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Andrea Bertacchi, T. Carducci, Tiziana Lombardi (*)

ECOLOGICAL AND PHYTOSOCIOLOGICAL ASPECTS OF FOREDUNE VEGETATION IN A NEOGENIC BEACH OF TUSCANY COAST (ITALY)

Abstract - *Ecological and phytosociological aspects of foredune vegetation in a neogenic beach of Tuscany coast (Italy).* An investigation of foredune vegetation along 2 km stretch of coast of North West Tuscany (Italy) has been conducted. This area has geomorphological features that are peculiar and different from the rest of the sandy shores of the Tuscan coast. The current beach of about 22 ha, is the result of recent deposits (from the early decades of the last century), resulting from the production of soda and mainly made from waste carbonate ($CaCO_3$ mainly) that are still discharged into the sea from a chemical factory nearby the coast. Thus, a marked progradation of this stretch of coastline, with a major development of dune vegetation in contrast with neighboring coastal areas, resulted. The vegetation analysis and zonation of plant communities show strong anomalies when compared with dune habitats of the nearby beaches. It has been noted that associations typical of ephemeral and embryonic dune such as *Salsolo-Cakiletum* and *Echinophoro - Elymetum*, are almost absent. These characteristic associations have now been replaced with extended surfaces of *Sporobolus virginicus* and an anomalous distribution of *Echinophoro-Ammophiletum.* This seems partly due to the significant human interference but also to the particular type of substrate. When human interference is absent and the soil type changes, we see the recovery of the typical zonation.

Key words - dune habitats, sands, substrate, ecology, dune vegetation, *Sporobolus*

Riassunto - *Aspetti ecologici e fitosociologici della vegetazione di duna in una spiaggia neogenica della costa toscana (Italia).* È stata studiata la vegetazione psammofila della "foredune" di un tratto di costa lungo 2 km del Nord Ovest Toscana (Italia). Questo settore costiero ha caratteristiche geomorfologiche molto particolari e diverse dal resto delle coste sabbiose della costa toscana. L'attuale spiaggia di circa 22 ettari, è infatti il risultato di depositi recenti (dai primi decenni del secolo scorso), derivati dalla produzione di soda, prevalentemente a base di carbonati ($CaCO_3$ principalmente), che somo tuttora scaricati dallo stabilimento chimico Solvay nel tratto prospiciente alla spiaggia. Da ciò deriva una progradazione marcata di questo tratto di litorale, con uno sviluppo importante di vegetazione dunale in controtendenza rispetto ai settori costieri limitrofi, anche se l'analisi della vegetazione mostra forti anomalie. È stata rilevata la quasi totale assenza delle associazioni tipiche della duna effimera e embrionale quali il *Salsolo-Cakiletum* e *l'Echinophoro-Elymetum*, che risultano prevalentemente sostituite da estesi popolamenti monofitici di *Sporobolus virginicus* e una distribuzione anomala dell'*Echinophoro-ammophiletum*. Ciò sembra in parte dovuto alla forte pressione antropica ma anche al particolare tipo di substrato. Infatti ove è assente la pressione antropica e mutano le caratteristiche pedologiche, si assiste alla ripresa di una normale zonazione.

Parole chiave - habitat dunali, sabbia, substrato, ecologia, vegetazione dunale, *Sporobolus*

Introduction

Phytocenosis that populate the beach-dune system are strongly conditioned, in their attendance, spread and coverage, by the physical and chemical characteristics of the substrate, by micro-topography and by system modifications as sea erosion or anthropic disturbance (Ranwell, 1972; Hesp, 2008; Bertacchi *et al.*, 2009; Ercole *et al.*, 2007).
Those kinds of plant populations usually occur along an ecological gradient that develops from the shoreline to inland, following a well-defined zonation (Pignatti, 1993; Acosta *et al.*, 2007). Particularly interesting from a naturalist point of view and with ecological relevance are the inhabitant populations of the foredune, or rather the areas between the shore line and the dunal *cacumen* (Barbour, 1992). This is because they are formed by psammophilous species suited to living in particularly hostile environments and because they form plant communities deputies to build the dunal system and his morphological maintenance (Doody, 2013). In this context is possible to find some associations that define three essential habitats (sensu Directive 92/43/EEC): *annual vegetation of drift lines* (H1210), *embryonic dunes* (H2110), *mediterranean white dunes* (H2120).
The three main associations (*Salsolo kalii-Cakiletum maritimae, Echinophoro spinosae-Elymetum farcti, Echinophoro spinosae-Ammophiletum arundinaceae*) (Pignatti, 1993) that respectively feature the three habitat mentioned above, are often flanked by sub-associations, variants, facies, or others local or less common associations (Biondi & Galdenzi, 2014).
Often the attendance and the distribution, as well as the floristic cortege of these associations, are supposed to be an indicator of the conservation state or, on the contrary, of the decay of the beach-dune system (Acosta *et al.*, 2000; Bertacchi & Lombardi, 2014).

