

An isolated *Ulmus minor* L. wood patch along the Tyrrhenian coast (central Italy): a floristic and structural characterization

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ABSTRACT

The structural vegetation features of an isolated backdune patch of *Ulmus minor* wood was carried out. The small wood lies in a coastal protected area of Tyrrhenian central Italy and can be attributed to an initial stage of the association *Aro italici-Ulmetum minoris*. Such vegetation mainly occurs along rivers and floodplains on soil with low salinity. The averaged tree diameters significantly increase passing from the lower tree height classes to the higher ones. No significant difference along a dune-woodcore-backdune gradient, was observed. This fact suggests a weak/absent role of distance from the sea as factor affecting the tree growth. The gradient of abiotic factors is probably blocked by local pedological and geomorphological factors. The *Ulmus minor* wood patch studied does not follow the usual spatial pattern of the dune vegetation probably because: (i) *Ulmus* woods are unusual for dunal systems being linked to inland floodplains with low soil salinity; (ii) such vegetation corresponds to an early dynamic stage with a low species composition in its inner as well as in its outer area, which corresponds to the wood edge. As the *Ulmus* woods are rarely found on the Mediterranean coastal plains a further monitoring is necessary for a better explaining about the origin of such woodpatch and its dynamic relationship with the surrounding local vegetation.

Key words: backdune, *Aro italici-Ulmetum minoris*, diameter, height classes, coastal plain.

RIASSUNTO

Un frammento isolato retrodunale di *Ulmus minor* lungo la costa tirrenica (Italia centrale); caratterizzazione floristica e strutturale.

È stata condotta una caratterizzazione floristica e strutturale di un frammento forestale retrodunale di *Ulmus minor* Mill. in un'area protetta costiera dell'Italia centrale tirrenica. A livello floristico sono state registrate 12 specie attribuibili ad una fase iniziale dell'associazione *Aro italici-Ulmetum minoris*, presente lungo i fiumi e nelle golene, in suoli a bassa salinità. A livello strutturale, il diametro medio delle piante aumenta significativamente passando dalle categorie di altezza più basse a quelle più alte con differenze significative tra le categorie di altezza inferiori. Non abbiamo osservato differenze significative lungo un gradiente duna-nucleo forestale-retroduna: probabilmente fattori pedologici e geomorfologici locali sono più determinanti nell'influenzare le caratteristiche strutturali rispetto alla distanza dal mare. Il bosco di *Ulmus minor* non segue il consueto schema di zonazione della vegetazione indicato per l'ecosistema dunale probabilmente perché: (i) la vegetazione ad *Ulmus minor* non è frequente nei sistemi retrodunali ma è propria delle pianure alluvionali con una bassa salinità; (ii) la vegetazione è in uno stadio iniziale, ecologicamente “bloccato” nella sua evoluzione, come è evidente dalla povertà floristica tra il nucleo interno più antico e l'area esterna più giovane ai margini del bosco. In assenza di disturbi al sistema della duna costiera è ragionevole pensare che questa vegetazione avrà un'elevata persistenza. Questo consentirà ulteriori dettagliate osservazioni sui processi dinamici della sua struttura nel medio-lungo periodo.

Parole chiave: retroduna, *Aro italici-Ulmetum minoris*, diametro, classi di altezza, pianura costiera.

