhu & Biondi 1995.

This is an association living on sandy or sandy-clay soils that are periodically flooded by stagnant brackish water. In Italy, it was reported for different localities. In Abruzzo, it has now been recorded for San Nicola at Vasto and for San Salvo Marina.

Relevé: Location: San Salvo Marina; date: 7 February 2014; vegetation coverage 100%; surface area: 30 m^2. *Juncus maritimus* (5), *Juncus acutus* (1), *Juncus littoralis* (2), *Carex extensa* (+), *Elytrigia atherica* (1), *Tripolium pannonicum* (+), *Bolboschoenus maritimus* (+), *Schoenoplectus tabernaemontani* (+), *Agrostis stolonifera* (1), *Phragmites australis* ssp. *australis* (1), *Asparagus tenuifolius* (+), *Epilobium hirsutum* (+), *Cyperus longus* (+).

JUNCO MARITIMI-SPARTINETUM JUNCEAE Biondi 1992

Syntaxonomy: *Juncetea maritimi* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952, *Juncetalia maritimi* Br.-Bl. ex Horvatic 1934, *Juncion maritimi* Br.-Bl. ex Horvatic 1934, *Puccinellio festuciformis-Caricenion extensae* Géhu & Biondi 1995.

Halophilic association that develops along the edges of brackish depressions. It was described for Sardinia (Biondi, 1992), and in Abruzzo it has now been recorded for San Salvo, near the mouth of the seasonal Buonanotte stream.

Relevé: Location: near the mouth of Buonanotte stream, San Salvo Marina; date: 7 February 2014; vegetation cover: 100%; surface area: 50 m^2. *Spartina versicolor* (4), *Juncus maritimus* (1), *Carex extensa* (2), *Sonchus maritimus* ssp. *maritimus* (1), *Elytrigia atherica* (2), *Juncus acutus* (1), *Tripolium pannonicum* (1), *Juncus littoralis* (1), *Dittrichia viscosa* (1), *Lotus tenuis* (+), *Epilobium hirsutum* (+), *Phragmites australis* ssp. *australis* (1), *Agrostis stolonifera* (+), *Carex otrubae* (+), *Euphorbia hirsuta* (+), *Artemisia campestris* ssp. *glutinosa* (+), *Glycyrrhiza glabra* (+), *Amorpha fruticosa* (1), *Calystegia sepium* ssp. *sepium* (+).

ELYMETUM ATHERICAE Pellizzari, Merloni & Piccoli 2004

Syntaxonomy: *Juncetea maritimi* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952, *Juncetalia maritimi* Br.-Bl. ex Horvatic 1934, *Halo-Artemision coerulescentis* Pignatti 1953.

This is an association of the slightly halophilic dense grasslands, as described by Pellizzari *et al*. (2004), that are dominated by *Elymus athericus* (=*Elytrigia atherica*). It is found on the higher edges of the depressed marshy areas occupied by the phytocoenoses of the alliance *Juncion maritimi*. This kind of grassland is known for a lot of sites along the Adriatic-Ionian coast (Pignatti, 1953, 1966; Caniglia & Salviato, 1983; Pirone, 1983, 1995; Ferrari *et al*., 1985; Corbetta *et al*., 1992; Piccoli, 1995; Merloni & Piccoli, 2007; and others) and it was generally reported as *Elytrigia atherica* or, due to incorrect identification, *Elymus pungens* (=*Agropyron pungens*) communities. The association is common along the coast of Abruzzo, both as communities weakly halophilic, and as transitional aspects towards the prairies of the *Molinio-Arrhenatheretea* class.

Relevé: Location: between the mouths of Rivers Sa-

line and Piomba; date: 31 April 2014; vegetation cover: 100%; surface area: 80 m^2. *Elymus athericus* (5), *Tripolium pannonicum* (1), *Carex extensa* (+), *Juncus acutus* (1), *Phragmites australis* ssp. *australis* (1), *Equisetum ramosissimum* (1), *Scirpoides holoschoenus* (+), *Blackstonia perfoliata* ssp. *perfoliata* (+), *Lotus tenuis* (+), *Glycyrrhiza glabra* (1), *Dittrichia viscosa* (1), *Holcus lanatus* (+), *Pulicaria dysentetica* (+), *Dactylis glomerata* (+), *Daucus carota* (+), *Convolvulus arvensis* (+).

CARICETUM OTRUBAE Pedrotti 1982, halophilic variant

Syntaxonomy: *Phragmito-Magnocaricetea* Klika in Klika & Novak 1941; *Magnocaricetalia* Pignatti 1954; *Magnocaricion elatae* Koch 1926.

This association of large sedges dominated by *Carex otrubae*, has now been reported in retrodunal areas between the mouths of Rivers Saline and Piomba, north of the mouth of River Piomba, and also along the coast of San Salvo, in depressions with slightly salty stagnant water.

Relevé: Location: coast of San Salvo; date: 7 February 2014; vegetation cover: 100%; surface area: 30 m^2. *Carex otrubae* (4), *Phragmites australis* ssp. *australis* (2), *Schoenoplectus tabernaemontani* (2), *Lythrum salicaria* (+), *Bolboschoenus maritimus* (+), *Juncus maritimus* (1), *Carex extensa* (+), *Sonchus maritimus* ssp. *maritimus* (+), *Juncus acutus* (+), *Agrostis stolonifera* (1), *Dorycnium rectum* (+), *Holcus lanatus* (+), *Equisetum ramosissimum* (1), *Calystegia sepium* ssp. *sepium* (1).

SCIRPETUM TABERNAEMONTANI Pass. 1964, halophilic variant

Syntaxonomy: *Phragmito-Magnocaricetea* Klika in Klika & Novak 1941; *Phragmitetalia* Koch 1926; *Phragmition communis* Koch 1926.

This is a halophilous association dominated by *Schoenoplectus tabernaemontani* now recorded along ditches in retrodunal areas along the coast of San Salvo and Scerne di Pineto, mouth of River Sinello, and south of the mouth of River Sangro.

Relevé: Location: coast of San Salvo; date: 7 February 2014; vegetation cover: 100%; surface area: 20 m^2. *Schoenoplectus tabernaemontani* (4), *Phragmites australis* ssp. *australis* (2), *Carex otrubae* (+), *Bolboschoenus maritimus* (1), *Cyperus longus* (1), *Lythrum salicaria* (+), *Cladium mariscus* (+), *Juncus maritimus* (1), *Agrostis stolonifera* (+), *Paspalum distichum* (2), *Calystegia sepium* ssp. *sepium* (1).

ULMUS MINOR AND *LAURUS NOBILIS* COMMUNITY

Syntaxonomy: *Salici purpureae-Populetea nigrae* (Rivas-Martínez & Cantó ex Rivas-Martínez, Báscones, T.E. Díaz, Fernández-González & Loidi 1991) Rivas-Martínez, T.E. Díaz, Fernández-González, Izco, Loidi, Lousa & Penas 2002; *Populetalia albae* Br.-Bl. ex Tchou 1948; *Populion albae* Br.-Bl. ex Tchou 1948.

This comprises the subcoastal and hilly coastal woods of *Ulmus minor* subsp. *minor* and *Laurus nobilis*, in the mesoMediterranean bioclimate, on pelitic-arenaceous substrates. This is the vicariant of the association *Symphyto bulbosi-Ulmetum minoris* Biondi & Allegrezza 1996 of Temperate climates. It has now been recorded in Abruzzo, and it is likely to be distributed in other areas of central-southern Italy. This community is under study.

Relevé: Location: Ditch between Torre Mucchia and Ripari di Giobbe (Ortona a Mare); date: 4 April 2014; altitude: 50 m a.s.l.; surface area: 200 m^2; tree layer: 90% cover, 12 m average height; shrub layer: 60% cover, 2.4 m average height; herbaceous layer: 60% cover. *Ulmus minor* ssp. *minor* (3), *Laurus nobilis* (3), *Quercus pubescens* ssp. *pubescens* (1), *Prunus spinosa* ssp. *spinosa* (2), *Euonymus europaeus* (1), *Cornus sanguinea* ssp. *hungarica* (+), *Sambucus nigra* (+), *Rubus ulmifolius* (2), *Robinia pseudoacacia* (+), *Hedera helix* (3), *Bryonia dioica* (+), *Symphytum bulbosum* (3), *Arum italicum* ssp. *italicum* (1), *Stachys sylvatica* (1), *Carex pendula* (1), *Melissa officinalis* (2), *Iris foetidissima* (1), *Galium mollugo* (+), *Brachypodium sylvaticum* ssp. *sylvaticum* (+), *Allium neapolitanum* (1).

LAURO NOBILIS-ALNETUM GLUTINOSAE Brullo & Guarino 1998

Syntaxonomy: *Salici purpureae-Populetea nigrae* (Rivas-Martínez & Cantó ex Rivas-Martínez, Báscones, T.E. Díaz, Fernández-González & Loidi 1991) Rivas-Martínez, T.E. Díaz, Fernández-González, Izco, Loidi, Lousa & Penas 2002, *Populetalia albae* Br.-Bl. ex Tchou 1948, *Carici remotae-Fraxinion oxycarpae* Pedrotti ex Pedrotti, Biondi, Allegrezza & Casavecchia in Biondi *et al*. 2014.