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As part of studies on psammophilous environments of Tuscany's coast, the dunal populations observed in a part of sandy littoral denominated "white beaches", in Vada (LI), has highlighted evident alteration in spread and coverage. This is mainly because of a high anthropic pressure caused by seaside fruition and by the contextual seasonal operations of beach cleaning (Bertacchi *et al.*, 2010). Nevertheless, in the area where these operations do not occur, because of a bathing restriction that makes the beach inaccessible, there is the most pronounced peculiarity of this dune vegetation landscape.
The aim of this research was to investigate this unusual vegetation landscape in relation to the modification of the coastline, to anthropogenic changes and the particular type of substrate.

Study area

The study area is situated on the coastal part (43° 22' 46. 44" N ; 10° 26' 29 13 E) that goes from Rosignano Solvay to Vada (Li, Tuscany), commonly known as *white beaches,* referring to the white sand color of this coast. The area is bordered by "Punta del Lillatro" in the North and by "Pennello di Pietrabianca" in the South. It covers a length of 2,2 km, a depth that ranges between 50 and 120 m and a total surface of about 22 ha (Bertacchi *et al.*, 2010) (Fig. 1).
The beach-dune system of this coastal part is described as "beach and dunes of white carbonate sand of industrial origin (1920-now)" and has to be considered a neo-genic formation beach (Squarci, 2002). Here the coast is affected by a longshore drift headed south and there is no significant input of a natural sediment source.
The only river is the Fine River that flows into the middle of the area and brings an irrelevant quantity of sediment source. Mainly clay type, this sediment source is not adequate for the amount of the actual pedological arrangement and for the progradation rhythm of the shoreline. The only significant input of sediment comes from the carbonate sand dump which is industrial in origin and is brought by the Solvay factory through a waste water canal, the "Fosso Bianco"(literally the White Trench) (Pranzini, 1978).
With an approximate estimated mass flow rate of suspended solid from 130.000 to 200.000 tons circa per year, through this trench the waste of the soda production flows into the sea. The waste is mainly made by Calcium Carbonate (limestone) and, in smaller quantities by Calcium Sulfate (gypsum) and Magnesium Sulfate (Cheli &Luzzati, 2010).
From the termo-pluviometrical data of the closest meteorological station in Collemezzano (Cecina) is possible to obtain the yearly average depth of the

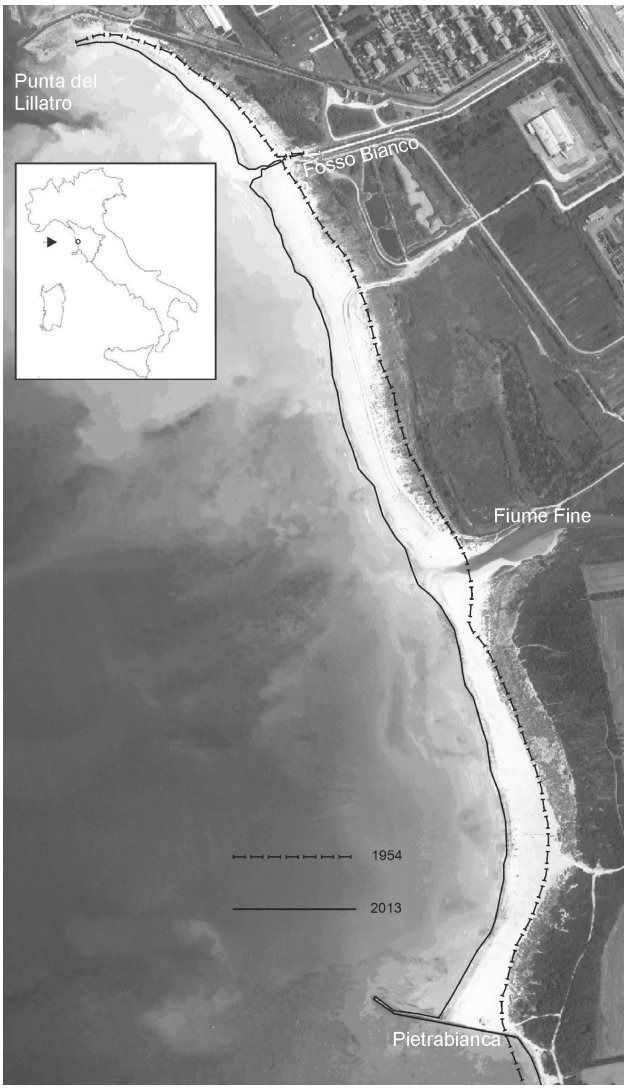

Fig. 1 - Location of the study area and of the shoreline in 1954 and in 2013.