INTRODUCTION

Coastal wetland ecosystems are heterogeneous environments, hosting different habitat types strongly related to the increasing distance from the sea, to the level of groundwater and to soil structure and composition (DRONOVA *et al.*, 2021). Along the Tyrrhenian coasts of Central Italy isolated patches of meso-hygrophilous forests [mainly composed of *Quercus robur* L., *Fraxinus angustifolia* subsp. *oxycarpa* (M. Bieb. ex Willd.) Franco & Rocha Afonso, *Ulmus minor* L.] are present (PETRICCIONE & PANI, 1992; PEDROTTI & GAFTA, 1996; BIONDI *et al.*, 2014). Such habitats have a high species diversity as their species composition is affected by a lot of factors, regarding soil geological features (i.e. clayey or sandy), soil acidity, the level of the groundwater and its salinity. This last one chiefly originates from the marine aerosol but more often from fossil salt in the coastal Tyrrhenian clays (ACOSTA *et al.*, 2007; CUTINI *et al.*, 2010). There are a plenty of studies on these vegetation types but attention has mainly been devoted to the *Quercus* and *Fraxinus* formations which are well preserved in a few preserves like Castel Porziano, Palo Laziale and Circeo National Park (e.g. BIANCO *et al.*, 2002; DELLA ROCCA *et al.*, 2003; LATTANZI *et al.*, 2004). Less attention has been given to the equally important small vegetations dominated by *Ulmus minor* Mill. which are scattered in many sites of the coasts near Rome (Fanelli, unpublished results): this tree species, growing usually on clays or tuffs, is related to high groundwater and low salinity. Aim of this work was the floristic and structural characterization of an *Ulmus minor* backdune wood patch in a coastal

protected area of Tyrrhenian central Italy. A part a descriptive arrangement, we also tested (i) the relationship between tree height and diameter and (ii) the role of distance from the sea, as a factor affecting the tree growth.

STUDY AREA

The study area was located into the “Palude di Torre Flavia” protected area (municipalities of Cerveteri and Ladispoli; Lazio, central Italy), a small coastal wetland (40 ha) on the Tyrrhenian coast (Special Protection Area according to the Directive 2009/147/ EC ‘Birds’; code IT6030020), relict of a larger wetland drained and transformed by land reclamation (BATTISTI, 2006; BATTISTI *et al.*, 2006). At a landscape scale, this area represents a remnant fragment of wetland inside an agricultural and urbanized matrix. At a local scale, it shows a seminatural heterogeneity with *Phragmites australis* L. reed-beds, ecotones and ponds used for fish farming from 1938 (MOCCIA, 2006). Near the reedbeds there are flooded meadows with *Carex hirta* L., *Juncus acutus* L., *Juncus subulatus* Forssk. and Cyperaceae corresponding to the *Juncetalia maritimi* habitat type according to the “Habitat” Directive 92/43/EC (GUIDI, 2006; FANELLI, 2006). The water flooding the wetland is both of meteoric/sea storm and artificial origin (BATTISTI *et al.*, 2008). Along the coastline patches of the EU Habitat type “Embryonic shifting dunes” (code 2110) are present (GUIDI, 2006; IONI *et al.*, 2020). In this context, we studied a small isolated *Ulmus minor* wood patch (41°57'46"N, 12°02'43"E), 573.9 m² wide (406.5 m² the