This is a phytocoenosis of *Alnus glutinosa* and *Laurus nobilis* that is generally located along the bottoms of deep valleys and gorges. It is a sub-Mediterranean vicariant of the association *Aro italici-Alnetum glutinosae*. It was described around Lake Garda by Brullo & Guarino (1998) and for the Province of Ascoli Piceno (Manzi, 2001), and the association has now also been reported for retrodunal areas along the coast of Ortona between the mouths of Rivers Foro and Arielli, in subcoastal valleys in the Province of Chieti (Manzi, 2001; unpublished data), along River Pescara (Pirone, 1981; unpublished data), and in the Regional Natural Reserve 'Pineta D'Annunziana' (unpublished data).

Relevé: Location: Ortona coast between Tollo railway station and the mouth of River Arielli; date: 19 May 2014; surface area: 100 m^2; tree layer: 90% cover, 8 m average height; shrub layer: 20% cover, 1.5 m average

height; herbaceous layer: 70% cover. *Alnus glutinosa* (4), *Populus alba* (2), *Salix alba* (2), *Laurus nobilis* (+), *Salix purpurea* ssp. *purpurea* (+), *Robinia pseudoacacia* (1), *Amorpha fruticosa* (+), *Rubus caesius* (1), *Phragmites australis* ssp. *australis* (+), *Carex pendula* (2), *Humulus lupulus* (2), *Bryonia dioica* (2), *Calystegia sepium* ssp. *sepium* (1), *Symphytum bulbosum* (1), *Arum italicum* ssp. *italicum* (1), *Mentha aquatica* (1), *Hedera helix* (1), *Lycopus europaeus* ssp. *europaeus* (+), *Epilobium hirsutum* (+), *Lythrum salicaria* (+), *Potentilla reptans* (+), *Eupatorium cannabinum* ssp. *cannabinum* (1), *Urtica dioica* (1), *Equisetum cfr. arvense* (+), *Lactuca serriola* (+), *Lolium perenne* (1), *Poa trivialis* (1), *Apium nodiflorum* (+), *Dactylis glomerata* ssp. *glomerata* (+), *Rumex crispus* (+), *Galium aparine* (+), *Bidens tripartita* (+), *Daucus carota* (+), *Persicaria lapathifolia* (+).

PHYLLITIDO SCOLOPENDRI-LAURETUM NOBILIS Biondi, Casavecchia & Biscotti (2008)
Syntaxonomy: *Querco roboris-Fagetea sylvaticae* Br.-Bl. & Vlieger in Vlieger 1937, *Fagetalia sylvaticae* Pawlowski in Pawlowski, Sokolowski & Wallisch 1928, *Lauro nobilis-Tilion platyphylli* Biondi *et al*. ex Biondi, Casavecchia & Biscotti in Biondi *et al*. 2013.

Woods dominated by *Laurus nobilis* along the edges of the deep valleys of seasonal rivers in southern Italy. This was described by Biondi *et al*. (2008) for Gargano, and has now been recorded for some subcoastal valleys in the Province of Chieti.
Relevé: Location: confluence of Fosso delle Farfalle and Fosso San Tommaso (CH); altitude: 40 m a.s.l.; surface area: 150 m^2. *Laurus nobilis* (4), *Phyllitis scolopendrium* ssp. *scolopendrium* (1), *Acer campestre* (3), *Fraxinus ornus* ssp. *ornus* (1), *Quercus cerris* (1), *Acer opalus* ssp. *obtusatum* (+), *Carpinus betulus* (+), *Populus nigra* (+), *Ruscus aculeatus* (2), *Rubia peregrina* (1), *Corylus avellana* (+), *Cornus sanguinea* ssp. *hungarica* (1), *Clematis vitalba* (+), *Euonymus europaeus* (1), *Ligustrum vulgare* (1), *Crataegus monogyna* (+), *Smilax aspera* (+), *Lonicera etrusca* (+), *Rubus hirtus* (1), *Rubus ulmifolius* (2), *Hedera helix* (4).

CYMODOCEETUM NODOSAE Br.-Bl 1952
Syntaxonomy: *Zosteretea marinae* Pignatti 1953; *Zosteretalia marinae* Béguinot 1941; *Zosterion marinae* Christiansen 1934.

Submerged grassland, with temporary emersion during low tide, and seen also for altered and polluted environments. It has now been reported for various locations along the Chieti coast.

Newly proposed plant communities

LOTO CRETICI-SIXALICETUM GRANDIFLORAE Pirone, Ciaschetti, Di Martino, Frattaroli, Cianfaglione & Giallonardo
ass. nova hoc loco *SIXALICETOSUM GRANDIFLORAE* Pirone, Ciaschetti, Di Martino, Frattaroli, Cianfaglione & Giallonardo subass. nova hoc loco
Diagnostic taxa: *Sixalix atropurpurea* ssp. *grandiflora* and *Lotus creticus*.
Description: Community of the retrodunal areas in relatively stationary sand, in a mesoMediterranean climate. Recorded for Abruzzo, it is likely to be distributed in other areas of central-southern Italy. The floristic and structural features leads us to put it into the alliance *Crucianellion maritimae* Rivas-Goday & Rivas-Martinez 1958 [*Helichryso staechadis-Crucianelletalia maritimae* (Sissingh 1974) Géhu, Rivas-Martinez & R.Tx. in Géhu 1975, *Helichryso staechadis-Crucianelletea maritimae* (Sissingh 1974) Géhu, Rivas-Martinez & R.Tüxen in Géhu 1975 em. Biondi & Géhu 1994].
Holotypus ass. and subass. *sixalicetosum*
Relevè: Location: Coast of San Salvo; date: 7 February 2014; vegetation cover: 75%; surface area: 40 m^2. *Sixalix atropurpurea* ssp. *grandiflora* (4), *Lotus creticus* (2), *Artemisia campestris* ssp. *glutinosa* (1), *Euphorbia terracina* (1), *Anthemis maritima* (+), *Rostraria litorea* (2), *Silene colorata* (+), *Ononis variegata* (+), *Oenothera suaveolens* (+), *Lagurus ovatus* (+), *Blackstonia perfoliata* ssp. *perfoliata* (+), *Centaurium pulchellum* ssp. *pulchellum* (+).

ANTHEMIDETOSUM MARITIMAE Pirone, Ciaschetti, Di Martino, Frattaroli, Cianfaglione & Giallonardo subass. nova hoc loco,
Differential taxon of the subassociation: *Anthemis maritima*.
Description: The subassociation anthemidetosum maritimae is associated with aspects on looser sands, with elements of *Ammophilion* and a greater presence of those of *Malcolmietalia*.
Holotypus: subass. *anthemidetosum*.
Relevè: Location: Coast of San Salvo; date: 29 March 2014; vegetation cover: 70%; surface area: 45 m^2. *Sixalix atropurpurea* ssp. *grandiflora* (2), *Lotus creticus* (2), *Anthemis maritima* (4), *Rostraria litorea* (2), *Silene colorata* (1), *Ononis variegata* (+), *Oenothera suaveolens* (+), *Vulpia fasciculata* (1), *Elymus farctus* ssp. *farctus* (+), *Pancratium maritimum* (+), *Cenchrus incertus* (1), *Salsola tragus* (+), *Silene vulgaris* ssp. *tenoreana* (+).

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The endangered or extinct vegetal communities along the Abruzzo coast

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Abstract
After a brief introduction on the causes of the degradation and the conservation status od Abruzzo coast, we highlight the dynamics of the coastal vegetation systems in Abruzzo over the past 35 years. This is provided through a comparison between the previous situation, as documented by the data in the literature, and the current situation. The study highlights a worrying loss of phytocoenotic biodiversity that affects large sections of the coast, with the extinction of very rare halophilic plant associations not only for Abruzzo, but also throughout the central-southern Adriatic coast. On a positive note, we highlight the presence of newly established plant communities for some of the coastal segments.

Key words: coast of Abruzzo, extinction, monitoring, phytocoenotic biodiversity

Introduction

The coastal systems, and particularly the sandy ones, are characterised by high plasticity, and as a consequence, they are also very sensitive to natural and anthropogenic perturbations. In the middle of the last century, Braun-Blanquet (1951) warned of the danger of the imminent disappearance of the flora and the psammophylic communities along the coasts of the Mediterranean because of the profound alterations that had been occurring, which were mainly of anthropogenic origin. In Italy, the risks to the coastal environments have been widely reported over the years by several authors, such as, for example Cederna (1975), Arrigoni (1981), Garbari (1984), Géhu & Biondi (1994), and Audisio *et al*. (2002). The same arguments can be found in the recent reports from the Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA; 'Natura 2000 conservation status and trends') and World Wildlife Fund for Nature (WWF) Italy ('Cement from coast to coast: 25 years of nature lost from the finest Italian coasts'). The latter report noted that the Adriatic coast is the most urbanised of the entire Mediterranean basin.

The degradation of the coastal systems arises from indirect human actions (greenhouse effect with rising sea levels and increased coastal erosion, removal of material from the beds of rivers, construction of dams, ports, breakwaters, and other coastal infrastructure) and direct human actions (urbanisation, tourism, pollution, flattening of dunes, introduction of exotic species, man-made pine forests, among others) (Géhu & Biondi, 1994). In terms of artificial pine forests, it should be stressed that they can compromise the existence of the native dune vegetation (albeit not in such a drastic way as happens for construction, tourism and reclamation activities) only when they are created on dunes and in other areas that are potentially recoverable; they can, on the other hand, contribute to the creation of semi-natural or anthropic environments that are of particular socio-cultural, ecological and historical interest.