rainfall, pertaining to the years 1989-2010. It is about 790 mm with a maximum of rainfall in Autumn, an average temperature of 15,2°C and a period of Summer dryness with a water deficit from June to September.
According to Rivas Martinez's bioclimatic classification (2004), the area belongs to the Mediterranean macrobioclimate, low meso-mediterranean belt and low sub-humid ombrotype.
The *white beaches*, despite their industrial origin and their proximity to a big factory such as Solvay establishment, attract a large number of tourists with a high surface exploitation during the Spring and Summer season.

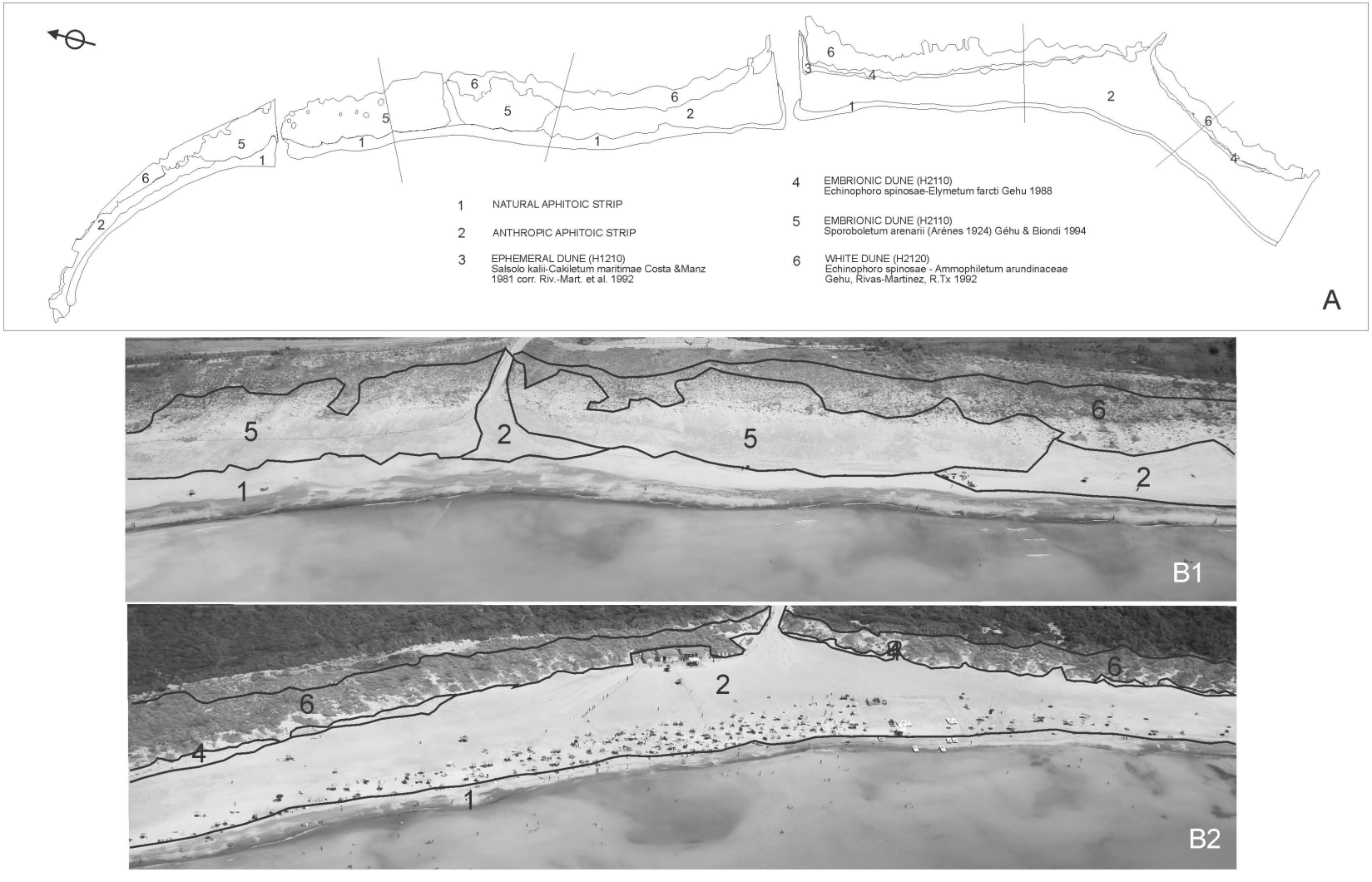

Fig. 2- A: landscape map of the study area; B1: angolate view of the north stretch; B2: angolate view of the south st retch (aerophotos by courtesy of U.S.-P.D.S.C.-LI)

METHODS

The plant associations and the concerning habitats of the *foredune* have been mapped using photo interpretation with aerial imagery from WMS Geoscopio platform (Regione Toscana), with GIS MapInfo® and with field analysis. Two other spatial typologies, distinguishable in the system, have been mapped: the natural aphytoic strip that is naturally free from vegetation, and the anthropic aphytoic strip where psammophile vegetation could potentially live, but doesn't because of the human activity (Bertacchi *et al.*, 2009). For the vegetation analysis, 30 phytosociological surveys have been collected, using the sigmatist school method from Zurigo-Montpellier (Braun-Blanquet, 1979). The surveys have been taken only on the psammophilous vegetation coverage of the foredune, excluding