PLANT COMMUNITIES ON COASTAL DUNES IN LAZIO (ITALY)

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ABSTRACT - Aim of the paper is to describe the conservation state of the dune plant communities of Lazio (central Italy), using both original and already published phytosociological relevés. This case study in particular analyses the effects of human disturbance on the species composition and the vegetation zonation in coastal sandy landscape, already classified in three land facets. 13 plant associations were recognised and 9 of them were identified as potential natural vegetation types for the sandy coastal ecosystems of Lazio. Incidence of ruderal species and alien taxa were calculated for each plant community and for each land facet. The results have produced evidence that, even if Lazio coastline is largely occupied by human settlements or infrastructures, several sites still preserve an high plant communities diversity and few alien taxa inside the natural habitats occur. On the contrary where the human impact is intense, dune plant communities disappear or if they are still present, the vegetation zonation is incomplete, ruderals are abundant and alien species are locally common. A data-base of dune plant diversity was realised for a monitoring purpose.

KEY WORDS - Coastal dunes, ruderal and alien species, potential vegetation zonation, phytosociology.

INTRODUCTION

In Italy, dynamic changes along the coastline are strongly influenced by the extraction of gravel in the rivers, as well as by human settlements and harbour constructions. Consequently impressive phenomena of erosion of dune-beach system occur.

Coupled with these phenomena are the effects of current global climatic change, which produces an increase in the sea-level and an acceleration of the coastal erosion, with a consequent water invasion of low littoral zones and of coastal marshes (Warrick *et al.*, 1993; Barange & Harris, 2003). These processes have a considerable effect on dune ecosystems, such as the fragmentation of the plant populations, with a risk of local extinction of species or plant communities, the entry of other species

or communities belonging to other ecosystems, as well as the invasion of alien species (Leatherman, 1989; Chapin *et al.*, 2001).

Therefore, the knowledge of the current vegetation zonation as well as of the bioindicators of environmental alterations should be increased, by completing various actions of monitoring with the aim of having under control the fragile equilibrium that regulates these ecosystems.

With this objective, a hierarchical land classification (Blasi *et al.*, 2000) allows the identification of definite but discrete homogenous units for environmental vocation and potential natural vegetation, in which it is possible to differentiate management interventions. For the Lazio sector of the sandy coast of central Italy, it was proposed a hierarchical land classification that recognises one system, three land facets and three environmental units (Acosta *et al.*, 2003a).

For the same stretch of coast, researches about vegetation are constituted from different phytosociological works on the more widespread psammophilous plant communities (Marinucci *et al.*, 1980; Géhu *et al.*, 1984; Lucchese & Pignatti, 1990; Biondi, 2000; Vagge & Biondi, 1999; Filesi & Ercole, 2000, Acosta *et al.*, 2000b). Only on the littoral of the Circeo National Park, the floristical and structural features of the dune communities, in sectors at different levels of disturbance, are in this specific case study analysed (Acosta *et al.*, 2000a, Acosta *et al.*, 2003b; Acosta *et al.*, in press).

Regarding the evaluation of naturalness of the coasts, several studies have been carried out by various Italian authors (Arrigoni et al. 1985; Géhu *et al.*, 1984; Pignatti, 1993; Géhu & Biondi, 1994a; Conti & Pirone, 1996; Adamoli *et al.*, 1997; Biondi, 1999) as well as international authors (e.g. van der Maarel, 1993; Curr *et al.*, 2000; Kutiel, 2001; van der Maarel, 2003).

In this paper we analyse the current conservation state of dune plant communities in Lazio coastline by using phytosociological information and evaluating the incidence of ruderal and alien taxa, and the coherence between current and potential vegetation zonation. A data-base for a monitoring of plant diversity in sandy coastal ecosystems was realised.

Study area

The Lazio coast extends for 250 km along the Tyrrhenian Sea (from 42°23' N-11°39' E to 41°11' N-13°20' E), and it is composed of sandy shores as well as rocky headlands and fluvial mouths. Recent dunes (Holocene) generally occupy a narrow strip along the sea-shore, mostly in contact with ancient dunes (Pleistocene) as well as contact with alluvial or lacustrine deposits. The Lazio coastal dune system presents a relatively simple structure which is formed by embryo-dunes, followed by a main mobile dune ridge and a fixed dune ridge. Complex dune systems are only found on the southern part of the river Tiber delta (Castelporziano). The climate is Mediterranean, and varies from meso-Mediterranean dry sub-humid climates to thermo-Mediterranean sub-humid climates (Blasi, 1994; 1998).

The landscape of the sandy Lazio coastal dunes was analysed by Acosta *et al.*, (2003a) following the hierarchical land classification approach (Blasi *et al.*, 2000). The classification scheme of Lazio sandy coast consists of 3 Land Facets: recent

coastal dunes under meso-Mediterranean dry/sub-humid climate (L.F. 1.1.1), recent coastal dunes under meso-Mediterranean sub-humid climate (L.F. 1.1.2), and recent coastal dunes under thermo-Mediterranean sub-humid climate (L.F. 1.1.3).