The erosion of the dunes destroys the normal topographic sequence of the plant communities, with the loss of phytocoenotic diversity and the triggering of the submersion of the retrodunal formations by the sand. The eutrophication of the sand and the degradation of the habitats favour the development of nitrophilous-ruderal species (*Cynodon dactylon*[1], *Bromus spp*., *Lobularia maritima* subsp. *maritima, Erigeron* spp., *Avena barbata, Raphanus raphanistrum,* ecc.) and exotic species (*Xanthium orientale* subsp. *italicum, Ambrosia coronopifolia, Cenchrus incertus, Carpobrotus* spp., *Oenothera* spp., and others), which often become invasive. Due to the profound human effects, in the Mediterranean basin it is difficult today to find dune systems that are still fully intact, and indeed, they have often been totally destroyed. When the intensity of the disruption is not high (e.g., trampling by visiting tourists, proximity to roads and cultivated fields), the effects on the phytocoenoses mainly relate to their specific composition, with the ingression of ruderal and exotic species, or of those with a wide distribution. If the intensity of the disruption increases (e.g., flattening of the dunes, fires, felling), there is the emergence of

[1]The nomenclature of the plant species generally agrees (with some exceptions) to that reported in Conti *et al*. (2005).

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replacement phytocoenoses that take the place of those potential. Finally, for intense and protracted impact, there is first the fragmentation and the gradual deterioration in the phytocoenotic toposequence, then the loss of some plant communities, and in the end, the total extinction of the dune vegetation (Ercole *et al*., 2007).

The state of the Abruzzo coast

Also in Abruzzo, the coastal environments are among the most degraded. Along the shoreline, the geomorphology is generally altered, and unfortunately, segments with the complete phytotopographic sequence of the typical plant communities cannot be found any more. These are often fragmented, impoverished and ruderalised, with an increasingly invasive presence of exotic species. Several contributions have been published on this topic (e.g., Tammaro & Pirone, 1979, 1981; Pirone, 1982, 1983, 1985, 1987, 1988, 1997; Acosta *et al*., 2007), in which the risks and the interference have been highlighted, with particular attention to the flora and the vegetation. These problems are related to the sandy coast, as the inherent geomorphological features of the high coast (e.g., the cliffs of Ortona, Rocca San Giovanni and Vasto) make them much less vulnerable to such anthropogenic disturbance.

In Abruzzo the role of substitution is taken mainly by the therophytic communities (in particular, the associations *Sileno coloratae-Vulpietum membranaceae, Sileno coloratae-Ononidetum variegatae, Ambrosio coronopifoliae-Lophochloetum pubescentis*, and *Xanthio italici-Cenchretum incerti*, and the *Cutandia maritima* community), with the replacement of perennial plant communities such as *Echinophoro spinosae-Elymetum farcti* and *Echinophoro spinosae-Ammophiletum arundinaceae*. These communities have become always more established, often as the only traces of the psammophylic vegetation. The process of fragmentation has become more and more damaging: from an original situation characterised by a wide variety of natural environments with some small 'islands' of degraded environment, this has moved to a framework in which this degradation has become dominant, within which there are increasingly small 'islands' of the natural environment.

According to monitoring carried out at the end of the 1990's (Pirone, 1997), there were 25 coastal plant communities that were degraded or endangered out of a total of about 50. Also, in these same years, there were some reports of extinct or endangered plant species along the coast (Conti & Pirone, 1996; Pirone & Conti, 1996). These studies indicated that about 30 species were considered to be extinct, and more than 60 species were strongly endangered or threatened with extinction.

There are only a few stretches of coast in Abruzzo that still retain dunal systems with their typical vegetation. The segment of the Province of Chieti is the one that has best preserved its natural value, which has been confirmed by the presence of four Sites of Community Interest and six Regional Natural Reserves. For this part of the coast, the quality of the environment has been analysed through floristic-vegetation parameters (Frattaroli *et al*., 2007).

Materials and methods

This report highlights the dynamics of the coastal vegetation systems in Abruzzo, which are generally regressive, through a comparison between the situation of the past few decades, as documented by reliable data in the literature, and the present situation.

Excluding the few generic and fragmentary details of the vegetation in past reports (Razzi, 1574; Tenore, 1831; Cesati, 1872; Rigo, 1877; Villani, 1921, Anzalone, 1955; and others), the beginnings of systematic studies of the coastal vegetation that were implemented according to phytosociological methods date from the second half of the last century. These studies were dedicated to particular segments (Tammaro & Pirone, 1979, 1981; Pirone, 1983, 1985, 1988; Géhu *et al*., 1984; Stanisci & Conti, 1990), with subsequent overviews that covered the whole coast (Pirone, 1995, 1997; Pirone *et al*., 2001). The investigations into the forest vegetation have included the "Pineta D'Annunziana" (Pescara) and the "Lecceta di Torino di Sangro" natural reserves. In the pine woods of Pescara, the only natural forest now surviving, are small nuclei with a dominance of the common elm. The remains of the pine forest of *Pinus halepensis* are mostly man-made or have been altered over time, except for some opposite cases due, most likely, to the surviving nuclei of the ancient pine forest that covered the dune ridges (Tammaro & Pirone, 1981; Pirone *et al*. 2003; Cianfaglione *et al*., 2014). The holm oak forest of Torino di Sangro does not cover the dune areas, but has developed on the conglomerate-arenaceous cliff, a location that has probably allowed this phytocoenosis to survive to date (Tammaro & Poldini, 1988; Ciaschetti *et al*., 2004), albeit with reduced surface area, and with periodic cutting and sections also rearranged over time.

Results

The comparison between the bibliographic data and the current situation is given in Table 1 These data show that in the past 35 years, the following plant communities have become extinct along the Abruzzo coast:

Suaedo maritimae-Salicornietum patulae, a pioneer association of alophylic annual species, dominated by *Salicornia patula*, which develops on sandy-loam soils

that are temporarily flooded, generally in clearings or in the small depressions of perennial salt prairies with *Salicornia*.

Sarcocornietum deflexae, an association with a dominance of *Sarcocornia fruticosa* var. *deflexa*, linked to areas that are periodically flooded, dry in summer, and with high salinity.

Suaedetum maritimae, an association of annual species with a dominance of *Suaeda maritima*, which develops on moist and salty soils with an accumulation of organic detritus, often modified for anthropogenic causes.

Salsoletum sodae, a thermo-halonitrophilous association built up by *Salsola soda*, which is established in the depressions with accumulation of organic material beached during storms.

Limonio serotini-Artemisietum caerulescentis, a xero-halophytic association that in its classic physionomy has a dominance of *Limonium narbonense* (= *Limonium serotinum*) and *Artemisia caerulescens* subsp. *caerulescens*.

The most endangered communities, because they have become very rare or degraded, are:

Echinophoro spinosae-Ammophiletum arundinaceae, an association that is typical of the high but still mobile dunes, based on *Ammophila arenaria* subsp. *australis*, spread in the north-western Mediterranean.

Sporoboletum arenarii, a markedly pioneering vegetation of the sands, in tufts or embryonic dunes.

Allietum chamaemoly and *Romulea rollii* community, as dry retrodunal meadows of therophytes and geophytes, and with a dominance of *Allium chamaemoly* and *Romulea rollii*.

Spartina versicolor community, a compact halopsammophylic community, which typically occupies the strip between the dune phytocoenoses and those halo-hygrophylic and interdunal, in more or less depressed areas.

Schoeno nigricantis-Erianthetum ravennae, an association with a weakly halophilic character of the wet depressions of the dune systems, with temporary contributions of brackish and fresh water, and with a top layer of soil that is rich in organic matter.

Caricetum otrubae and *Carex otrubae* community, as grasslands of large sedges with a dominance of *Carex otrubae*.

Schoenoplectus tabernaemontani community, a marshy vegetation, in water that is generally still or slow moving.

Scirpetum compacto-littoralis, low marshy reed thicket, in the retrodunal lagoons and depressions, with a dominance of *Bolboschoenus maritimus*.

Juncetum acuti, an association linked preferentially to the base of the dunes, between the psammophylic communities and the halophilic depression communities.

Suaedo verae-Atriplicetum halimi, a nanophanerophytic-chamaephytic and halophyte cliff community on nitrified soils, built up by *Suaeda vera* and *Atriplex halimus*.

Crithmo maritimi-Limonietum virgati, an aerosaline association of the conglomerate cliff that is endemic of the southern Abruzzo, with *Crithmum maritimum* and *Limonium virgatum*. On accumulations of gravel, a particular aspect can be seen that is characterised by the presence of *Inula crithomoides*.

Crithmo maritimi-Adiantetum capillus-veneris, an association of the loose sandstone cliffs, with dripping water.

Myrto-Pistacietum lentisci, a Mediterranean shrub community, with a dominance of *Myrtus communis* and *Pistacia lentiscus*.

Schoeno nigricantis-Plantaginetum crassifoliae, an association of the brackish retrodunal depressions that is physiognomically characterised by *Schoenus nigricans, Plantago crassifolia* and *Juncus littoralis*.