the inland areas of the stabilized dunes. The vegetation data collected have been subjected to a multivariate analysis procedure using the software Syntax (Podani, 2001). The (29 species x 30 surveys) matrix has been analyzed according to Cluster Analysis, using UPGMA algorithm and the Brian/Curtis similarity measure.
The subsequent surveys processing and the comparison with the literature data has enabled the assignment of syntaxonomical characterisation to every vegetation unit collected. The collected plants' nomenclature follows Conti *et al.* (2005) and Pignatti (1982).
For the soil analysis, 12 sand samples have been collected at a depth range from 20 to 30 cm in 3 different sectors of the study area in relation with the dunal typologies investigated (*annual vegetation of drift lines, embryonic dune, mediterranean white dune*) plus 3 other samples in the inland stabilized dune to have some reference values out of the foredune. The following analysis has been made of the samples: Granular Composition (soil texture), determined by sieving; Carbonates (ISO 10693); pH (ISO 10390); Electrical Conductivity (ISO 11265); Organic Matter estimated as loss-on-ignition.

RESULTS

The geo-referenced superimposition of the cartographic aerial photos taken between 1954 and now has highlighted a shoreline progradation to a maximum of about 90 mt, with a beach spatial increase of about 15 ha. From the resulting cartography of the area, the contemporary landscape of the beach-dune system could be divided in: natural aphytoic area (2,5 ha; anthropic aphyotic area (9,5 ha); *annual vegetation of drift*