Each land facet was sampled, and phytosociological relevés have been only carried out where dune ecosystems with vegetation are still present, as well as where some fragments of psammophilous communities have survived; the majority of these habitats have been proposed as Sites of European Community Interest, sensu EU Habitat Directive 43/92 (FIGURE 1): 1-p S.I.C Montalto di Castro (L.F. 1.1.1); 2-p S.I.C. Tarquinia-Cerveteri (L.F. 1.1.1); 3-p S.I.C. Litorale romano National Reserve (L.F. 1.1.2); 4-p S.I.C. Castelporziano Reserve (L.F. 1.1.2); 5-p S.I.C. Tor Paterno Capocotta (L.F. 1.1.2); 6-Torvaianica (L.F. 1.1.2); 7-p S.I.C. Lavinio (L.F. 1.1.2); 8-p S.I.C. Torre Astura (L.F. 1.1.2); 9-p S.I.C. Circeo National Park (L.F. 1.1.3); 10-p S.I.C. Sperlonga beach (L.F. 1.1.2).

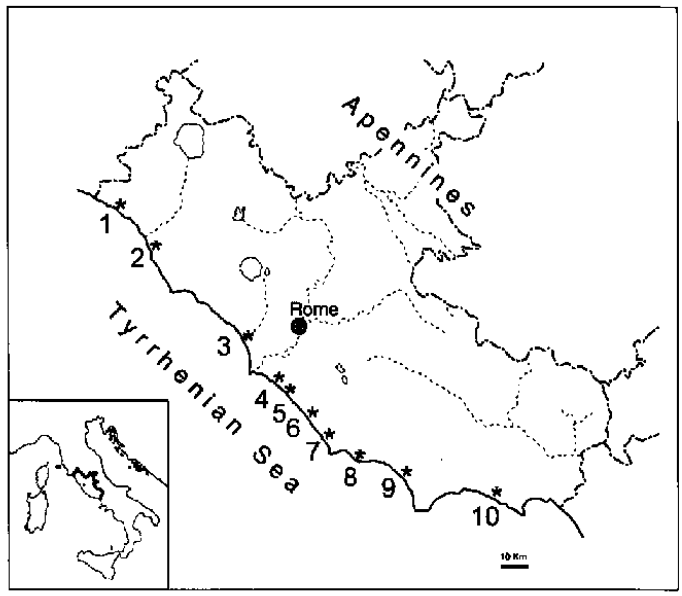

FIGURE 1 - Location of sampled sites (for site names see chapter of study area)

MATERIAL AND METHODS

Two matrixes of phytosociological data for Lazio sandy coasts were realised, one for the vegetation of the beach and mobile dunes and another for the woody vegetation of back dunes. These matrixes contains 235 phytosociological relevés of which 154 are original (carried out between 1999 and 2002) and 81 already published (Géhu *et al.*, 1984; Lucchese & Pignatti, 1990; Vagge & Biondi, 1999, Filesi & Ercole, 2000; Biondi, 2000).

The matrixes were processed by cluster analysis using chord distance and average linkage methods, for binary as well as for the quantitative data (Podani, 1998). For each plant community, syntaxonomy and geographical distribution in the study area were analysed. Moreover, for each plant association the percentages of ruderal

and alien species on the total census of species, for the community in each land facet, were calculated. Synoptic table (species X relèves) were realised, using the frequency scale (V=81-100%, IV=61-80%, III=41-60%, II=21-40%, I=1-20%).

For each site studied, the coherence between the current vegetation zonation (CVZ) and the potential vegetation zonation (PVZ) was deduced calculating the ratio between the number of the VNP communities present in the site, and the expected total number of the VNP communities.

For awarding the categories of ruderal and alien taxa, we referred to already published papers (Pignatti, 1982; Géhu & Biondi 1994a; Géhu & Biondi 1994b; Tammaro & Pirone, 1979; Viegi *et al.*, 1974; Viegi, 1998) and to personal observations.

Taxa nomenclature follows Anzalone (1994; 1996) and Anzalone *et al.*, (1997). Syntaxa nomenclature follows the syntaxonomical synthesis realized by Biondi (1999) and by Diez Garretas *et al.*, (2003), it also refers to the rules of the Phytosociological Code (Weber *et al.*, 2000).

RESULTS

The cluster analysis applied to the data matrix has allowed to recognise the following 13 plant communities. For each association a short description of the conservation state is reported.

Salsolo kali-Cakiletum aegyptiacae (TABLE 1: column 1): the annual community of the beach, within the sea storm mark, is strongly influenced by coastal erosion as well as from summer tourism. Along Lazio coastline, it is rather sporadic as it has been largely eliminated because of the mechanical cleaning of the beaches as well as of the processes of withdrawal of the shoreline. The *Cakiletum* is only very well represented in the land facet 1.1.1 (Filesi & Ercole, 2000). It is the community more interested in the invasion of alien species, especially *Xanthium italicum*, whereas ruderal species are almost absent (FIGURE 2).