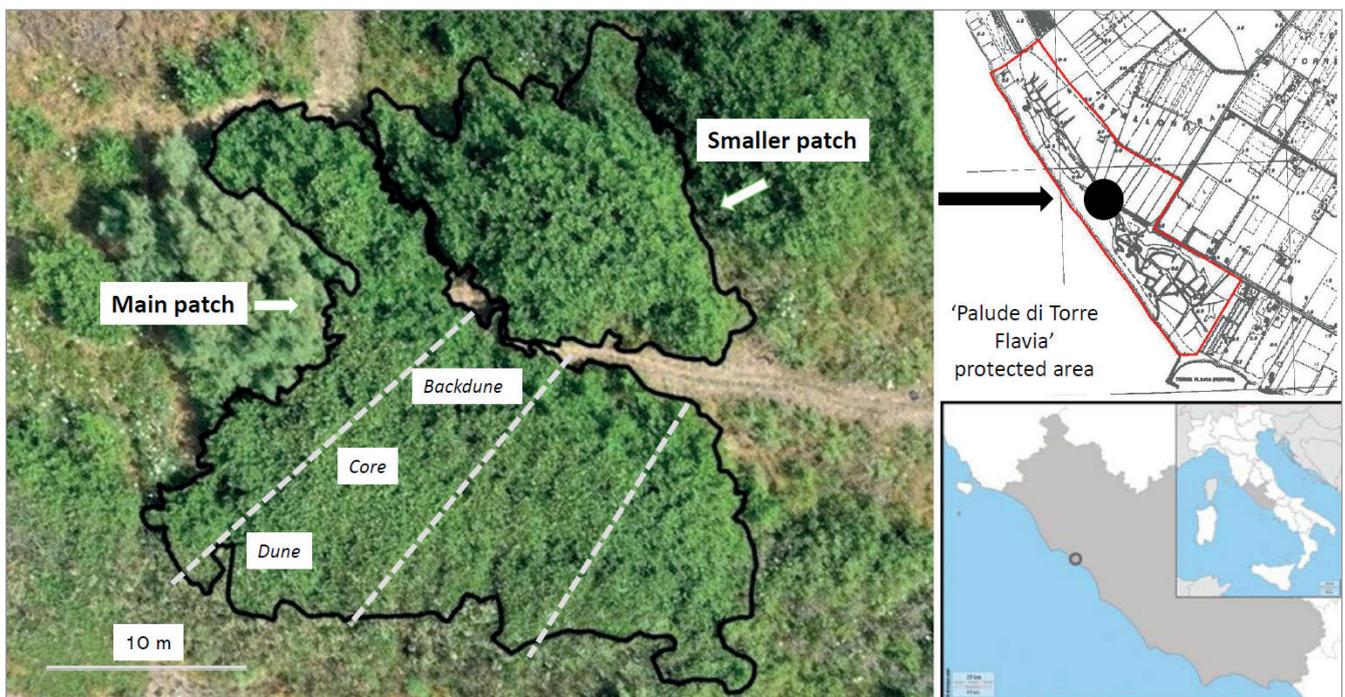


Fig. 1. The *Ulmus minor* wood patch. On the right, the map of the ‘Palude di Torre Flavia’ protected area (black point the wood patch studied) and the location at the regional scale. Dashed lines represent the three linear transects along the dune-woodcore-backdune gradient. Original photo by drone (45 m-height; Photo: L. Cicillini).

main patch and 167.4 m² a neighboring smaller patch; Fig. 1), located in a backdune at about 100 m from the beach. Climate is xeric-meso-Mediterranean (BLASI & MICHETTI, 2005). For details on chemistry and water quality: SABIA *et al.* (2018); for morpho-dynamics of the coastal landscape, see Raffi *et al.* (2018), DAVOLI *et al.* (2019); for a faunal arrangement: BATTISTI *et al.* (2021).

MATERIALS AND METHODS

Floristic characterization. - A relevé was carried out with the Zürich-Montpellier school method (WESTHOFF & VAN DER MAREL, 1970). All species were listed for each stratum of vegetation and a cover was visually estimated according to the Braun-Blanquet phytosociological scale (BRAUN-BLANQUET, 1964). It is based on cover percentages, but for species with low plant cover abundance estimates were used. Cover was estimated using the original 5-point cover scale (Braun-Blanquet or the Domin scale; BRAUN-BLANQUET, 1932), assigning '+' when species was occasional (cover 1-5%; 2: >5-25%; 3: >25-50%; 4: >50-75%; 5: >75-100%). Nomenclature followed BARTOLUCCI *et al.* (2018).

Structural characterization. - First, to test for relationship between tree diameter and height, searching for threshold in growing, we carried out a census of all trees measuring for each one, the diameter (dbh in cm; using a professional caliper) at breast height and the height (considering four size classes: 0-2 m, 2-4 m, 4-6 m, > 6 m) in the main patch. After, we obtained the averaged values of dbh (and standard deviation).

