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Plant Functional Types in Tuscan coastal dunes

Abstract

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The coastal dune vegetation in Migliarino-San Rossore-Massaciuccoli Regional Natural Park (NW Tuscany, Italy) was studied using morphological and functional traits of 34 species. The species composition of the vegetation was recorded in 5 different sites, from Viareggio (Province of Lucca) to Marina di Vecchiano (Province of Pisa). A multivariate analysis applied to a single matrix of traits vs. species made it possible to classify all the plant units living on dune ecosystems into five functional types. The identified PFTs may be related to the most important community types described for coastal dunes, which range from annual communities on the shoreline to Mediterranean "macchia" on the inland stabilized dunes. The occurrences of these functional groups in the different sites was analysed in order to check any differences along the coastline studied.

Key words: psammophytes, vegetation, NW Tyrrhenian coast.

Introduction

The concept of Plant Functional Types (PFTs) has received new attention as one possible framework for predicting ecosystem response to human-induced changes at a global scale (Díaz & Cabido 1997). PFTs are nonphylogenetic grouping of species showing similar responses to environmental conditions and having similar effects on the dominant ecosystem processes. In other words, different PFTs are expected to play different roles in terms of matter and energy processes in ecosystems. Their identification is an essential step in global change research initiatives and has been given priority in international research agendas (Smith & al. 1997; Díaz & al. 2004).

The aim of this study is to analyse the coastal dune vegetation in Migliarino-San Rossore-Massaciuccoli Regional Natural Park (NW Tuscany, Italy) using morphological and functional traits of some wild species. In particular, we propose a comparative study of functional groups through ordination techniques focusing on the possibility to use PFTs to check any differences among the sites studied.

Methods

The study site regards the sand dune system of Marina di Vecchiano, Torre del Lago and Viareggio (Pisa and Lucca Provinces), in the northern part of the Park on the right side of Serchio River. This area is characterized by a C2 type of climate, Mediterranean sub-humid (Thornthwaite 1948; Rapetti 2003), with an annual average temperature > 15°C. Average temperature is 8.3°C in the coldest month (January) and 23.4°C during the warmest month (July). Annual rainfall average is 800 mm, 37.9% of which falls in autumn, 26.1% in winter, 22.4% in the spring and only 13.6% during the summer. In October and November average rainfall is 120-130 mm. July is the driest month with an average rainfall of 20 mm.

The species composition and the cover of the vegetation, expressed as classes of abundance following Braun-Blanquet (1932, 1951), was recorded in 5 different sites (spring-summer 1999), from Viareggio to Marina di Vecchiano. At each site three plots (100 m x 20 m with the long axis parallel to the shoreline) were established: the first (plot a) along the frontal dune, the second (b) along the second dune and the last (c) in the inland area in front of the coastal forest.

The following set of functional characters was chosen: growth form, life form, plant height, vegetative propagation (clonality), leaf phenology, leaf size, leaf consistency, pollination system, flowering period and flowering start (Table 1). In most cases, trait categories suggested by Cornelissen & al. (2003) were adopted.

To identify major trends in these traits, Cluster Analysis (CA) and Non-metric Multi-Dimensional Scaling (NMDS) were applied to a single matrix of 10 traits by 34 vascular species recorded in the area.

To calculate PFT abundance in each plot we added the class abundance value of each species belonging to the same functional group. PFT distribution among different plots was studied using Principal Component Analysis (PCA) applied to a matrix of functional types versus plots.

To check any significant differences among sites, Two-way ANOVA was applied to plots a, b and c respectively.

Multivariate analysis was conducted using PRIMER program, while univariate tests were done by EXCEL software.

Results and Discussion

The multivariate approach to 34 plant species from coastal dune vegetation in Migliarino-San Rossore Massaciuccoli Regional Natural Park (NW Tuscany, Italy) on the basis of 10 traits made it possible to establish five functional types (Table 2).

Cluster analysis (CA) separated at the first hierarchic level (Bray-Curtis similarities = 84.97) FT1 group from the remaining plants (Fig. 1). At a second hierarchic level (Bray-Curtis similarities = 88.37), species were subdivided into two main groups: the first one included FT2, while the second cluster was formed by FT3, FT4 and FT5. The same functional groups were confirmed by the non-metric Multi-Dimensional Scaling (NMDS) with a stress value of 0.21 (Fig. 2).

Table 1. Plant traits selected for cluster analysis and principal component analysis.