Site N°	Land Facets	Sal-Cak	Ech-Ely	Ech-Amm	Cru mar	Sil-Ono	Eri-Seh	Asp-Jun	Pis-Rha	Vib-Que	Coherency CVZ/ PVZ (%)
1	1.1.1	+	+	+	-	+		+	+	+	89
2		+	+	+	.	.		+	.	.	44
3	1.1.2		+	+		+	+	+	.	+	66
4		.	+	+		+	+	+	+	+	78
5		.	+	+	.	.	+	+	+	+	67
6		.	.	.	.	.		+	.	.	11
7		+	+	+	+	+		+	+	+	89
8		-	+	+	-	.		.	+	+	67
9	1.1.3	+	+	+	.	+		+	+	+	78
10		+	+	+	.	.		+	.	+	55
Occurrence for each association (%)		60	90	70	30	50	30	90	60	80	

FIGURE 2 - Distribution of the plant associations in the Lazio coast. For a location of the sites look at FIGURE 1.

Echinophoro spinosae-Elytrigetum junceae (TABLE 1: column 2): the association of embryo-dunes is subjected to trampling and to the removal caused by summer tourism, and it is influenced by the withdrawal of the coast line. In Lazio, it is rather frequent but the *Elytrigia juncea*-communities in a better condition are present in the land facet 1.1.3, meanwhile in the others, their floristical and structural integrity is compromised. It is often invaded by alien species, such as *Carpobrotus acinaciformis/edulis* and *Xanthium italicum*. Some ruderal taxa as *Centaurea sphaerocephala, Arundo plinii, Raphanus raphanistrum* also occur.

Echinophoro spinosae-Ammophiletum australis (TABLE 1: column 3): It is the community makes stable the mobile dunes; in Lazio region, it is rare and often not well structured. It is frequently affected by trampling and by the contraction of the dune-beach system, caused by processes of marine erosion and principally by the levelling of the dunes for enlarging the bathing area on the beach. Anyway, it can be found locally in a good state in all the three land facets. The ruderal species are occasionally present with a higher incidence in the land facets 1.1.1 and 1.1.2, e.g. *Hordeum murinium* and *Silene niceensis*. Alien species are very rare.

Crucianelletum maritimae (TABLE 1: column 4): coenosis of interdunes of the mobile dunes, which was found only in the land facets 1.1.1 and 1.1.2, meanwhile, in other studied sites, it is replaced by annual grasslands and open *Crucianella*-communities dominated by *Pyonocomon rutifolium*. Ruderal and alien species (*Agave americana*) only occasionally occur. It is currently quite rare in Lazio region, and this is caused by the anthropic alteration of dune morphology and by erosive phenomena.

Pycnocomo-Crucianelletum maritimae (TABLE 1: column 5): it is a replacement community of *Crucianelletum maritimae*, linked to dune habitat disturbances, caused by the proximity to roads and pedestrian crossings, it is quite frequent in Lazio coastline. Several annual species like *Silene canescens, Cutandia divaricata, Vulpia fasciculata* often occur; furthermore some ruderal species as *Hordeum murinum, Plantago lanceolata, Silene niceensis* are present.

Sileno-Ononidetum variegatae (TABLE 1: column 6): it is an annual grassland playing a double role in the geosigmetum of embryo-and mobile dunes, it in fact occupies the natural gaps of the other perennial psammophilous communities and it replaces the other plant associations, when these are eliminated. The association has been described for Tunisian coasts and is probably distributed within the central and southern Mediterranean basin.

It is in a good state of conservation within the land facets 1.1.1 and 1.1.3 whereas it is richer of ruderal species within the land facet 1.1.2.

Vulpio fasciculatae-Silenetum coloratae (TABLE 1: column 7): that annual community is linked to a high human disturbance which consists of trampling and enrichment with nitrogen. It includes several ruderal taxa which are trampling resistant such as *Anagallis arvensis, Polycarpon tetraphyllum, Parantucellia viscosa, Chondrilla juncea.*

Asparago acutifolii-Juniperetum macrocarpae (TABLE 2: column 1): it is a woody community of stable grey dune and is quite abundant in Lazio. The high resistance against the disturbance of this pioneer macchia allows its persistence in many sites. In case of pronounced erosion of the coastline, it occurs in direct contact with the beach, with evident signs of leaf alteration due to the salt winds. The

high incidence of ruderal species, within the land facets 1.1.2 and 1.1.3, is caused by the human disturbance produced by coastal pedestrian crossings on the almost fixed dunes. The alien species which are occasionally present are *Carpobrotus aci-naciformis/edulis* and *Coniza canadensis*.

Phyllireo angustofoliae-Ericetum multiflorae (TABLE 2: column 2): it represents a regressive stage of *Juniperus phoenicea* macchia when it is thinned out. It occurs in Circeo National Park and at Sperlonga. Its survival is conditioned by the presence of consolidated dunes, which have to be scarcely disturbed and preceded by a pioneer juniper macchia, as it grows sheltered from the salt winds. Alien and ruderal species are absent.

Where juniperus brushwood has been thinned out by fires the garigue *Helychryso stoechadis-Cistetum eriocephali* takes place; dominant species are *Cistus creticum* subsp. *eriocephalus, Helychrysum stoechas, Rosmarinus officinalis, Dorycnium hirsutum*. It was firstly described on the Roman coast (Biondi 2000), but it was also found on the northern and southern coast of Lazio.