Second, we carried out three plant transects (SUTHERLAND, 2006), located along a dune-core-backdune gradient to test the role of distance from the sea as factor affecting the growth of the specimens. Inside the transect belt (50 cm-wide), we measured both the dbh and height of each tree, and the location along the gradient dune (0-5 m from the dunal ridge)-core of wood patch (5-10 m)-backdune (10-15 m from the dunal ridge).

A non-parametric Kruskal-Wallis test was used to search the significance in the averaged diameter between the height size classes and between the distinct ranges (dune-core-backdune) along the transects. Mann-Whitney U test was performed to compare paired averaged data. Finally, a Kolmogorov-Smirnov test was performed to test the differences in the frequency distribution in height classes between the main and the smaller patch (DYTHAM, 2011). To perform the statistical tests, we used the PAST software (HAMMER *et al.*, 2001). Alpha level was set at 0.05.

RESULTS AND DISCUSSION

The species composition of *Ulmus minor* wood patch is very poor (12 species; Tab. 1), with the species of the undergrowth mainly related to ruderal grasslands (e.g. *Anisantha rigida*, *Hordeum bulbosum*, located at the wood edge). This low species content indicates as this patch corresponds to an early pioneer stage of vegetation development.

	%
Area	50
cover tree	100
height tree	6
cover herb	50
height herb	40
tree layer	scale
<i>Ulmus minor</i> Mill.	5
herbaceous layer	scale
<i>Anisantha rigida</i> (Roth) Hyl. (<i>Bromus rigidus</i> Roth)	3
<i>Galium aparine</i> L.	1
<i>Carex otrubae</i> Podp.	+
<i>Laurus nobilis</i> L.	+
<i>Prunus spinosa</i> L.	+
<i>Hedera helix</i> L.	+
<i>Solanum nigrum</i> L.	+
<i>Asparagus acutifolius</i> L.	+
<i>Torilis arvensis</i> Spreng.	+
<i>Beta vulgaris</i> L.	+
<i>Hordeum bulbosum</i> L.	+
<i>Rubus ulmifolius</i> Schott	+

Tab. 1. Floristic composition of the *Ulmus minor* wood patch (Zürich-Montpellier school method). Values of cover tree, height tree, herbaceous cover and height have been reported. Data in cover both for tree and herbaceous species followed the Braun-Blanquet scale (shrubby layer is absent).

The wood patch can be attributed to the association *Aro italici-Ulmetum minoris* Rivas-Martinez ex López 1976, described for the Iberian Peninsula but widely present in Italy along rivers and in floodplains where the flooding regime is very short (PEDROTTI & GAFTA 1996; PIRONE *et al.* 2003; DE LA FUENTE GARCIA, 1986; MAIORCA *et al.* 2007). The character-species *Arum italicum* is lacking, indicating that the association is present in an initial stage. The *Aro italici-Ulmetum minoris* is the potential vegetation of the reclamation plains, still little known and extremely localized in the lowland areas. These formations are typical of low salinity edaphic conditions, unlike the woods of *Quercus robur*, *Quercus frainetto* and *Fraxinus oxycarpa* which are located on acidic pleistocenic sandbanks without salinity. At the structural level, totally we sampled 129 elm trees in the two sub-patches. Difference between the main patch and the smaller one was not significant neither considering the frequency distribution in height classes (Kolmogorov-Smirnov test), nor the mean tree diameter (Mann-Whitney U test; Tab. 2).

height classes (m)	main patch		smaller patch	
	N	fr	n	Fr
0-2	4	0.038	0	0
>2-4	36	0.343	0	0
>4-6	59	0.562	14	0.583
>6	6	0.057	10	0.417
N	105	1	24	1
Kolmogorov-Smirnov	D = 0.5; p = 0.53			
mean dbh (and s.d.)	6.676 (± 3.198)		6.500 (± 1.458)	
Mann-Whitney U test	Z = 0.125; p = 0.900			

Tab. 2. Number and relative frequency of *Ulmus* trees subdivided in four height classes both for the main sub-patch and smaller sub-patch. Significance of difference in frequency distribution has been tested with the Kolmogorov-Smirnov test. Averaged tree diameters (dbh, in cm) for the two sub-patches and two-sample U Mann Whitney test (to test for differences) have been reported.