Plantagini crassifoliae-Caricetum extensae, a thermophilic subsaline grassland that has developed in the retrodunal areas that have fresh soil for long periods of the year. In Abruzzo this has a dominance of *Carex extensa* and *Juncus littoralis*.

Carex extensa community, thermophilic subsaline grassland, which represents an impoverished phase of *Plantagini-Caricetum*.

Cyperus kalli community, a pioneer phytocoenosis of embryonic dunes that sometimes represents an aspect of *Agropyron prairie*.

Imperato cylindricae-Schoenetum nigricantis and *Imperata cylindrica* community , a retrodunal community, on humid sandy substrate at times with silt, physiognomically dominated by *Imperata cilindrica,* a thermo-cosmopolitan species that is very rare in Abruzzo.

Junco maritimi-Cladietum marisci, an association with a dominance of *Cladium mariscus*, which develops in flooded retrodunal areas.

Caricetum divisae, a vegetation of few species reported for small depressions, on weakly saline soils that are flooded in winter.

Aro italici-Ulmetum minoris, a hygrophilous wood with a dominance of common elm (*Ulmus minor* subsp. *minor*), sometimes with white poplar (*Populus alba*) and southern ash (*Fraxinus angustifolia* subsp. *oxycarpa*).

Lauro nobilis-Alnetum glutinosae, alder wood with a Mediterranean character, and a vicariant of the association *Aro italici-Alnetum glutinosae* of the Temperate climates.

Ulmus minor and *Laurus nobilis* community, mesohygrophilic wood of common elm (*Ulmus minor* subsp. *minor*) and laurel (*Laurus nobilis*), which is found along the watersheds on soil that is constantly moist.

Tab. 1 - Comparison of bibliographic data and the current situation.

Martinsicuro (center)	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	x
Echinophoro spinosae-Elymetum farcti	x	x
Sileno coloratae-Ononidetum variegatae	x	x
Sileno coloratae-Vulpietum membranaceae		x
xanthio italici-Cenchretum incerti		x
Cutandia maritima community		x
Parapholiso incurvae-Spergularietum marginatae	x	
Catapodio marini-Parapholisetum incurvae	x	x
Cyperus fuscus community	x	
Polygonum maritimum community		x
Paspalo-Polypogonetum viridis	x	
Carex extensa community		x
Scirpetum compacto-littoralis	x	
Elytrigia atherica community		x
Ulmus minor community		x
(*) Pirone, 1997		

Martinsicuro (Villa Rosa)	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	
Echinophoro spinosae-Elymetum farcti	x	
Sileno coloratae-Vulpietum membranaceae	x	
Sileno coloratae-Ononidetum variegatae	x	
Ambrosio coronopifoliae-Lophochloetum pubescentis	x	
Elytrigia atherica community		x
Parapholis incurva community		x
Carex extensa community	x	
Scirpetum compacto-littoralis	x	
Elytrigia atherica community	x	
Phragmitetum australis	x	
Cyperetum longi	x	
(*) Pirone, 1997		

Giulianova, Tortoreto, Alba Adriatica	Past (*)	Current
Sileno coloratae-Ononidetum variegatae	(x)	x
Sileno coloratae-Vulpietum membranaceae	(x)	x
Cutandia maritima community	(x)	x
Salsolo kali-Cakiletum maritimae	(x)	x
Tordino, Salinello and Vibrata rivers mouths		
Elytrigia atherica community	x	x
Phragmitetum australis	x	x
(*) Pirone, 1997, 2005		

Roseto (Villa Mazzarosa)	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	
Sileno coloratae-Ononidetum variegatae	x	
Sileno coloratae-Vulpietum membranaceae	x	x
xanthio italici-Cenchretum incerti		x
Echinophoro spinosae-Elymetum farcti		x
Elytrigia atherica community	x	
Atriplex prostrata community	x	
Scirpoides holoschoenus community		x
Spartina versicolor community		x
Phragmitetum australis		x
Ulmus minor community		x
(*) Pirone, 1997, 2005		

Promenade of Roseto	Past (*)	Current
Sileno coloratae-Vulpietum membranaceae		x
Sileno coloratae-Ononidetum variegatae	x	x
Cutandia maritima community	x	x
Ambrosia coronopifolia community		x
Parapholiso incurvae-Spergularietum marginatae	x	
Elytrigia atherica community		x
(*) Pirone, 2005		

Vomano river mouth	Past (*)	Current
Atriplex prostrata community	x	
Suaedetum maritimae	x	
Suaedo maritimae-Salicornietum patulae	x	
Parapholiso incurvae-Spergularietum marginatae	x	
Scirpetum compacto-littoralis	x	
Phragmites australis halophilous community	x	x
Elytrigia atherica community	x	
(*) Pirone, 1995, 1997, 2005		

Between Pineto and Scerne	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	
Echinophoro spinosae-Elymetum farcti	x	
Echinophoro spinosae-Ammophiletum arundinaceae	x	
Ambrosio coronopifoliae-Lophochloetum pubescentis	x	
Plantagini crassifoliae-Caricetum extensae juncetosum litoralis	x	
Carex extensa community		x
Elytrigia atherica community		x
Phragmites australis community		x
Caricetum otrubae		x (fragm.)
Glaucium flavum gravel community		x
Schoenoplectus tabernaemontani community		x
Scirpetum compacto-littoralis		x
(*) Pirone, 1995, 1997; Pirone et al., 2001		

Pineto (Torre Cerrano)	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	x
Echinophoro spinosae-Elymetum farcti	x	x
Echinophoro spinosae-Ammophiletum arundinaceae	x	x
Sileno coloratae-Ononidetum variegatae	x	x
Sileno coloratae-Vulpietum membranaceae	x	x
Ambrosio coronopifoliae-Lophochloetum pubescentis	x	x
Sporoboletum arenarii	x	x
Romulea rollii community	x	x
(*) Pirone, 1995, 1997; Pirone et al., 2001; Pirone, 2006 (unpublished)		

North of the Piomba river mouth	Past (*)	Current
Salsolo kali-Cakiletum maritimae		x
Sileno coloratae-Vulpietum membranaceae		x (fragm.)
Cutandia maritima community		x
Echinophoro spinosae-Elymetum farcti		x
Elytrigia atherica community		x
Phragmitetum australis		x
Carex otrubae community		x
Piomba river mouth		
Suaedo maritimae-Salicornietum patulae	x	
Sarcocornietum deflexae	x	
Limonio serotini-Artemisietum caerulescentis	x	
Elytrigia atherica community	x	
(*) Pirone, 1988		

Between Saline and Piomba	Past (*)	Current
Parapholiso incurvae-Spergularietum marginatae	x	
Suaedetum maritimae	x	
Atriplex prostrata community	x	
Elytrigia atherica community	x	x
Phragmitetum australis		x
Juncetum acuti		x
Carex otrubae community		x
Saline river mouth		
Suaedo maritimae-Salicornietum patulae	x	
Spartina versicolor community	x	
Scirpetum compacto-littoralis	x	
Limonio serotini-Artemisietum caerulescentis	x	
Elytrigia atherica community	x	
Phragmitetum australis		x
(*) Pirone, 1988		

Montesilvano coastline	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	x (fragm.)
Echinophoro spinosae-Elymetum farcti	x	
Echinophoro spinosae-Ammophiletum arundinaceae	x	
Sileno coloratae-Vulpietum membranaceae	x	x (fragm.)
Schoeno nigricantis-Erianthetum ravennae	x	
Scirpetum compacto-littoralis	x	

(*) Pirone, 1983

Pescara coastline	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	x
Sporoboletum arenarii	x	
Echinophoro spinosae-Elymetum farcti	x	x (°)
Echinophoro spinosae-Ammophiletum arundinaceae	x	
Sileno coloratae-Vulpietum membranaceae	x	x
Polygonum maritimum community		x (°)
Schoeno nigricantis-Erianthetum ravennae	x	x
Allietum chamaemoly	x	x (fragm.)
Cistus creticus ssp. *creticus* and *C. salviifolius* community	x	x
Pinus halepensis and *Laurus nobilis* community	x	x
Aro italici-Ulmetum minoris	x	x

(*) Tammaro & Pirone, 1979, 1981; Pirone, 1983, 1997; Pirone et al., 2003
(°) Newly formed

Francavilla coastline	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	
Echinophoro spinosae-Elymetum farcti	x	
Elytrigia atherica community	x	
Sileno coloratae-Vulpietum membranaceae		x

(*) Géhu et al., 1984; Pirone, 1997

Ortona, between the train station of Tollo and the Arielli river mouth	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	x
Echinophoro spinosae-Elymetum farcti	x	x
Sporoboletum arenarii	(x)	
Euphorbia terracina community	x	x
Sileno coloratae-Vulpietum membranaceae	x	x
Sileno coloratae-Ononidetum variegatae	x	x
Ambrosio coronopifoliae-Lophochloetum pubescentis	x	x
Cutandia maritima community		x
Spartina versicolor community	x	x
Phragmitetum australis	x	x
Scirpetum compacto-littoralis	x	x
Carex otrubae community		x
Alnus glutinosa community		x