Pistacio lentisci-Rhamnetum alaterni (TABLE 2: column 3): it is the macchia of the fixed dunes, which occupies the narrow strip of the vegetation zonation between the *Asparago acutifolii-Juniperetum macrocarpae* and the *Viburno-Quercetum ilicis* communities. In the few areas where it was found, it is very well preserved both from a floristic and structural point-of-view, and its presence depends upon the survival of an intact vegetation zonation of the mobile dunes. Ruderal species are only present in the land facet 1.1.2, meanwhile alien species are absent.

Viburno tini-Quercetum ilicis (TABLE 2: column 4): it is the evergreen wood of back dunes. Because of its closed structure, the ruderal species are only occasionally present, and it is resistant to the invasion of alien species. In Lazio it has become rare because of the tourism exploitation and coastal building, as well as the planting of pine reforestation. The *Quercus* ilex-wood is enriched with deciduous oaks, such as *Quercus suber, Q. virgiliana, Q. cerris*, within the transition zone towards the deciduous forest of the hinterland. In case of contact with the coastal lagoon environment, the subass. *quercetosum roboris* occurs, with differential species *Quercus robur* (Stanisci *et al.*, 1998).

In the interdunal depressions, which are seasonally humid, some cane thickets of *Eriantho-Schoenetum nigricantis* have been also found. They have become rather rare due to the human alterations of their habitat. In Lazio they occur on the Roman coastal reserve (Lucchese & Pignatti, 1990). The ruderal species *Inula viscosa* often is present, as a demonstration of the human pressure on these humid residual interdunes.

Analysing the distribution pattern of the nine mature plant associations, which represent the PNV of Lazio sandy coast, it can be highlighted that in each land facet, there are some sites where at least more than 70% of the PNV communities occur (FIGURE 2: sites 1, 4, 7, 9). Anyway, in the analysed sites, the coherence between the current vegetation zonation (CVZ) and the potential vegetation zonation (PVZ) is quite high (64%), with certain exceptions concerning exploited coastal sectors, where the vegetation zonation is strongly impoverished (FIGURE 2: sites 6 and 2).

The associations PNV *Crucianelletum maritimae* and *Eriantho-Schoenetum nigricantis* are more rare, occurring in only 30% of the studied sites.

Analysing the incidence of ruderal and alien species in the PNV communities along the Lazio coast, there are clear indications of the effects of human disturbance on the dune ecosystem for each land facet (FIGURE 3).

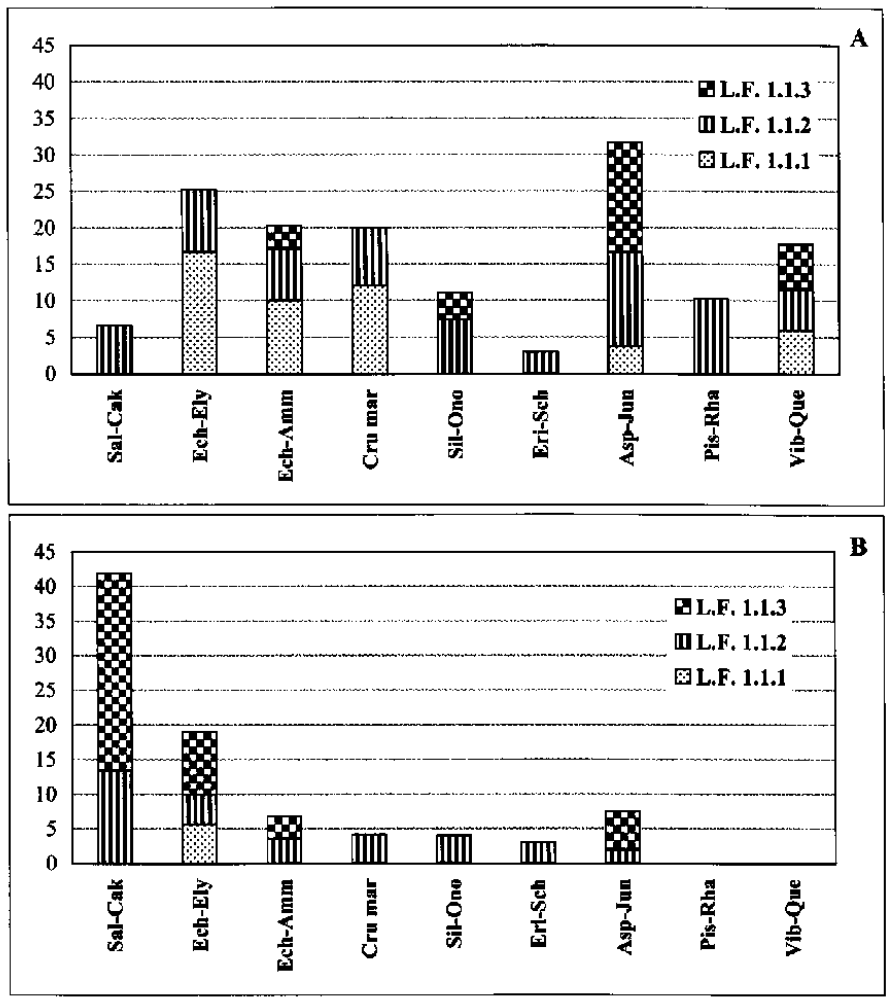

FIGURE 3 - Incidence of the ruderal species (a) and of the alien species (b) within the potential natural vegetation of the Lazio coast.