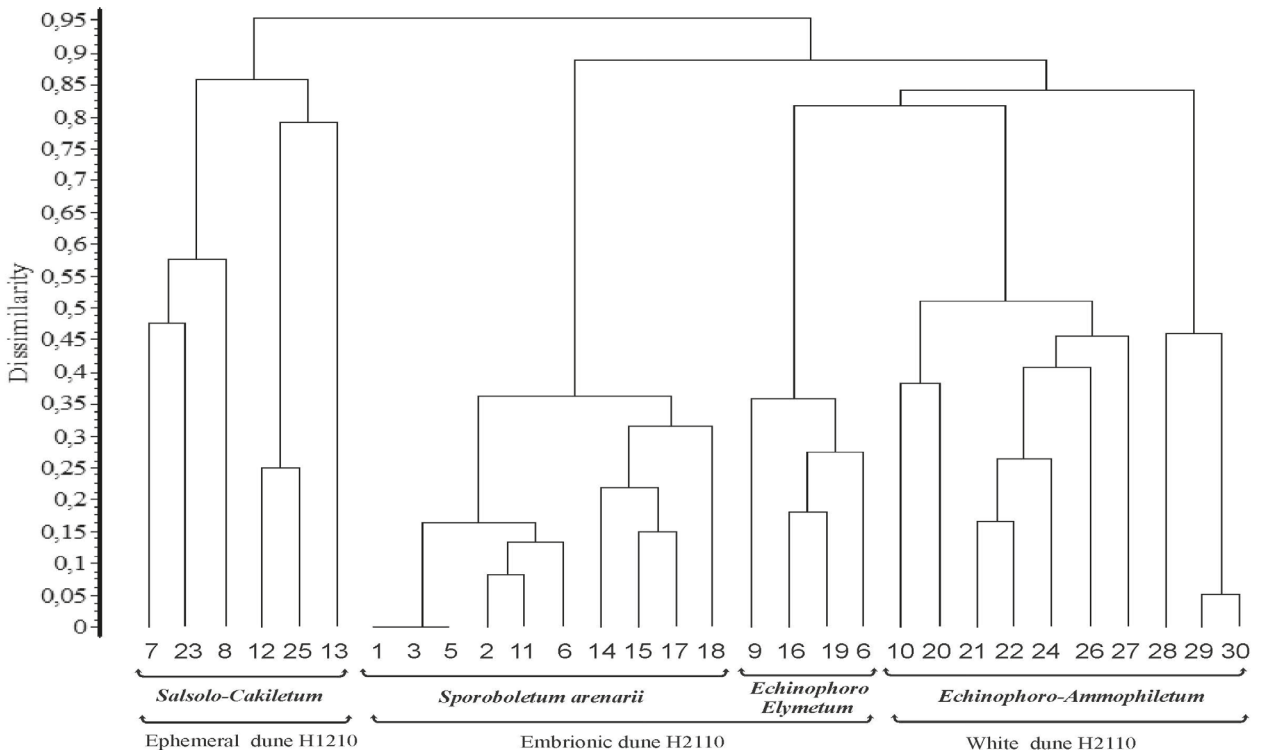

Fig. 3 - Cluster Analysis graphic applied to the 30 surveys.

lines (H1210) (0,16 ha); *embryonic dune* (H2110) (2,3 ha); *mediterranean white dune* (H2120) (3,8 ha) (Fig. 2). The vegetation characteristics of the area could be better observed in a more detailed way, integrating the phytosociology survey's data (Tabb. 1,2,3,4) with the statistic elaborations summarized in the graphic of the Principal Coordinate Analysis (Fig. 3). Cluster analysis divides with sufficient significance four different phytocenosis typologies belonging respectively to *annual vegetation of drift lines*, *embryonic dune*, with two significant variations and to the *mediterranean white dune*. From phytosociological point of view, the vegetation typologies identified and diversified by topographical localization, are the follows:

ANNUAL VEGETATION OF DRIFT LINE (H1210)
- *Salsolo kalii-Cakiletum maritimae* Costa & Manz 1981 corr. Riv.-Mart. *et al.* 1992

EMBRYONIC DUNE (H2110)
- *Sporoboletum arenarii* (Arénes 1924) Géhu & Biondi 1994
- *Echinophoro spinosae-Elymetum farcti* Géhu 1988

WHITE DUNE (H2120)
- *Echinophoro spinosae - Ammophiletum arundinaceae* Géhu, Rivas-Martinez, R.Tx 1992

The spatial distribution of the anthropic aphytoic strip appears uniformly distributed along all the area, according to the depth reached by the beach and, excluding the mouth of the Fine, it seems to be without interruptions (Fig.2). Otherwise, the different identified vegetation typologies seem to differentiate by total extension, distribution, and partly by zonation. The *annual vegetation of the drift lines* is almost non-existent from a spatial point of view (total of 0,16 ha) and the association that characterizes it (*Salsolo kalii-Cakiletum maritimae*) seems to be extremely rarefied, with weak coverage and with the few species that naturally characterize it in a very small number (Tab.1).
The *embryonic dune*, from the vegetation point of view, is almost exclusively represented by *Sporoboletum arenarii,* while the *Echinophoro spinosae-Elymetum farcti,* representative association of this habitat and basically common and widespread in Tuscany coastline, here only occurs with marginal and insignificant coverage. In fact, the *embryonic dune*, in the foredune in the north of the Fine river, near the discharge channel of the carbonate solids is exclusively populated by *Sporoboletum arenarii*, while in the southern sector of the Fine river it occurs in a thin and discontinuous strip with *Elymus farctus* (Tabb. 2,3).
The granulometry of the sand samples collected highlighted as the pedological substrate is almost exclusively represented by fine sand ranged from 0,2 and 0,1 mm of diameter, without remarkable differences among all samples. These fine sands are almost