Trait	Class description	Source of data
Growth form	7 classes: 1. Short/tall succulents and palmoids, 2. Climbers and scramblers, 3. Short basal, 4. Long and semi basal, 5. Erect leafy, 6. Cushions, tussocks and dwarf shrubs, 7. Shrubs and trees	Literature
Life form	5 classes: 1. Phanerophyte, 2. Chamaephyte, 3. Hemicryptophyte, 4. Geophyte, 5. Therophyte	Literature
Plant height	4 classes: 1. 0.02-0.29 m, 2. 0.30-0.59 m, 3. 0.60-1 m, 4. > 1 m	Field observation
Vegetative propagation (clonality)	3 classes: 1. Non-clonal, 2. Clonal aboveground, 3. Clonal belowground	Field observation
Leaf phenology	2 classes: 1. Deciduous, 2. Evergreen	Literature
Leaf size	4 classes: 1. 0-0.9 cm^2, 2. 1-4 cm^2, 3. 4.1-15 cm^2, 4. > 15 cm^2	Literature
Leaf consistency	2 classes: 1. Soft, 2. Tough	Field observation
Pollination system	2 classes: 1. Not specialised or anemophilous, 2. By insects or birds	Literature
Flowering period	Normal duration of flowering period (months)	Literature
Flowering start	6 classes: 1. First flowering in March or earlier, 2. in April, 3. in May, 4. in June, 5. in July, 6. in August or later or before leaves in spring	Literature

The identified PFTs are related to the most important community types described for coastal dunes (Arrigoni, 1990; Vagge & Biondi, 1999) which range from annual communities on the shoreline to Mediterranean "macchia" on the inland stabilized dunes (Table 2, 3). FT1 includes shrubs and trees typical of the evergreen Mediterranean "macchia" of consolidated dunes related to the phytosociological association *Asparago acutifolii-Juniperetum macrocarpae* (R. & R. Molinier 1955) De Bolos 1962 typicum Géhu, Costa & Biondi 1990. FT2 and FT3 are mainly constituted by annuals or biennials with soft leaves that characterize nitrophilous and ephemeral communities of the shoreline (*Salsolo kali-Cakiletum maritimae* Costa & Manz. 1981 corr. Rivas-Martínez, Costa & Loidi 1992) or annual grass communities growing in the interdunal spaces (*Sileno coloratae-Vulpietum membranaceae* (Pignatti 1953) Géhu & Scoppola 1984). FT4 is constituted by evergreen species, without clonal habit, and with soft leaves, related to perennial interdunal communities (*Pycnocomo rutifolii-Seseletum tortuosi* Arrigoni 1990). FT5 is formed by evergreen

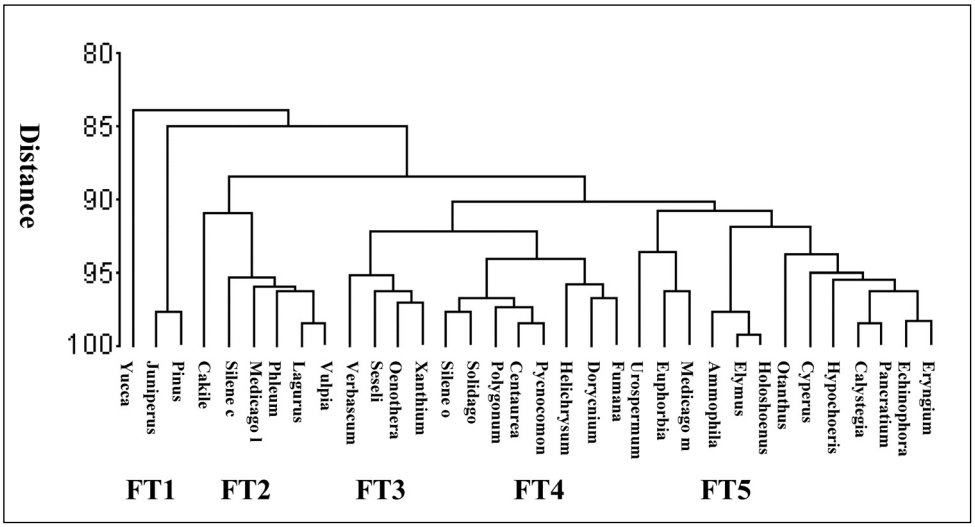

Fig. 1. Cluster analysis (CA) of 34 plant species from coastal dune vegetation in Migliarino-San Rossore Massaciuccoli Regional Natural Park (NW Tuscany, Italy) on the basis of 10 traits. All the plants divided in five functional groups (FT1-FT5).