(*) Géhu et al., 1984; unpublished data

Ortona coastline	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	
Echinophoro spinosae-Elymetum farcti	x	
Suaedo maritimae-Salicornietum patulae	x	
Parapholiso incurvae-Spergularietum marginatae	x	x
Crithmum maritimum community	x	x
Suaedo verae-Atriplicetum halimi	x	x

(*) Géhu et al., 1984; Pirone, 1995; unpublished data

Rocca S. Giovanni (Punta Cavalluccio)	Past (*)	Current
Crithmo maritimi-Limonietum virgati	x	x
Elytrigia atherica community	x	
Fossacesia Marina		
Crithmo maritimi-Limonietum virgati	x	
Sileno coloratae-Vulpietum membranaceae	(x)	x
Parapholiso incurvae -Spergularietum marginatae	(x)	x
Elytrigia atherica community	(x)	x
Hainardia cilindrica and *Spergularia media* community	(x)	x

Torino di Sangro Marina	Past (*)	Current
Allietum chamaemoly	x	x
Anthemis maritima and *Stachys maritima* community	x	
Crithmum maritimum and *Anthemis maritima* community		x
Osento river mouth		
Echinophoro spinosae-Elymetum farcti	x	x
Echinophoro spinosae-Ammophiletum arundinaceae	x	x (fragm.)
Sileno coloratae-Vulpientum membranaceae		x
Ambrosio coronopifoliae-Lophochloetum pubescentis		x
Anthemis maritima and *Lotus creticus* community		x
Phragmitetum australis (halophilous)	x	

(*) Pirone, 1995, 1997; Pirone et al., 2001

Promenade of Casalbordino	Past (*)	Current
Echinophoro spinosae-Elymetum farcti		x
Echinophoro spinosae-Ammophiletum arundinaceae		x
Sileno coloratae-Vulpietum membranaceae	x	x
Anthemis maritima and *Lotus creticus* community		x
Sinello river mouth		
Scirpetum compacto-litoralis		x
Suaeda maritima community		x
Parapholiso incurvae -Spergularietum marginatae		x

(*) Pirone, 1995

Punta Aderci	Past (*)	Current
Crithmo maritimi-Adiantetum capillus-veneris	x	x
Atriplex halimus community	x	x
Scirpetum compacto-littoralis	x	
Myrto-Pistacietum lentisci	x	x
Raphano maritimi-Glaucietum flavi		x

(*) Pirone, 1995; Pirone et al., 2001

Punta Penna	Past (*)	Current
Echinophoro spinosae-Elymetum farcti	x	x
Echinophoro spinosae-Ammophiletum arundinaceae	x	x
Sileno coloratae-Vulpietum membranaceae	x	x
Ambrosio coronopifoliae-Lophochloetum pubescentis	x	x
Juncetum acuti	x	
Crithmo maritimi-Limonietum virgati	x	x
Cutandia maritima community		x
Beacon of Vasto		
Juncetum acuti	x	
Schoeno nigricantis-Plantaginetum crassifoliae	x	
Holoschoenetum romani	x	
Plantagini crassifoliae-Caricetum extensae	x	
Elytrigia atherica community	x	
Parapholiso incurvae-Spergularietum marginatae	x	
Catapodio marini-Parapholisetum incurvae	x	
Atriplex halimus community	x	

(*) Pirone, 1985, 1995, 1997; Pirone et al., 2001

Vasto Marina	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	x
Sporoboletum arenarii	x	x
Echinophoro spinosae-Elymetum farcti	x	x
Echinophoro spinosae-Ammophiletum arundinaceae	x	x
Cyperus kalli community	x	x
Sileno coloratae-Vulpietum membranaceae	x	x
Sileno coloratae-Ononidetum variegatae	x	x
Ambrosio coronopifoliae-Lophochloetum pubescentis	x	x
Schoeno nigricantis-Erianthetum ravennae	x	x
Imperata cilindrica community	x	x
Spartina versicolor community	x	x
Schoeno nigricantis-Plantaginetum crassifoliae	x	x
Holoschoenetum romani	x	x
Plantagini crassifoliae-Caricetum extensae	x	x
Elytrigia atherica community	x	x
Scirpetum compacto-littoralis	x	
Phragmitetum australis (halophilous)	x	x

(*) Géhu et al., 1984; Pirone, 1985, 1995; 1997; Stanisci & Conti, 1990; Pirone et al., 2001

S. Salvo coastline	Past (*)	Current
Salsolo kali-Cakiletum maritimae	x	x
Cutandia maritima community	x	x
Echinophoro spinosae-Elymetum farcti		x
Echinophoro spinosae-Ammophiletum arundinaceae		x
Sileno coloratae-Vulpietum membranaceae	x	x
Sileno coloratae-Ononidetum variegatae	x	x
Anthemis maritima and *Lotus creticus* community		x
Schoeno nigricantis-Plantaginetum crassifoliae	x	x
Imperato cylindricae-Schoenetum nigricantis	x	x
Schoeno nigricantis-Erianthetum ravennae	x	x
Phragmitetum australis (halophilous)	x	x
Cladietum marisci	x	x
Scirpetum compacto-littoralis	x	x
Spartina versicolor community	x	x
Schoenoplectus tabernaemontani community	x	
Caricetum divisae		x
Chara globularis and *Chara intermedia* community	(x)	x

(*) unpublished data (2000-2001)

It is a Mediterranean vicariant of *Symphyto bulbosi-Ulmetum minoris*, of the Temperate climates.

On a positive note, it can be highlighted that the investigation also revealed the presence of coastal segments that at one time had low vegetation value, in which phytocoenoses that are typical of coastal habitats are now re-established. These include:

The coast between the mouths of Rivers Saline and Piomba, with the emergence of a vast grassland of *Elytrigia atherica* and a nucleus of *Juncus acutus*;

North mouth of the seasonal River Piomba; the most significant plant communities now present are *Echinophoro spinosae-Elymetum farcti*, the grassland of *Elytrigia atherica*, and grouping of *Carex otrubae*;

The coast of Pescara, close to the port canal, the newly formed beach is colonised by species such as the psammophyles *Elymus farctus* and *Polygonum maritimum*. In an area with a slight depression, some individuals of the very rare *Limonium virgatum* are also present;

The coast between Tollo railway station and the mouth of River Arielli, where a retrodunal forest nucleus of *Alnus glutinosa* has developed;

The Casalbordino coast, with the formation of new dune ridges colonised by *Echinophoro spinosae-Elymetum farcti;*

The San Salvo coast, where also here there are new dune ridges with edges of *Echinophoro spinosae-Elymetum farcti* and of *Echinophoro spinosae-Ammophiletum arundinaceae*. In the retrodunal area of San Salvo, numerous halophilic and halo-hydrophilous communities have also been detected.

Conclusion

From these comparisons between previous data and the most recent data related to the presence of the typical vegetation, it is possible to infer the state of conservation of the coastal ecosystems, as the plant communities of the dunes provide excellent bio-indicators of the level of human disturbance (as well as natural disturbance) of these ecological systems, and the sedimentological, geomorphological, hydrological and biological changes they have undergone.

The picture that emerges for Abruzzo from this comparison is not, unfortunately, comforting. Although there has been positive dynamic reconstruction of the dune phytocoenoses in the rare cases mentioned above, this is offset by a loss of floristic and phytocoenotic biodiversity that affects large sections of the coast. The recent census of the vascular flora of the coastal dune environments of central Italy (Izzi *et al.*, 2007) showed the presence along the Abruzzo coast of about 160 vascular species; this is counterbalanced by the high number of alien and synanthropic species, of which many have assumed an invasive character.

The remodelling, infrastructure and urban developments suffered by the mouths of rivers and their surroundings and the destruction of the original geomorphology, as in the case of Rivers Vomano, Saline, Piomba and Sangro, have resulted in the extinction of halophilic plant associations that were very rare not only in the Abruzzo region, and also throughout the central-southern Adriatic coast. This same fate has affected the psammophylic associations of the strip of beach closest to the shoreline, which in many segments is systematically 'ploughed' mechanically at the start of each summer, which eliminates all forms of plant life.

Despite everything, the last stretches of the Abruzzo coast that have not yet become mere geographical expressions provide a priceless heritage of biodiversity that must be bequeathed to future generations, as a 're-

servoir' at the disposal of the processes of biological evolution and for the ecosystem services, and as witness to the extraordinary natural history of our country.

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Relevant aspects of the Abruzzo coast transformation during last centuries (Central Adriatic Italy)

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Abstract
The aim of this study is to shed light on plant physiognomy and landscape changes which have characterized the Abruzzo coast in the past, analysing different historical documents in order to join the information with those related to the actual vegetation focusing on some events and historical processes which influenced the modification of the landscape, causing a huge spillover on natural environment and relapse of the soil use. The existence of different types of coastal woodlands is documented by some texts and geographic maps showing that in the past centuries the Abruzzo coast was covered by thick and impervious forests named "selvae", which were integral part of the economy of local populations, mostly based on non-wood products. About the past plant physiognomy, most of the available information are fragmentary, but a few well detailed documents give an acceptable representation of some plant formations, as in the case of large coastal pine woods, which have been remodeled and reshaped over time, even with reforestation and are today restricted in small areas. Many documents are also important to prove the close link between these formations and the daily life of local people in the past, underlining at the same time their cultural and historical-environmental value. The study of this documentation is also useful for the analysis of those species whose presence status is nowadays considered critical or cryptic, as well as for the study of introduced species which are now historicized in the landscape and in some cases have become typical.