Considering the main patch (n=105 trees), the intermediate class in height (>2-4 and >4-6 m) was more represented (90.5%). Here, the averaged tree diameter significantly increased passing from the lower tree height categories to the taller ones (H= 17.29; p=0.0006; Kruskal-Wallis test). However, this relationship was not constant. Indeed, we observed a significant difference only when comparing the first two height categories (0-2 vs. 2-4 m: p=0.004; 2-4 vs. 4-6 m: p=0.018), while difference between 4-6 vs. >6 m was not significant (p=0.086; pairwise Mann-Whitney U test; Fig. 2).

Although mean tree diameter slowly decreased passing from the dune-woodcore-backdune gradient: we did not observe si-

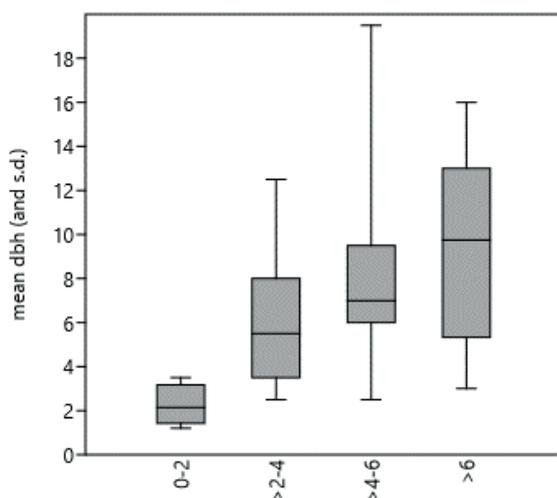


Fig. 2. Averaged tree diameter at breast height (in cm) for the four size height classes (n=105 trees). Bars represent the standard deviations.

gnificant differences (H=0.912; p=0.633; Kruskal-Wallis test; Fig. 3), suggesting a weak/absent role of distance from the sea as factor affecting the tree growth.

There was a main difference between the main and the smaller wood patch. In the smaller wood all the trees belonged to only two size classes with the smaller size classes not represented. This size structure indicates that the smaller wood patch was dynamically stable, whereas the main patch was probably young, and it is incurring a phase of expansion.

Since the strong gradient of abiotic factors (marine aerosol, the effects of salty wind and landfill due to sand) progressively decreases in intensity from the sea towards the hinterland (ACOSTA *et al.*, 2007), one would expect an impact on trees and therefore a progressive difference between the one closest to the sea, passing through the intermediate one to the farthest one. However, this difference was not found, as the gradient of abiotic factors is probably blocked by: (i) a series of pedological and geomorphological factors, (ii) the presence of halo-psammophilic plants and marsh reeds (*Phragmites australis* L.), (iii) the location in the less-exposed back of the dunal ridge. The *Ulmus minor* wood patch studied does not follow the usual pattern of zonation of the vegetation suggested for dune ecosystems (ACOSTA *et al.*, 2007; ANGIOLINI *et al.*, 2018). A multiplicity of reasons underlies the fact that we did not retrieve the usual seriation of dune systems. The first is that the vegetation of *Ulmus* forest is not typical of dune systems but it is instead typical of floodplains often with some salinity. The vegetation of *Ulmus* is usually referred to riparian ecosystems (PEDROTTI & GAFTA, 1996) but it was clearly widespread also in the floodplains where it is now absent due to transformation of the marshes into crops after reclamation (MAIORCA *et al.*, 2007). As a matter of fact, dune systems in Torre Flavia are present only in a narrow fringe along the coast (GUIDI, 2006), whereas most of the area is a coastal marsh that dies up in summer. Temporary salt marshes are the typical environment of the endangered *Juncetalia maritimi* ha-