Dune strip		1(Eph)	2 (Emb)	3 (Whi)	4 (Fix)
CaCo3 (%)	a	96.7	95.4	93.3	n.p.
	b	96.3	96.6	92.4	85.3
	c	n.p.	91.0	91.4	74.4
O.M. (%)	a	0.0	0.29	0.33	n.p.
	b	0.0	0.23	0.34	1.10
	c	n.p.	0.34	0.60	1.16
pH	a	10.2	10.2	10.1	n.p
	b	10.2	10.2	9.9	9.4
	c	n.p.	9.5	9.6	9.2
Salinity (mS/cm)	a	5.4	0.32	0.34	n.p
	b	4.9	0.21	0.30	0.16
	c	n.p.	0.44	0.14	0.18

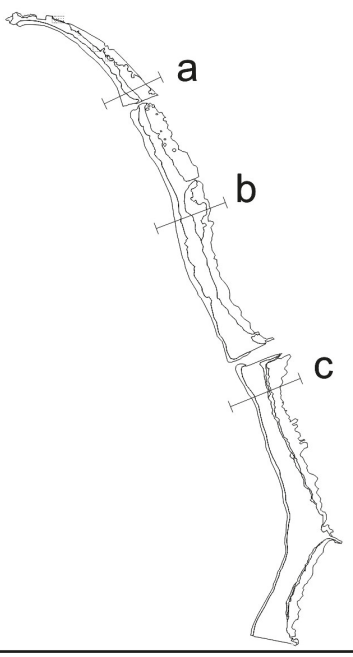

Fig. 4 - Analytic values of the sand samples (Eph: annual vegetation of drift lines; Emb: embryonic dune; Whi: white dune; Fix: Fixed dune; n.p.: not present).

Tab. 1 - *Salsolo kali-Cakiletum maritimae* Costa e Manzanet 1981 nom.mut. propos. in Rivas-Martínez et al. 2002

Survey n°	7	8	23	12	13	25
Metersa.s.l.	0.5	0.7	0.5	0.5	0.5	0.7
Sq.m	4	10	6	4	2	6
Total cover %	10	10	8	5	5	5
Species n°	3	6	2	2	1	1
Habitat	H1210	H1210	H1210	H1210	H1210	H1210
Cakile maritima Scop. subsp. *maritima*	r	r	1	r	r	+
Salsola kali L.	+	.	+	.	.	.
Atriplex littoralis L.	+	1	+	.	.	.
Xanthium orientale L. subsp. *italicum* (Moretti) Greuter	.	r	+		r	.
Elymus farctus (Viv.) Runemark ex Melderis subsp. *farctus*	.	.	+	.	.	.
Sporobolus virginicus Kunth	.	.	.	+		+
Euphorbia paralias L.	.	.	r	.	.	.

Tab. 2 - *Sporoboletum arenarii* (Arénes 1924) Géhu & Biondi 1994

Survey n°	1	2	3	5	6	11	14	15	17	18
Metersa.s.l.	1.5	2	2.5	2.5	1	2.5	1.5	2	2.5	2
Sq.m	6	12	12	6	10	6	10	6	6	6
Total cover %	45	80	80	80	50	10	50	45	60	60
Species n°	1	1	1	1	3	4	3	4	5	2
Habitat	H2110	H2110	H2110	H2110	H2110	H2110	H2110	H2110	H2110	H2110
Sporobolus virginicus Kunth	5	4	5	5	4	4	3	3	3	2
Elymus farctus (Viv.) Runemark ex Melderis subsp. *farctus*	.	.	.	.	+	r	1	r	+	.
Ammophila arenaria (L.) Link subsp. *australis* (Mabille) Lainz	.	.	.	.	.	.	.	+	1	1
Cakile maritima Scop. subsp. *maritima*	.	.	.	.			r		.	.
Calystegia soldanella (L.) Roem.&Schult.	.	.	.	.	+	.	.	.	.	.
Echinophora spinosa L.	.	.	.	.	.	.	.	+	r	.
Eryngium maritimum L.	.	.	.	.	.	r	.	.	.	.
Euphorbia paralias L.	.	.	.	.	.	+	.	.	.	.

entirely made by carbonate aggregation with fluctuating values, in the foredune, from 91 to 97%. Those values are averagely double compared to the other of the Tuscany's coastline and devoid of quartz (Anselmi *et al*., 1978). Only in the stabilized dune, do the values considerably decrease (74.4-85.3 %). The organic matter is always lower than 1%, reached also in the case of the stabilized dune. Salinity values, already quite low in the band of the *annual vegetation of the drift lines,* become irrelevant moving inland; pH registers values always definitely high, between 9,2 and 10,2 and basically uniform among the bands (Fig. 4).
These sands represent a singularity despite the average composition of the Italian shoreline sands, that, in their elevated difference in mineralogical composition, range between 20% and 80% of carbonate compounds with a relevant attendance of the quartz fraction (Audisio & Muscio, 2008).