Regarding the invasive alien species, it is important to note that their incidence is higher on the beach as well as on embryo-dunes, and is principally due to the presence of *Xanthium strumarium* subsp. *italicum* and *Carpobrotus acinaciformis/edulis*; the phenomenon mainly occurs in the land facet 1.1.3 and subordinately the land facet 1.1.2. On the inside of the juniper macchia, only *Agave americana* is found in a more opened-area and nearer to roads. There is therefore evidence of a gradient from the beach towards the internal dunes, with a higher occurrence of alien species where the stress of marine aerosol is stronger and the vegetation cover is lower.

Regarding the presence of the ruderal species, such as *Silene italica, Anagallis arvensis, Bromus rigidus* subsp. *ambigens, Plantago lanceolata, Polycarpon tetra-*

phyllum, Sherardia arvensis, their frequency is higher in the juniper macchia and in the *Elytrigia* community. Ruderal species are more abundant in the land facet 1.1.2, which is more strongly influenced by the flux in tourism from Rome and is more occupied by residential settlements.

The high incidence of Mediterranean ruderal taxa can be linked to ancient human disturbance in the Mediterranean basin, as they have evolved withstanding human disturbance, just as has been highlighted for the urban flora of the Mediterranean cities (Celesti Grapow & Blasi, 1998; Pignatti, 1995).

Discussion

Considering the coherence between the potential and the current dune vegetation zonation, and the incidence of ruderal and alien species for each land facets, it is important to note that the Lazio coast still maintains an high floristic and coenological diversity in the Nature 2000 sites (sites p.S.I.C). Anyway, sometimes the specific composition of the plant communities indicates an alteration in comparison with the phytosociological models.

The results of this work have produced evidence that the land facet 1.1.2 is more modified because the vegetation zonation is often incomplete and fragmented, ruderals are abundant and alien species are locally common within the sea-ward communities of the coastal vegetation zonation. On the contrary, the land facet 1.1.1 still presents a lot of sectors well preserved, with high plant communities diversity and few alien species.

The use of phytosociological data, associated with the hierarchical land classification of the landscape of dunes, has allowed a floristic-quantitative evaluation of the conservation state of natural coastal habitats. Furthermore, a database of coastal plant taxa and communities as reference frame for the monitoring of dune ecosystems was compiled.

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Riassunto

Viene analizzato lo stato di conservazione delle comunità vegetali delle dune costiere del Lazio (Italia centrale), utilizzando rilievi fitosociologici originali e già pubblicati. In particolare vengono valutati gli effetti del disturbo antropico sulla composizione specifica e la zonazione delle comunità dunali nei siti litoranei laziali dove permangono ecosistemi dunali, almeno parzialmente conservati.

Partendo dalla classificazione gerarchica del paesaggio costiero già precedentemente svolta (Acosta *et al.*, 2003), viene valutato lo stato di conservazione degli ecosistemi dunali per ciascun sot-

tosistema di paesaggio, sulla base dell'incidenza di specie ruderali e specie esotiche nelle comunità vegetali, e della coerenza tra la zonazione reale della vegetazione e quella potenziale.

Vengono riconosciute 11 associazioni vegetali, delle quali 9 costituiscono le tappe mature della sequenza catenale dunale del litorale sabbioso laziale. Nonostante l'alto grado di antropizzazione del litorale sussistono ancora diversi siti, per lo più proposti come Siti di Importanza Comunitaria (Direttiva Habitat 43/92), che mantengono un'alta diversità di comunità vegetali e sono scarsamente interessati dall'invasione di specie esotiche e ruderali. Al contrario, dove l'impatto antropico è più forte, si registrano una zonazione vegetazionale profondamente alterata e l'ingresso di specie ruderali ed esotiche nelle comunità vegetali. È stata allestita una banca dati della flora e della vegetazione dunale per avviare un programma di monitoraggio del sistema spiaggia-duna nel Lazio.

APPENDIX 1-SYNTAXONOMICAL SCHEME

CAKILETEA MARITIMAE Tüxen et Preising ex Br.-Bl. et Tüxen 1952

Euphorbietalia peplis Tüxen ex Oberdorfer 1952, *Euphorbion peplis* Tüxen ex Oberdorfer 1952

**Salsolo kali-Cakiletum aegyptiacae* Costa et Manzanet 1981

EUPHORBIO PARALIAE-AMMOPHILETEA AUSTRALIS Géhu et Géhu-Franck 1988

Ammophiletalia Br.-Bl. 1933, *Ammophilion australis* Br.-Bl. 1921 corr. Rivas-Martínez, Costa et Izco in Rivas-Martínez, Lousã, Díaz, Fernández-González et Costa 1990