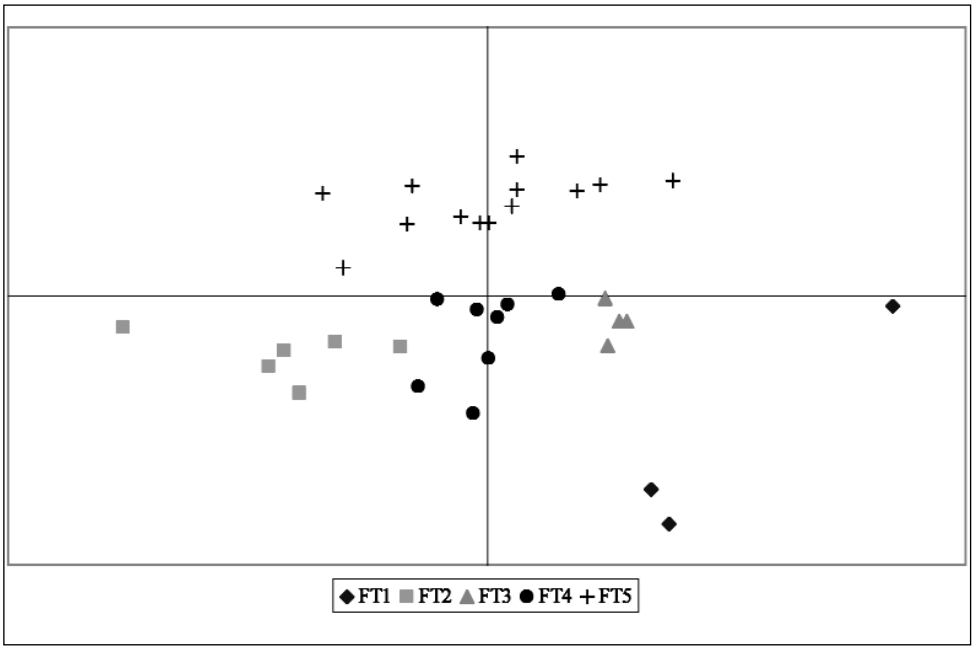

Fig. 2. Two-dimensional non-metric Multi-Dimensional Scaling (NMDS) of 34 plant species from coastal dune vegetation in Migliarino-San Rossore Massaciuccoli Regional Natural Park (NW Tuscany, Italy) on the basis of 10 traits (stress = 0.21).

Table 2. Plant species classification resulting from cluster analysis (CA) and related community types for each PFT.

FT1	FT2	FT3	FT4	FT5
Evergreen "macchia" of consolidated dunes	Nithophilous and ephemeral communities of the shoreline or annual grass communities growing in the interdunal spaces	Communities growing in the interdunal spaces	Perennial interdunal communities	Communities growing on the foredunes
Juniperus oxycedrus	*Cakile maritima*	*Seseli tortuosum*	*Centaurea subciliata*	*Ammophila arenaria*
Pinus pinaster	*Lagurus ovatus*	*Oenothera biennis*	*Dorycnium hirsutum*	*Calystegia soldanella*
Yucca aloifolia	*Medicago littoralis*	*Verbascum sinuatum*	*Fumana procumbens*	*Cyperus kalli*
	Phleum arenarium	*Xanthium italicum*	*Helichrysum stoechas*	*Echinophora spinosa*
	Silene colorata		*Polygonum maritimum*	*Elymus farctus*
	Vulpia membranacea		*Pycnocomon rutifolium*	*Eryngium maritimum*
			Silene otites	*Euphorbia paralias*
			Solidago littoralis	*Holoschoenus romanus*
				Hypochoeris radicata
				Medicago marina
				Otanthus maritimus
				Pancratium maritimum
				Urospermum dalechampii

Table 3. Functional types defined according to plant traits in the coastal dune vegetation.