Discussion

In literature is highlighted how the pounding, the permanence, the access or any cleaning, smoothing, shaping operations could influence the distribution of the psammophilous populations on sandy coastline,

Tab. 3 - *Echinophoro spinosae-Elymetum farcti* Géhu & Biondi 1988

Survey n°	9	16	6	19
Metersa.s.l.	0.5	1	1	1
Sq.m	6	6	6	6
Total cover %	8	10	10	10
Species n°	5	5	4	3
Habitat	H2110	H2110	H2110	DH2110
Elymus farctus (Viv.) Runemark ex Melderis subsp. *farctus*	1	1	1	1
Echinophora spinosa L.	+	+	1	+
Ammophila arenaria (L.) Link subsp. *australis* (Mabille) Lainz	+	+	+	+
Calystegia soldanella (L.) Roem.&Schult.	.	.	.	+
Euphorbia paralias L.	.	.	.	1
Hypochaeris radicata L.	+	.	.	.
Poligonum maritimum L.	+			
Sporobolus virginicus Kunth	+	r	.	.
Chamaesyce peplis (L.) Prokh.	.	+	.	.

in different and in more or less effective way (Curr *et al.*, 2000; Doody, 2013, Ciccarelli, 2014; Bertacchi & Lombardi, 2014). At the same time, the different dune phytocenosis and their zonation are strongly related to soil characteristics, as organic matter content, pH and salinity (Ranwell, 1972; Isermann, 2005; Frederiksen *et al.*, 2006; Fenu *et al.*, 2103).

In the coastal area investigated, in the same way as the other Tuscan sandy shoreline, the anthropic disturbance comes out constantly through the years, with the presence of an aphytoic strip that implies the impossibility of the evolution of a dune system and a normal zonation. The areas where the activities mentioned above occur for most of the year are superimposed, in large scale, with the one that should be occupied from some of the habitat as H1210 e H2120 that occur in absence of disturbance. Indeed the annual vegetation of drift lines (H1210) is almost non-existent and the embryonic dune (H2110) is only exclusively present in the north sector of the Fine River, while, on the south is only restricted to a thin and discontinuous strip.

Some photographic surveys taken in late Winter , before cleaning, in the south sector of the Fine, confirm the potential vegetation that could possibly grow here. In fact, these surveys have highlighted a reconstruction dynamic of the psammophilous vegetation with *Cakile maritima* and *Elymus farctus ,* in the large drift line in connection with the embryonic dune, successively transformed by the beach cleaning operations (Fig. 5).

Outside of the area of anthropic action or on the hedge, the white dune (H2120) seems to be the only partially conserved habitat.

However, in this case study, in the conditioning factors can also be highlight an other anthropogenic factor: an indirect factor releated to pedologic characteristics. Effectively in the North sector of the area investigated by us, where the cleaning operations are not prone to happen and there is a low presence of tourists, both *Cakiletum* and *Elymetum* are missing and it is possible to observe the prevailing development of only one vegetation association: *Sporoboletum arenarii* (Fig. 2a). In literature, *Sporoboletum arenarii* (Arénes, 1924) Géhu & Biondi, 1994 is often referred as an association that is possible to find from the halo-nitrophilous zone of the *Cakiletum* to the beginning of the embryonic dune, in particularly disturbed regions or where the penetration of the wave motion occurs (Gehu *et al.*, 1984; Biondi *et al.*, 2004). The presence of the association is already documented along the Tuscan coastline, but it has never been noted as being so extended and predominant.

In this area, this association seems to be the more representative of the embryonic band (87%, 2 ha circa), distributed from the drift line to the foredune *cacumen,* creating almost mono-specific populations (cfr. Tab. 1, Rill.1,2,3,5) (Fig. 6).

Although the analytical data of the sand samples could not be considered indicative of the entire system, compared with presence/absence of the *Sporoboletum,* there seems to exist a correlation between this association and this special kind of soil. Specifically, where the $CaCO_3$ and pH values are higher and, by contrast, the organic matter values are smallest. Independently when the typology of the dune is considered - annual vegetation of the drift line, embryonic or white – *Sporoboletum* seems to be the only association able to colonize the surfaces. This trend begins to stop with the decrease of the $CaCO_3$ and pH values. Therefore, even if in an extremely limited way, with the increase of the organic matter content in the mono-specific *Sporoboletum,* starts to penetrate other species, until these species are gradually replaced in the shared

Fig. 5 - Before (top) and after (bottom) the beach cleaning operations.