**Echinophoro spinosae-Elytrigietum junceae* Géhu 1988 corr. Géhu 1996

**Echinophoro spinosae-Ammophiletum australis* (Br.-Bl. 1921) Géhu, Rivas-Martínez et Tüxen in Géhu 1975

Crucianelletalia maritimae Sissingh 1974, *Crucianellion maritimae* Rivas-Goday et Rivas-Martínez 1958

**Crucianelletum maritimae* Br.-Bl. 1933

**Pycnocomo rutifolii-Crucianelletum maritimae* Géhu, Biondi, Géhu-Franck et Taffetani 1987

QUERCETEA ILICIS Br.-Bl. ex A. et O. Bolòs 1950

Quercetalia ilicis Br.-Bl. ex Molinier 1934, *Quercion ilicis* Br.Bl. ex Molinier 1934

**Viburno tini-Quercetum ilicis* Br.-Bl. (1915) 1936

Pistacio lentisci-Rhamnetalia alaterni Rivas-Martínez 1975, *Oleo-Ceratonion* Br.-Bl. ex Guinochet et Drouineau 1944

**Pistacio lentisci-Rhamnetum alaterni* Bolòs 1970

Juniperion turbinatae Rivas-Martinez 1975 corr. 1987

**Asparago acutifolii-Juniperetum macrocarpae* (R. et R. Molinier 1955) Bolòs 1962

**Phyllireo angustifoliae-Ericetum multiflorae* Arrigoni, Nardi et Raffaelli 1985

ROSMARINETEA OFFICINALIS Br.-Bl. 1947

Rosmarinetalia officinalis Br.-Bl. ex Molinier 1934, *Cisto eriocephali-Ericion multiflorae* Biondi 2000

**Helychriso stoechadis-Cistetum eriocephali* Biondi 2000

HELIANTHEMETEA GUTTATI (Br.-Bl. in Br.-Bl., Roussine et Nègre 1952) Rivas Goday et Rivas-Martínez 1963, *Cutandietalia* Rivas-Martinez, Diez-Garretas & Asensi in Rivas-Martinez *et al.*, 2002, *Alkanno-Maresion nanae* Rivas-Goday 1958 corr. Costa, Diez-Garretas, P.Soriano & Perez-Badia in Perez-Badia 1997

**Sileno coloratae-Ononidetum variegatae* Géhu et Géhu-Franck 1987

**Vulpio fasciculatae-Silenetum coloratae* Pignatti 1953 corr. Diez-Garretas & Asensi 2003

JUNCETEA MARITIMI Br.-Bl. in Br.-Bl., Roussine et Nègre 1952

Juncetalia maritimi Br.-Bl. ex Horvatic 1934, *Plantaginion crassifoliae* Br.-Bl. in Br.-Bl., Roussine et Nègre 1952

**Eriantho-Schoenetum nigricantis* (Pignatti 1953) Géhu 1984

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TABLE 1 - Synoptic table of herbaceous vegetation of embryo-and mobile dunes

Reference number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Total number of relèves	**16**	**40**	**37**	**18**	**24**	**13**	**11**
Mean species richness	**6**	**8**	**8**	**11**	**11**	**10**	**12**
Salsolo kali-Cakiletum aegyptiacae							
Euphorbion peplis, Euphorbietalia peplis, Cakiletea maritimae							
Cakile maritima	V	II	I	I	.	I	.
Polygonum maritimum	IV	I	.	.	.	I	.
Salsola kali	V	I	.	.	.	.	.
Chamaesyce peplis	II	I	.	.	.	.	.
Salsola soda	I	.	.	.	.	.	.
Atriplex latifolia	I	.	.	.	.	.	.
Atriplex tatarica	I	.	.	.	.	.	.
Echinophoro spinosae-Elytrigetum juncene							
Medicago marina	I	III	II	II	I	II	II
Echinophora spinosa	II	IV	III	I	II	I	.
Elytrigia juncea	V	V	IV	IV	IV	III	.
Otanthus maritimus	II	III	I	.	.	.	.
Echinophoro spinosae-Ammophiletum australis							
Calystegia soldanella	.	III	III	II	II	II	.
Ammophila arenaria subsp australis	.	.	V	II	I	.	.
Ammophilion australis, Ammophiletalia australis							
Eryngium maritimum	I	III	II	I	I	III	.
Euphorbia paralias	II	I	I	.	.	.	I
Crucianelletum maritimae							
Crucianella maritima	.	I	II	V	III	I	.
Pycnocomo rutifolii-Crucianelletum maritimae							
Lotus cytisoides	.	I	II	.	V	I	II
Pycnocomon rutifolium	.	I	I	.	IV	I	.
Teucrium capitatum	.	.	.	.	I	.	.
Crucianellion maritimae, Helichryso staechadis-Crucianelletalia maritimae							
Cyperus capitatus	I	II	II	V	IV	IV	II
Euphorbia terracina	.	I	II	II	III	.	I
Pancratium maritimum	.	III	III	V	.	III	I
Daucus gingidium	.	.	I	I	I	II	II
Reichardia picroides	.	.	I	II	II	.	II
Plantago macrorrhiza	.	I	.	I	.	II	I
Helichrysum stoechas	.	.	I	I	.	.	I
Euphorbio paraliae-Ammophiletea australis							
Sporobolus virginicus	II	IV	II	IV	IV	III	I
Anthemis maritima	I	II	V	V	V	V	III
Sixalix atropurpurea subsp maritima	.	.	I	II	I	.	III
Aetheorhiza bulbosa	.	.	I	I	I	.	.
Silene coloratae-Ononidetum variegatae							
Ononis variegata	.	I	I	II	II	V	IV
Phleum arenariuam	.	I	I	I	II	IV	II
Vulpio fasciculatae-Silenetum coloratae							
Vulpia fasciculata	.	I	I	III	II	I	V
Bromus rigidus subsp ambigens	.	.	I	II	II	.	IV
Alkanno-Maresion nanae, Cutandietalia, Helianthemetea guttati							
Silene canescens	.	I	II	II	V	IV	V
Cutandia maritima	.	I	I	I	II	III	II
Medicago littoralis	.	.	I	III	II	III	V
Pseudorlaya pumila	.	I	.	I	.	II	IV
Lagurus ovatus	.	.	I	III	.	I	II
Plantago coronopus	.	.	I	.	III	II	III
Phleum subulatum	.	.	.	.	I	I	I
Cutandia divaricata	.	.	.	I	III	.	I
Reference number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Hedypnois rhagadioloides	.	.	.	.	I	.	I
Medicago minima	.	.	.	.	.	I	I
Maresia nana	.	.	.	.	.	.	I
Malcolmia ramosissima	.	.	.	.	.	.	I
Arenaria serpyllifolia	.	.	.	.	.	.	I
Catapodium marinum	.	.	.	.	.	.	II
Trifolium campestre	.	.	.	.	.	.	I
Trifolium cherleri	.	.	.	.	.	.	I
Trifolium glomeratum	.	.	.	.	.	.	I
Trifolium nigrescens	.	.	.	.	.	.	I
Trifolium resupinatum	.	.	.	.	.	.	I
Trifolium scabrum	.	.	.	.	.	.	I