Trait	FT1	FT2	FT3	FT4	FT5
Growth form	Shrubs, Trees	Erect, Short basal	Erect, Long and semi basal	Various	Various
Life form	Phanerophyte	Therophyte	Hemicryptophyte, Therophyte	Chamaephyte, Hemicryptophyte	Various
Plant height	> 1 m	< 60 cm	Various	< 60 cm	< 1 m
Clonality	(-)	(-)	(-)	(-)	(+) Beloground
Leaf phenology	Evergreen	Deciduous	Deciduous	Evergreen	Evergreen
Leaf size	Various	< 4 cm^2	< 15 cm^2	< 15 cm^2	< 15 cm^2
Leaf consistency	Tough	Soft	Soft (except *Verbascum*)	Soft	Various
Pollination system	Various	Various	Entomophilous	Entomophilous	Various
Flowering period	2-4 months	3 months (except *Cakile*)	3-4 months	2-4 months	2-6 months
Flowering start	Various	March-April	Various	May-July	Various

Table 4. Class of abundance of the five functional types at each study site (MDVS = South Marina di Vecchiano, MDVN = North Marina di Vecchiano, TDLS = South Torre del Lago, TDLN = North Torre del Lago, VG = Viareggio) and at each plot (a = along the frontal dune, b = along the second dune, c = in the inland area in front of the coastal forest). Values of class of abundance: 0 = 0%, p = < 1%, 1 = 1-5%, 2 = 5-25%, 3 = 25-50%, 4 = 50-75%.

Site	Plot	FT1	FT2	FT3	FT4	FT5
MDVS	a	0	1	1	1	3
	b	0	1	1	3	2
	c	1	1	1	2	+
MDVN	a	0	+	+	2	3
	b	0	+	1	2	2
	c	2	+	+	2	1
TDLS	a	0	0	0	+	4
	b	0	1	+	2	2
	c	+	1	1	3	2
TDLN	a	0	+	0	+	3
	b	+	+	+	2	2
	c	1	+	+	3	2
VG	a	0	+	+	2	3
	b	+	+	+	3	2
	c	+	+	+	2	2

Table 5. Eigenvectors values of the five functional types (FT1-FT5) after PCA ordination of a matrix of FT vs. plots. Numbers in parentheses denote eigenvalues of each axis.

FT	PCA 1 (56,1%)	PCA2 (24,8%)
FT1	-0.335	-0.713
FT2	-0.422	0.491
FT3	-0.471	0.399
FT4	-0.464	0.001
FT5	0.522	0.301

plants with belowground vegetative propagation, growing on the foredunes (*Echinophoro spinosae-Ammophiletum arundinaceae* Géhu, Rivas-Martínez & R. Tüxen 1972 in Géhu, Costa, Scoppola, Biondi, Marchiori, Géhu-Frank, Caniglia & Veri 1984; *Echinophoro spinosae-Elymetum farcti* Géhu 1988). This functional type includes dune-forming plants such as *Ammophila arenaria* and *Elymus farctus*. Our results are in accordance with a similar research conducted on the coastal dune vegetation of Central Italy (Acosta & al. 2006).

At each site we calculated the class of abundance of each functional type (Table 4). FT1 plants are shrubs and trees especially found in plots c that are located in the inland area in front of the coastal forest, while FT5 group, which includes species mainly related to the foredunal communities, is predominant in plots a. FT2, FT3 and FT4 are distributed along the three different types of plots (a, b and c) mainly because they characterise communities of the shoreline or growing in the interdunal spaces.

A Principal Component Analysis was applied to a matrix of 5 functional types versus 15 plots in order to study PFT distribution among the different sites. FT5 gives the most important contribute to the variation on PCA axis 1 (eigenvector value = 0.522) (Tab. 5); while FT1 has the highest score (eigenvector value = -0.713) regarding PCA axis 2. Starting from the assumption that FT1 and FT5 seem to play the most important role in site discrimination, we applied a two-way ANOVA analysis to a matrix of plots versus the two functional types selected. This statistical approach did not show any significant differences among plots a (degrees of freedom = 4, Fischer variable = 1, Probability = 0.5), plots b (d.f. = 4, F = 1, P = 0.5) and plots c (d.f. = 4, F = 0.30, P = 0.86) analysed separately. Thus, the coastal dune vegetation from Viareggio (Province of Lucca) to Marina di Vecchiano (Province of Pisa) does not seem to vary significantly along the three types of plots selected (a = frontal dune, b = second dune, c = inland area).

Conclusions

The multivariate methodology to plant traits of dune species showed a number of functional types related to the most important plant communities of coastal vegetation zonation. Our study of PFT occurences among the different sites have not shown any significant differences along the coastline studied. Anyway, further studies will be conducted examining other morpho-functional traits (such as specific leaf area, leaf dry matter content, seed mass, etc.) and extending the research area.

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