Fig. 6 - The large extension of *Sporoboletum arenarii* in the northern sector of the beach along the entire shape of the foredune .

Tab. 4 - *Echinophoro spinosae-Ammophiletum australis* (Br.-Bl. 1933) Géhu, Rivas-Martinez & R. Tx. 1972 in Géhu et al.1984

Rilievo n.	10	20	21	22	24	26	27	28	29	30
Survey n°	3	2.5	3	3	3	1.5	2	3	3	3
Elevation (m a.s.l.)	12	50	12	25	30	60	50	50	25	25
Sq.m	70	80	65	100	80	70	80	50	80	100
Total cover %	5	6	1	8	9	8	11	6		
Habitat	H2120	H2120	H2120	H2120	H2120	H2120	H2120	H2120	H2120	H2120
Ammophila arenaria (L.) Link subsp. *australis* (Mabille) Lainz	2	2	5	4	4	3	3	1	+	+
Echinophora spinosa L.	.	1	.	+	r	.	+	+	.	.
Anthemis maritima L.	.	.	.	.	.	.	1	.	.	.
Bromus madritensis L.	.	.	.	.	.	+	+	.	.	.
Calystegia soldanella (L.) Roem.&Schult.	.	.	.	.	.	r	+	+	.	.
Crepis vesicaria L. s.l.	.	r	.	.	.	.	.	.	.	.
Crithmum maritimum L.	.	.	.	.	+	.	.	.	.	
Cutandia maritima (L.) Barbey	.	.	.	r	.	.	.	.	.	.
Elymus farctus (Viv.) Runemark ex Melderis subsp. *farctus*	+	r	.	.	.	+	+	.	.	
Eryngium maritimum L.	1	.	.	.	+	+	r	.	.	.
Euphorbia paralias L.	.	+	+	+	1	+	.	.	.	.
Hypochaeris radicata L.	.	.	.	.	+	.	.	.	.	.
Limbarda crithmoides L. Dumort s.l.	+	.	.	.	.	.	.	.	.	.
Lagurus ovatus L. s.l.	.	.	.	.	+	.	.	.	.	.
Medicago littoralis Loisel	.	.	.	.	.	1	.	.	.	.
Pancratium maritimum L.	.	.	.	.	.	.	+	.	.	.
Reichardia picroides L. Roth	.	r	.	+	.	.	+	+	.	.
Solidago littoralis Savi	.	.	.	.	.	.	r	.	.	.
Spartina versicolor Fabre	.	.	.	.	.	.	.	2	4	4
Sporobolus virginicus Kunth	1	.	.	.	.	.	.	.	.	.
Urospermum dalechampii (L.) F.W.Schmidt	.	.	.	r	r	+	.	.	.	+
Vulpia fasciculata (Forssk.) Fritsch	.	.	.	r	+	.	+	+	.	.

dunal typology by *Elymetum* and by *Ammophiletum* on the white dune (Fig. 2, Fig. 4).
Salinity, that is slightly higher in the samples collected on the strip of the annual vegetation of drift lines, seems to be another selection element for *Sporoboletum* that however can also be found in the sectors of the embryonic dune and white dune, where the salinity values highly decrease (cfr. Fig. 4).
The vegetation landscape of the foredune in the *white beaches* seems to be deeply conditioned by anthropic action. Primarily because in all likelihood without the deposits of industrial origin the beach-dune system could not have developed. The strong progradation of the shoreline, in contrast with the important erosion process that is occurring in the neighboring coast and in the other part of the Tuscany (GNRAC, 2006), is undoubtedly connected with dump of the carbonatic industrial waste. In this particular context, an important coverage of psammophilous vegetation has evolved. Nevertheless the steady rearrangement of the beach has preventes the natural development on higher surface and the formation of new dune lines. Where this does not occur,

the particular kind of substrate influences the development of some defined phytocenosis more than others. In conclusion, from the data collected, it is possible to hypothesize a division of the human impact on the vegetation landscape of the white sands foredune of "white beaches". In one sector on the northern side of the Fine, the elements that influence the expression of different phytocenosis can be mainly attributed to the peculiar characteristics of the carbonate substratum, while south the principal element of disturbance seems to be the persistent land consumption.

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