Lobularia maritima	.	.	.	.	.	.	II
Trigonella gladiata	.	.	.	.	.	.	I
Euphorbia exigua	.	.	.	.	.	.	I
Hymenocarpus circinnatus	.	.	.	.	.	.	I
Hypochoeris radicata	.	.	.	.	.	.	I
Linum strictum	.	.	.	.	.	.	I
Medicago rigidula	.	.	.	.	.	I	.
Romulea columnae	.	.	.	.	.	.	I
Rostraria litorea	.	.	.	.	.	.	I
Vulpia ciliata	.	.	.	.	.	.	I
Vulpia myuros	.	.	.	.	.	.	I
Companions							
Carpobrotus acinaciformis/edulis	I	I	I	.	I	.	.
Centaurea sphaerocephala	.	I	.	I	.	I	I
Juniperus oxycedrus subsp macrocarpa	.	.	I	I	I	.	I
Smilax aspera	.	I	I	I	.	.	I
Xanthium italicum	II	I	.	.	.	II	.
Arundo plinii	I	I	I	.	.	.	.
Rubia peregrina	.	.	I	I	.	.	I
Silene niceensis	.	.	I	III	I	.	.
Clematis flammula	.	I	.	.	I	.	.
Orobanche artemisiae-campestris	.	.	.	I	I	.	.
Phillyrea angustifolia	.	.	.	.	I	.	I
Hordeum murinum	.	.	I	.	I	.	.
Raphanus raphanistrum	.	I	.	.	.	I	.
Portulaca oleracea	I	.	.	.	.	.	.
Quercus ilex	.	.	.	.	I	.	.
Senecio leucanthemifolius	.	.	I	.	.	.	.
Agave americana	.	.	.	I	.	.	.
Anagallis arvensis	.	.	.	.	.	.	I
Asparagus acutifoiuls	.	.	I	.	.	.	.
Carex flacca	.	.	.	.	.	I	.
Chondrilla juncea	.	.	.	.	.	.	I
Cistus salvifolius	.	.	.	I	.	.	.
Crithmum maritimum	.	I	.	.	.	.	.
Dorycnium hirsutum	.	.	.	.	.	.	I
Geranium purpureum subsp.purpureum	.	.	I	.	.	.	.
Holcus lanatus	.	.	.	I	.	.	.
Imperata cilindrica	.	.	.	I	.	.	.
Lonicera implexa	.	.	.	.	.	.	I
Parantucellia viscosa	.	.	.	.	.	.	I
Plantago lanceolata	.	.	.	.	I	.	.
Polycarpon tetraphyllum	.	.	.	.	.	.	I
Sherardia arvensis	.	.	.	.	.	.	I
Silene otites	.	I	.	.	.	.	.
Vicia pseudocracca	.	.	.	.	.	.	I