Key words: Abruzzo, Ancient forest, Coast, variation, vegetation, *Pinus*, selvae, species lost, typical.

Introduction

The risks for the Italian coastal environments have been described by several authors over the years (i.e. Cederna, 1975; Arrigoni, 1981; Garbari, 1984; Géhu & Biondi, 1994; Audisio *et al*., 2002). Recent reports about the issue have been conducted by ISPRA ("Rete Natura 2000, stato di conservazione e trend", 2014), WWF Italia ("Cemento coast to coast: 25 anni di natura cancellata dalle più pregiate coste italiane", 2014), Legambiente ("Mare Monstrum"; 2013); FAI and WWF Italia ("Terra rubata. Viaggio nell'Italia che scompare"; 2012). These documents underline the worrying conditions of Italian environment, more specifically of the Adriatic coast, that is one of the most urbanized areas of the Mediterranean. The simplified sequence of plant communities, from the water's edge up to the hills, may be therefore schematized as follows: beach vegetation, represented by an association with *Cakile maritima* subsp. *maritima*; vegetation of sand-spits interested by seawater ingression, characterized by an association with *Sporobolus virginicus*; vegetation of dune ridges, on elevations, constituted by associations with *Elymus farctus* subsp. *farctus* and *Ammophila arenaria* subsp. *australis*; vegetation of maquis, dominated by junipers (*Juniperus* spp.); Mediterranean woodland and the related maquis, rich in evergreen sclerophyllous species and with *Pinus* species. *Pinus halepensis* is the more representative one, generally dominant on poorer, parched and termoxeric substrates, with a preference for rocky and detritus ones (of different types and grain size) or in strongly acclivitous slopes. On more fresh and fertile substrates it is more common to find deciduous oaks and those species belonging to the *Orno-ostrietum* s.l. formation; also *Celtis australis* subsp. *australis* is occasionally present. The vegetation of dune ridges, into the hollows, is characterized by alophylous and alo-hygrophylous grasslands, rich in Chamaephytes and Hemicryptophytes and succulent plants. Other shrubs are represented mainly by *Tamarix* spp. and *Vitex agnus-castus*. the strips of mesophilic forests are mainly characterized by *Quercus robur* and *Caprinus betulus*. Hygrophilous wood, constituted by poplars (*Populus* spp.), ashes (*Fraxinus* spp.), willow-trees (*Salix* spp.), black alders (*Alnus glutinosa*) and elms (*Ulmus* spp.). The nomenclature adopted in this paper refers to Conti *et al*. 2005.

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Analisys of the Abruzzo coastal transformation

During the Roman empire period Abruzzo coast showed some signs of urbanization. After the fall of the Western Roman Empire (deposition of *Romulus Augustus*), the coast was under the Byzantine control until the mid-seventh century afterwards under the Longobardic dominion, with a related process of abandonment of the coastal zone led to the disappearance of large settlements like Truentum, ports and villages. The Pest plague of the mid-XIV century led to the vanishment of many settlements, especially in the southern area. With the restructuring of transhumant pastoralism by the Kingdom of Naples, decided by Alfonso of Aragon in the middle of the XV century, most of the coastline of Abruzzo was intended for winter grazing (demonticazione) of sheep flocks. This practice prevented the agricultural exploitation and the establishment of permanent settlements. From the 16th century, the flat areas along the coast and the final stretch of the rivers, which were often subject to winter grazing, were exploited for the cultivation of rice. Abruzzo became the first region within the Kingdom of Naples for its production (Manzi, 2006). Rice cultivation was abolished in the middle of 19th century because of the spread of malaria. During the 16th century, as a result of a general demographic and economic growth, many hilly coastal areas in Chieti province, not subject to the grazing practice, were deforested for plantations of olives trees and vineyards. Several villages were founded from scratch in order to accommodate the need of the Dalmatian and Albanian workforce used to cultivate the land. From the 14th century the region started a market of "mortelle" (*Myrtus communis*) and "lentisco" (*Pistacia lentiscus*), leaves. The forests were used in a few cases for pasture but especially to obtain mostly non-wood materials. Resin and pitch were extracted in the coastal forests; other products were twigs, branches and bark for the furnaces ("legno novo"), dead wood ("legno fracicone"). Especially in the southern part of the region, the woodlands with *Fraxinus ornus* subsp. *ornus* and *Fraxinus angustifolia* subsp. *oxycarpa* were exploited for the extraction of manna. In the 18th century started the industrial exploitation of licorice roots (*Glycyrrhiza glabra*). The rivers were used for the fishing of mullet (*Mugil cephalus*) and twait shad (*Alosa fallax*), which was contracted by the local feudal lords. The fishing of sturgeon (*Acipenser sturio*) was also practiced until the 19th century; this species is not present anymore and is thought to be extinct within the Italian side of the Adriatic Sea, according to Zerunian (2002) and Kottelat & Freyhof (2007). De Torres (1932) discussed about the name origins of Silvi and Montesilvano cities from the Latin word "*silvae*" referring to past coastal forests once present there. The existence of a large coastal pine forest (Selva dei Chiappini) in the 14th century was reported by Muzii (1923) and a document entitled "Platea storica di Pescara" (1713)[1] . The forest was so extended and the density of human population was so low during this period, that only the most peripheral parts that were close to the towns could be used for a notable exploitation. Razzi (1576) described this large pine forest as: "so beautiful that it was a garnish for the sea". In 1653 huge cuts of this forest were done for the reinforcement of the Pescara Fortress, resulting in protests by local population who depended to the forest products. Other cuts have occurred even later, for various reasons. Palma (1837) described the whole territory of Abruzzo, discussing also about the vegetation; in particular it can be noted: "On the sea level grows naturally the chaste tree (*Vitex agnus-castus*), the mastic (*Pistacia lentiscus*), the rosemary (*Rosmarinum officinale*), the myrtle (*Myrtus communis*), the oxicedro (*Juniperus deltoids*), the Aleppo pine (*Pinus halepensis*)". He stated that, before the cuts, that forest served as a shield against invasions coming from the sea. He also described the effects of the lack of vegetation on land and on water courses, that are ruined by the absence of adequate plant covering. He underlined the importance of a dense forest coverage to avoid soil instability, especially within the arenaceous coastal areas, where he recommended to plant: "the maritime pines trees… which grow rapidly and whose seeds are easily found on the beach of Montesilvano, where there was a large forest that is now rapidly disappearing in order to put the land under cultivation. This vast forest is marked on old maps under the name of "Selva dei lentischi" or "Selva delli Chiappini" or Ciappini. In addition, there are several testimonies of cuts and illegal deforestation[2,3], seldom carried out with the consent of the Marquise D'Avalos, in order to make the land cultivable. In 1890 the works for the opening of a quarry in the area of the pine forest, designed for the construction of the Adriatic railroad[4], created further troubles in the woody area. The analysis of past data and actual observations show that the term "Chiappino", commonly used on Abruzzo coast, should refer to the generic term "Pine", with special reference to the maritime pines and particularly the *Pinus halepensis*.

[1] Ordered by the Marquis D'Avalos. Preserved in the Archivio Storico di Stato (Historical State Archive) of Pescara. Pages not numbered.

[2] Verbal trial for the contravention of the arts. 96, 104, 173 of the Forestry Act of the 21st August 1826 in force; issued in 1875 by the State Forestry Administration, Department of Abruzzo Citeriore, District of Chieti. Document preserved in the Archivio Storico di Stato (Historical State Archive) of Pescara, envelope 134, folder 10.

[3] Report from the Mayor of Pescara to the Prefect of Chieti. 11th November 1879. Document preserved in the Archivio Storico di Stato of the of Pescara, envelope 134, folder 10.

[4] Registered mail from the Prefecture to the Major of Pescara of the 13th November 1890 and communication from the Major of Pescara to the Prefect of the Province and following. Documents preserved in the Archivio Storico di Stato of Pescara, envelope 69, folder 38.