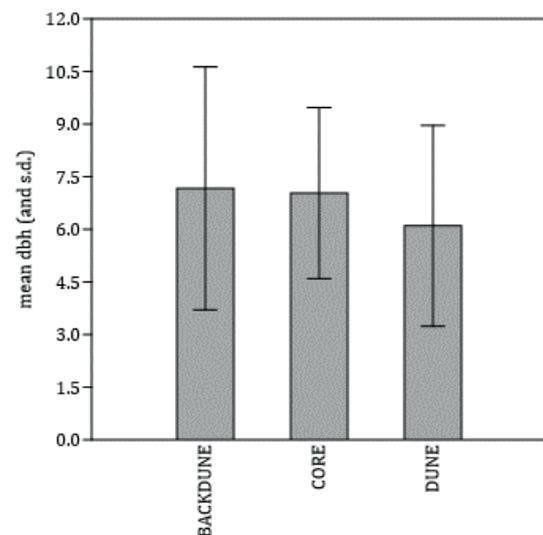


Fig. 3. Averaged tree diameter (mean dbh; and standard deviation, in cm) in the three sectors along the dune-woodcore-backdune gradient (transect method).

bitat type, largely represented in the reserve (FANELLI, 2006; GUIDI, 2006), but the floodplain-marsh habitat continued before the environmental change in the cultivated plain surrounding the reserve. The main difference between the dune system and the floodplain-marsh unit is in the soil: the former being sandy or gravelly, whereas the latter is clayey and with some salinity. The ecology of the floodplain-marsh units is distinct from that of the dune system: for example, in Castel Porziano or Circeo ancient dune systems occur, hosting a completely different vegetation (e.g. BIANCO *et al.*, 2002).

Apart from the ecological characterization, the *Ulmus* wood patch is also set apart because it is in an obvious stage of intensive dynamics, reflected in the different size structure between the two sub-patches, the main patch with the representation of young size classes typical of an initial stage of recolonization. The smaller is more ancient and it has therefore stabilized its age structure, whereas the main patch is invading the surrounding landscape in a wave form, reflecting in the age structure of the trees. The early dynamic stage of the forest is also reflected in the poor floristic pool, where the more diagnostic species such as *Arum italicum* are still lacking and where the main floristic element is represented by ruderal grassland species. The forest is spreading in the surrounding ruderal grasslands but not on the more saline areas, where halotolerant and halophytic species are instead present and where *Ulmus* cannot thrive due to relatively high salinity.

CONCLUSION

Ulmus minor forests represent the potential vegetation in the coastal floodplains of Latium and probably in the entire Italian Peninsula South of Tuscany (MAIORCA *et al.*, 2007). These habitats have almost completely been destroyed due to reclamation of land for agricultural purposes. The wood patch of Torre Flavia represents a beginning of recolonization of the floodplain by this potential vegetation, still in an intense dynamic phase. That offsets the environmental factors that usually shape the coastal gradient from the sea inwards.

The *Ulmus minor* wood patch does not host rare species; nonetheless it has an important historical and conservation value, since it represents the beginning of the natural restoration of the potential vegetation of the floodplain, probably in relationship with the protection of the area since the last three decades. The *Ulmus* formation is rarely recognized as potential formation for the coastal plain (BLASI *et al.*, 2003) due to its rarity, that forbade ecologists to appreciate its importance, but it is nonetheless present with many small examples along the coast near Rome. More attention should be paid to this vegetation and more research is needed on *Ulmus* forests, that have been overshadowed by the better-preserved *Quercus* and *Fraxinus* plain forests, at least in Latium.

ACKNOWLEDGMENTS

Silvia De Michelis, Laura Di Blasio, Inés Macías Tarrío, Priscilla Nesi, Luca Rufini, Noélie Zegza (students in Biodiversity

and Ecosystem Management - University Rome III) for data collecting in the field during the ‘Manager for a day’ trip. Luigi Cicillini made the aerial shots from drone. An anonymous reviewer largely improved the first draft of the manuscript.

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