TABLE 2 - Synoptic table of woody vegetation of back dunes

Reference number	**1**	**2**	**3**	**4**
Total number of relévés	**36**	**7**	**15**	**18**
Mean species richness	**13**	**13**	**10**	**14**
Asparago acutifolii-Juniperetum macrocarpae				
Daucus gingidium	III	I	I	I
Juniperus oxycedrus subsp macrocarpa	V	IV	I	.
Prasium majus	III	.	I	I
Phyllirea angustifoliae-Ericetum multiflorae				
Osyris alba	I	III	I	I
Cistus salvifolius	I	III	I	I
Rosmarinus officinalis	I	III	.	.
Erica multiflora	.	V	.	.
Juniperion turbinatae				
Juniperus phoenicea	II	V	I	II
Dorycnium hirsutum	II	III	.	.
Tamus communis	I	II	.	.
Pistacio lentisci-Rhamnetum alaterni				
Rhamnus alaternus	IV	III	IV	I
Phillirea angustifolia	II	V	V	.
Oleo-Ceratonion, Pistacio lentisci-Rhamnetalia alaterni				
Rubia peregrina	IV	III	IV	IV
Clematis flammula	III	I	III	IV
Asparagus acutifolius	IV	III	IV	V

Table 2 (continues)				
Reference number	**1**	**2**	**3**	**4**
Malus sylvestris	.	.	I	I
Salix atropurpurea subsp. maritima	I	I	.	.
Spartium junceum	I	.	.	I
Teucrium chamaedrys	I	I	.	.
Viola suavis	.	.	I	I
Carpobrotus acinaciformis/edulis	I	.	.	.
Coniza canadensis	I	.	.	.
Aetheorhiza bulbosa	I	.	.	.
Acer monspessulanum	.	.	.	I
Ammophila arenaria subsp.australis	I	.	.	.
Anagallis arvensis	I	.	.	.
Anthemis maritima	I	.	.	.
Arabis sagittata	I	.	.	.
Arenaria leptoclados	.	.	I	.
Arisarum vulgare	.	.	.	I
Arum italicum	.	.	.	I
Asphodelus fistulosus	.	.	I	.
Brachypodium retusum	I	.	.	.
Brachypodium sylvaticum	.	.	.	II
Bromus rigidus subsp.ambigens	I	.	.	.
Calamintha nepeta	I	.	.	.
Carex flacca	.	.	.	I
Celtis australis	.	.	.	I

Pistacia lentiscus	V	V	III	V	Cephalanthera longifolia	.	.	.	I
Daphne gnidium	III	III	II	I	Cercis siliquastrum	.	.	.	I
Arbutus unedo	II	V	1	III	Cistus monspeliensis	I	.	.	.
Smilax aspera	V	IV	V	V	Coronilla emerus	.	.	.	I
Teucrium flavum	I	I	.	.	Crucianella maritima	I	.	.	.
					Daphne sericea	.	I	.	.
Viburno tini-Quercetum ilicis					Dianthus sylvestris subsp. longicaulis	I	.	.	.
Viburnum tinus	I	.	I	II	Elytrigia juncea	I	.	.	.
Phillyrea latifolia	.	.	I	V	Fraxinus ornus	.	.	.	I
Myrtus communis	.	.	I	II	Geranium robertianum subsp purpureum	I	.	.	.
Cyclamen hederifolium	.	.	.	I	Halimium halimifolium	.	.	.	I
Cyclamen repandum	.	.	.	III	Helichrysum stoechas	II	.	.	.
Carex hallerana	.	.	.	I	Laurus nobilis	I	.	.	.
Rosa sempervirens	.	.	.	I	Ligustrum vulgare	.	.	.	I
Quercus suber	.	.		I	Limodorum abortivum	.	.	I	.
Quercus virgiliana	.	.	.	II	Linaria purpurea	I	.	.	.
Asplenium onopteris	.	.	.	I	Melica uniflora	.	.	.	I
					Oryzopsis miliacea	.	.	.	I
Quercion ilicis, Quercetalia ilicis, Quercetea ilicis					Phleum arenarium	I	.	.	.
Quercus ilex	III	V	V	V	Pinus halepensis	.	I	.	.
Lonicera implexa	V	V	II	II	Pinus pinaster	.	.	I	.
Carex distachya	I	I	I	II	Plantago lanceolata	I	.	.	
Hedera helix	I	I	III	V	Pulicaria odora	.	.	.	I
Erica arborea	I	I	I	II	Pyrus pyraster		.	.	I
Ruscus aculeatus	I	.	III	IV	Quercus cerris	.	.	.	I
					Quercus frainetto	.	.	.	I
Companions					Rubus hirtus	I	.	.	.
Cistus creticus subsp eriocephalus	II	II	I	I	Senecio lividus	I	.	.	.
Pteridium aquilinum	I	I	I	I	Sherardia arvensis	I	.	.	.
Teucrium capitatum	I	II		I	Silene italica subsp italica	I		.	.
Pinus pinea	I	.	I	I	Silene otites	I	.	.	.
Rubus ulmifolius	I	.	I	I	Sonchus oleraceus	I	.	.	.
Centaurium erythraea	I	I	.	.	Sorbus domestica	.	.	.	I
Crataegus monogyna	.	.	I	II	Sporobolus virginicus	I	.	.	.
Lagurus ovatus	I	II	.	.	Ulmus minor	.	.	.	I
Lotus cytysoides	I	.	.	I					