Penzig (1924) reported that also *Pinus pinaster* is clearly named "Chiappine" (which is still in use along the coast), "Zappino" (in disuse) or "Pignolo" (term that Penzig associates to the area of L'Aquila; in disuse); the *Pinus halepensis* is reported as "pino marittimo" (still in use, in the whole Abruzzo) or "Pinoca" (in disuse). Manzi (2001) takes these terms but associates them to *P. halepensis*. Tenore (1831) reporting the presence of *P. halepensis* in Abruzzo, adding the following common names: "Pinoca" (Abruzzo) and "Zappino" in Basilicata and Puglia. About the presence of *Pinus domestica* (species that has been widespread in the Italian peninsula, at least since the Roman times), in Abruzzo we can find evidence of an historical presence in the "Statute of Campli" from the 16th century (Finamore, 1893; Malasecchi, 1973). Albi (1915) dissertation is according that the name of Pescara City does derive from the word Pine in Byzantine Greek. Moreover, in the Chronicon Casauriense, a flumen piscariae meaning "the river of the pine forest", is mentioned; from the word, "Pefkos" (simplified in "Peskos"). This hypothesis was recently proved by Damiani (2007). The composition of Pescara coastal forest had probably a physiognomy similar to the *Coronillo emeroidis-Pinetum halepensis*, with parts of the *Pistacio-Pinetum halepensis* and shrub lands of *Myrto communis-Pistacietum lentisci* and *Pistacio lentisci-Juniperetum oxycedri*. In the past centuries, people normally did not use roads but small boats to move along the coast because the forest was so impenetrable. There are some nautical charts indicating "local" shipping routes allowing the transfer from the fluvial port to the inner areas. The first known cartographic representations concerning the ancient coastal pine forest of Pescara (1550 to1650) locate it from the mouth of Pescara river up to Salino river (*Cumara flumen*), with an extension that could be estimated to at least 10,000 hectares covering the whole territory in which today we have Pescara and Montesilvano; extended from the seashore to the hills, occupying the inner land area up to about 400 meters above sea level. It is never represented in the southern part of Pescara river may be because of humidity and clayey soil do not foster its diffusion assuming a "mosaic" aspect, with scattered pines among the broadleaf trees. However, the coastal pine forest of Pescara was covering more or less the whole territory in which today we have the Pescara conurbation. Nevertheless, the old maps show that it extended to the North, up to the river Vomano. No evidences of pine nuts collection here, exclude a significant presence of *Pinus pinea* in this area, reinforcing the idea that the central arboreal element of the Pescara coastal forest was the *Pinus halepensis*. Also the presence of *Pinus pinaster* subsp. *pinaster* is to be considered less characteristic and sporadic for the Pescara coastal pine forest, because as among the maritime pines it can be defined as "the least Mediterranean". The documents analysed up to now make inconsistent the hypothesis of an artificial origin of the ancient pine forest. Recent analysis of the ribosomal DNA, carried out comparing several specimens of *Pinus halepensis* from Francavilla to Pineto with others from various Italic locations, including also Dalmatia, seem to confirm that Abruzzo coast specimens have unique genetic features (Damiani, 2007). The ancient forest, now reduced to residual scrubs surrounded by roads and buildings, in the past represented probably the proper element of the area and the entire landscape. The old forest that somehow influenced the poet D'Annunzio is now reduced to residual scrubs surrounded by buildings and roads. Only the so-called "Pineta Dannunziana" survives as a significant entity; it has been largely reforested (between XIX and XX centuries) also with *Pinus pinea* that is now historicized. The area is managed by the Municipality of Pescara with various difficulties and criticalities, despite being declared "Natural Reserve". According to Damiani (2007), the area looks more like a public garden than a protected area, being subject to further actions of disturbance and erosion of biodiversity. Some parts of the forest today are also affected by the urbanization: the original level of the ground is now lower than the surrounding areas that have been elevated and filled with digging material in order to construct buildings. These areas have become wetter than normal and pines suffer or die, being replaced by elms and other species. More at the north, also the pine forest "Pineta di Santa Filomena", can be listed among the last parts of the ancient pine forest. It is now looking more as public garden, although it is classified as a "Natural State Reserve". The Ministerial administration and the Forestry State Corps have partially eliminated the forest and in some case they substitute *P. halepensis* with *P. pinea* and broadleaves.

The dynamics occurred in the last 50 years in Pescara's park "Ex-Caserma di Cocco" prove how the *Pinus halepensis*, without any anthropic disturbances, could autonomously regain many space by simple secondary succession, recreating evocative landscapes and creating picturesque scenery with trees which reiterate after lying on the ground (Colazilli *et al*. 2014). Other residuals of the ancient littoral pine forest can be currently identified in the territories of Roseto, Pineto, Silvi, Montesilvano Colli, Pescara Colli, Francavilla e San Giovanni Teatino, and more other small nuclei and scattered trees elsewere.

The problem of the indigenous or not status of some conifer species is still open in Italy, instill this is a problem too subjective, to become sometimes an irrelevant issue, given the historical ties and the widevalence for the territory of these species. The presence of *Pinus halepensis* in Italy is considered indigenous

[5] Also known as *Liber instrumentorum seu chronicorum monasterii Casauriensis*. Document from the 12th century. Preserved at the Bibliothèque nationale de France (French national Library), Paris.

in almost every region, including Abruzzo (see also: Conti *et al*., 2005; Conti, 1998; Pignatti, 1982; Agostini, 1964; Brilli-Cattarini, 1965, 1967; Zodda, 1967; Francini-Corti, 1953). As for the other regions, in Abruzzo its presence is sometimes considered questionable only at a local level, due to prejudice or to its use for reforestation. Same authors had often included too general or contrasting considerations. The first study, regarding the vegetation of the "Pineta Dannunziana", documented with field surveys, dates back to the early 80's of the last century (Tammaro & Pirone, 1981), followed by explanations of the unique aspects present in that forest (Pirone, 1983, 1985, Pirone *et al*., 2001). Around Pescara, the *P. halepensis* grows in two different bands, distinct for geomorphology and substrate: the first is the silty and sandy coastline; the second are the geological hills formations, dominated by Pliocene clays (Pirone, 1985). Pirone (2014) also confirms the presence in the Abruzzo of the *Coronillo emeroidis-Pinetum halepensis*, plant association described by Allegrezza *et al*. (2006) for the Marche and Abruzzo, giving more value to *Pinus halepensis*. This species extended itself also inland generating remarkable forests, sometimes with other species, mainly *Quercus pubescens* and *Q. ilex*; situations not necessarily always climax, where *P. halepensis* tend to dominate mostly on the more hard areas (Pedrotti, 1982), like in Umbria, (according to Pirone 1985 and Damiani, 2007). These environments, whatever their origin, are important surfaces, often with remarkable forest structure and with wonderful trees and large specimens. Remarkable examples of this, can be found, in the areas surrounding Rosciano, Val Pescara, Gole di Tremonti, Valle del Tirino, Valle Peligna, Valle del Sagittario and Gole di San Venanzio (see also: Damiani 2007; Cianfaglione and Di Felice, 2012), where they insist rocks, steep slopes and parasteppe areas. It would be also interesting to know if the *Pinus halepensis*, has never gone further inside; for example in the area of Pescina, where among other things they insist arid parasteppe areas or supramediterranean tendencies. In some cases, at first glance, it is not possible to understand if a pine forest is from natural or anthropic origin. Even when it can be understood by their planting order, these forests show the presence of interesting natural dynamics with important historical and cultural consequences that fully legitimize their presence. Therefore, the reforestation, both in the coast and the inland, should be considered more as a re-introduction, or as semi-natural environments of various interests. The phytosociological research is leading to new proposals, such as the new order *Pinetalia halepensis* on the *Pinus halepensis* and *Pinus pinea* forests, including also the "long-established plantations" present within their natural area of occurrence (Biondi *et al*, 2014). Unfortunately, in Abruzzo, like other regions, we are instead witnessing the elimination or destruction of pine forests, sometimes due to excess of prejudice, sometimes as a result of questionable forestry works. These are publicly funded operations or European projects which theoretically would serve for fire prevention or re-naturalization, but, for the way are carried out, they prove to be speculative, only to take advantage of funding or to get easily virgin biomasses for energetic purposes; jeopardizing the renewal and affirmation of the deciduous trees and the undergrowth. Sometimes fires, as seen for example in the Gole di Tremonti and in various parts of Val Pescara and Valle Peligna, in one hand they can promote the regeneration of *Pinus halepensis*, while destroying the physiognomy of the forest; and in other hand, favoring the erosion and the input of species such as *Ailanthus altissima*. As seen, if these fires would be lit too often or if the areas would be "cleaned up" or left for pasture (of wild or domestic animals), there is an high risk of eliminating the renovation capability, degenerating these woods into something different. This could be a further example of how these ancient forests may have easily disappeared.

At the beginning of the nineteenth century, following the subversive laws of feudalism, many communal or feudal forests were divided and privatized. They were suddenly cleared to be put under cultivation. Many coastal forests and lowland woods were destroyed in order to favor the formation of small private properties and expand the cultivated fields. Other woods were dismembered after the unification of Italy for the same socio-economic reasons. Even the construction of the Abruzzo Railways caused the destruction of the last coastal forests, for various reasons; the wood of the genus *Quercus* was the most sought for the construction of railway ties; where other woods such as beech (*Fagus sylvatica* subsp. *sylvatica*), chestnut (*Castanea sativa*) and conifers were used more marginally. On the coastland up to this period was remaining also a large oaks forest, from some species: mainly to the group of the pubescent oak (*Quercus pubescens* s.l.) with stretches even substantial characterized by the presence of *Q. robur* and also by the presence of *Q. petraea* and *Q. cerris*. These large and dense oak forests, covered a huge part of the northern Abruzzo coast (mostly flat) and many of the most fertile areas and valley bottoms (more orographic), like the inland. Now disappeared, but some huge descendant trees persist as a proof of that, together with toponyms and collective memories. For example, in the locality "Selva Alta", of the of Mosciano Sant'Angelo Municipality, the people have handed the memory of a very extended forest in the area, with huge trees, and which is famous for an interesting anecdote dating from the 19th century, when Garibaldi's army arrived in the area, many prisoners escaped from the jails of Teramo and some

of them were able to get away, eluding the scent of the Two Sicilies Kingdom gendarmerie dogs, by covering the all way from Teramo to Giulianova (almost 24 km as the crow flies) through the branches of the trees without touching the ground. This story, regardless of the truth, gives a tangible idea of the dimensions of that ancient forest. Today the residuals of this ancient forest are represented by a large *Q. pubescens* s.l. tree, known as "Quercia Regina" (Queen Oak), together with many other oaks derived from the ancient ones. Also the *Q. dalechampii* has been reported for the coastland, but it is considered as a doubtful species due to the variability of the features observed (Bussotti & Grossoni, 1997). Concerning the holm oaks (*Q. ilex* subsp. *ilex*), the only forest still present today (with big surfaces) is the famous one in Torino di Sangro, albeit reduced, disturbed, coppiced, adjusted and fragmented by time. In fact, the areas with *Q. ilex* have been altered in order to be suitable for cultivation and pasture, to produce firewood and coal. More recently, also because of urbanization and tourism activities. Romanelli (1790), referred also about *Q. suber* trees used for the production of cork in Chieti; and whose presence seems to be confirmed by the analysis of pollen and remains of wooden fragments found in a cistern of the Byzantine age in Crecchio (Sciò, 1993). As for other species, the cork oak (*Q. suber*) can be considered as typical, mostly like native, although it might have been cultivated in the area in the past. Manzi (2012) underlines the existence of some toponyms still present today in the coastal area of Chieti, that seem to refer to trees producing cork; in agreement of another trace, the presence of *Q. crenata*, living in different areas and listed by Conti (1998) and that pertain both to the coast and the inland. The *Q. suber* has not been currently reported in the flora of Abruzzo (Conti, 1998). The nineteenth century was also the period of the reclamation of many humid retrodunal areas, especially around the mouths of the rivers Sangro and Trigno. Some coastal ponds were filled, including those in Vignola and Vasto. The low and sandy coast of Teramo, when pasture servitude was abolished, underwent a profound transformation driven by the construction of the railway. The coastal areas were acquired by middle-class families, coming also from Marche, in order to be reclaimed to boost the agricultural production, often by entering into sharecropping contracts. There was also the beginning of a process of urbanization of the coastal zone with the foundation of new and densely populated urban areas (i.e. Roseto, Pineto, Alba,), destroying huge surface of dunes areas. Azonal forests of the coast were almost eliminated. In a few residual areas where they are trying to re-expand, sometimes with a remarkable presence of *Juglans regia*, even in the industrial zones; struggling against anthropic works, the competition with exotic species, the incorrect cleaning of the waterways, the cuts made to obtain virgin biomasses for the production of energy and the erroneous policies of land management, such as the elimination of the forest along the southern bank of the mouth of the river Tronto, promoted by the local administrations, not for the collection of wood, but in an attempt to deter prostitution.

Between the 19th and the 20th century, Abruzzo (as the rest of Italy) started to witness concretely all the ethical and practical issues regarding the distress of the territory (Orsini & Manzi 2012; Scimia, 2013; Colazilli & Cianfaglione 2014). In the same period, appeared along the coast of Abruzzo, the famous "Città Giardino" (Garden Cities), with villas and gardens; made known by prominent personalities such as Gabriele D'Annunzio and Francesco Paolo Michetti, together with the members of the "Cenacolo Michettiano di Francavilla al Mare", portrayed the coastal landscape until the '40s, '50s. There was an expansion concerning the use of various exotic species (mainly for decoration), species that today can characterize the coastal area in various ways. There was also a strong boost for reforestation and for the creation of public gardens (Ville comunali[6,7,8,9]). On the Coastal line *Eucalyptus* spp. were also planted (isolated or as reforestation) which are now historicized, reaching a certain ecological and historical-cultural interest, despite being threatened and sometimes destroyed by recent and actual urbanization and by the latest expansion of tourist activities. This eucalyptus is appreciated in the study area by farmers and beekeepers, it is not manifested as invasive, while having a good regenerative capacity after fires.

The reforestation, was a good intervention for soil protection, with its own characteristics and importance (Cianfaglione, 2011; 2014), and that should be seen as a source for biogeographical, historical and sociocultural study. Nevertheless, these formations have become important and famous in their own way: the best known today is the pine forest of Pineto, planted in the early XX century by the Filiani family, which became the fortune of the namesake town, although it is somehow losing its appeal due to the excessive urbanization, as often happens with other planted coastal

[6] Postcard. 21st November 1889. Document preserved in the Historical State Archive of Pescara, envelope 2523, file 4.
[7] 28th July 1903: letter from the State Forestry Administration to the Major of Castellammare Adriatico regarding a "sample of forest plants for the purpose of reforestation". Original document preserved in the Archivio Storico di Stato (Historical State Archive) of Pescara, envelope c.a. 18, folder 8. And following.
[8] 4th April 1914: from the Royal Forestry Corps, Forest Inspectorate of Teramo, District of Penne, Brigade of Farindola, to the Major of Castellammare Adriatico. Original document preserved in the Archivio Storico di Stato of Pescara, envelope 2393, folder 05.
[9] 15th January 1921: postcard from the Royal Forestry Corps to the Major of Pescara. Archivio Storico di Stato of Pescara, envelope 177, folders 8 and 19.

pine forests (Colazilli & Cianfaglione, 2014). Another example is the famous pine forest heavily modeled by the wind (Foresta a bandiera), with remarkable blooms of *Fraxinus ornus* subsp. *ornus* and *Cercis siliquastrum* subsp. *siliquastrum*, at the east entrance of the Gole di Tremonti. Between XIX and XX centruries, the coastal area still retained significant aspects as pleasing scenery; the poet Gabriele d'Annunzio in his poem "I pastori" (The shepherds), describes his memories of the Pescara Adriatic coast, even "wild and green as the pastures of the mountains", from his "Sogni di terre lontane" (Dreams of distant lands) opera. In the period between the two world wars, most of the area was already bound to agriculture and pastoralism; although now the ancient forests were almost completely gone and the reclamation almost all made. Popular cities were made primarily of farmers, fishermen and ranchers, while the "città giardino" were made of noble, wealthy, middle class and cultured people. The town of Pescara prepares a remarkable series of reforestation and planting of trees for ornamental purposes, along the streets of the city; in this regard there are a huge number of documents, archived in the State Historical Archives of Pescara, that attest the plants received by the municipality from various Italian nurseries.

Afterwards, as a result of the explosion of tourism, on the coast of Abruzzo concrete substituted nature. Today it is however possible to find cultivated or abandoned agricultural areas characterized by the growth of reeds (of *Arundo donax*, *A. plinii* s.l., or *Phragmites australis* subsp. *australis*), scrubs like tamarisk (*Tamarix* spp.) groves and also reforestations. A similar scenario is characteristic of some environments on the Conero Mountain in the Marche region and the Gargano Mountain in Puglia (Tassi, 1968; 1971). Finally, a last consideration should be made about the formations of *Robinia pseudoacacia* and the *Ailanthus altissima*: now well represented on the coast, being favored by human disturbance, they are dangerous when competing with indigenous formations. However, sometimes they represent the only possible example of vegetation in the most anthropized and degraded environments of the coast that, otherwise, should be exploited for productive purposes, while saving more worthy of protection locations.

Conclusion

The coast of Abruzzo, from the Roman period to the present days, has faced an alternation between anthropization and abandonment, but every time the anthropization has been significantly higher than the previous re-naturalization. The presence of coastal forests of various types is documented through texts and maps showing evidence of how the area was covered by dense and large "Selve" alias forest of various types: coniferous and broadleaved; which were very important for the local population during the history as an integral part of an economy largely made up by non-wood products. It can be noted how the transfer of public areas to private entities, the overbuilding and a strong use of the land has led to changes the environment that have compromised the aesthetic landscape, together with the slope's stability and the biodiversity, reducing and altering the biotic communities and populations and often causing the extinction of animal and plant species, according to Pirone & Conti (1996) and Conti & Pirone (1996). Over the centuries, the changes of the coastal vegetation of Abruzzo have been so deep and massive that the ecosystems were strongly altered. Today there are only small rests of the ancient forests, always remodeled in some way. However, there is still a consistent activity associated to the exploitation of the natural resources of the coastal area. The evidence of the ancient vegetation are rare today, but they still represent the potential vegetation of Abruzzo coastal line. Further analysis of fossil pollen, would be needed to clarify and learn about various details of the past vegetation. The problem of the indigenous or not status of some conifer species is still open in Italy, instill this is a problem too subjective, to become sometimes an irrelevant issue, given the historical ties and the wide-valence for the territory of these species. The Mediterranean conifers need to be considered as key species for Italian coastlands, in any case, unlike some prejudices that can sometimes be revealed about them and not as the same time with other species of the same level. In particular *Pinus halepensis*, for the Abruzzo is demonstrate to represent a really typical species, with a general high value: in environmental, historical and cultural sense. The pine forests can represent habitats of European Community interest; including also those of artificial origin. By protective, economic and social purposes in which reasons they were planted, these particular and delicate forests have been under progressive evolution until the present day, in which it is clear the priority of the role of this forest ecosystems as caskets for biodiversity, conservation and the protection of the territory. As for the others kind of ancient disappeared forests and environments would be interesting to promote policies to safeguard or recovery them, guaranteeing up to the stage of fluctuation, at least within small representative patches. As is the case of the dunes of San Salvo, where various dunal species once extinct was re-planted and now they are in re-expansion independently and successfully.

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