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# Contribution to the knowledge of the diffusion of *Pinus* tp. *sylvestris* during Lateglacial in the central Apennines

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**Abstract**
A fossil trunk was found in the clay layer, covered by colluvial material along the Topino river, near Nocera Umbra (Province of Perugia). The still woody consistency of the finding allowed the xylotomic analysis, carried out on the transversal, radial and tangential sections that highlighted the following fundamental characteristics for the determination of the find: i) pinoid pits in the crossing fields; ii) transverse tracheids of the rays with indentures; iii) lack or rare presence of pits of transverse fibretracheids. On the basis of the characters listed above, the wood has been attributed to the genus *Pinus* and to the *sylvestris* section. In the fossil state the presence of macroremains of *Pinus sylvestris* or *Pinus nigra* has been highlighted for the Conca river, at Gran Sasso and along the Esino and Metauro rivers. The pollen frequencies of *Pinus*, between 10 and 30%, are always recorded during the Lateglacial period in Umbria Marche and Abruzzo. The research of pollen analysis rarely relate the presence of the macroremains to that of the pollen, without therefore having the possibility to quantify the population. The finding of Nocera Umbra, dated 14100 B.P., is the youngest discovered in central Italy. The presence of *Pinus* tp. *sylvestris* in natural vegetation is therefore certain up to this date. For later periods there are no findings yet.

Key words: Paleoecology, *Pinus* tp. *sylvestris*, Lateglacial, Xylology.

## Introduction

The plant species currently characterizing the landscape of central Italy, have had, during history, alternate events that have led to their diffusion, rarefaction or disappearance. This is the case of the genus *Pinus* whose current presence in the central Apennines is linked to the reforestation of the past decades, except in the case of *Pinus mugo* living in the subalpine belt, generally on limestone, in the Maielletta, Camosciara, M. Greco, Tre Confini and Zaffinetto and the *Pinus nigra* in Villetta Barrea and in differents areas of Abruzzo (Pignatti, 2017). In particular in a small area of the Pian Grande (in the Gran Sasso d'Italia) where a small *Pinus nigra* subsp. *nigra* wood has been naturally reconstituted with *Juniperus communis* subsp. *hemisphaerica* and *J. communis* subsp. *nana* (Blasi & Biondi, 2017). These residuous populations would derive from the rarefaction of those that should have been present during the last ice age along the Apennines chain. The presence of *Pinus* during the last glacial and the postglacial is shown through numerous paleopalinological and paleobotanical research. In particular pollen *Pinus* is found in the pollen diagrams of the Lateglacial and Holocene of numerous sites of the central Umbria, Marche and Abruzzo Apennines: starting from the research of Marchesoni and Paganelli during the 30s to the 50s up to the most recent in Montelago of Sassoferrato (Savelli *et al*., 2013; Coccioni *et al*., in press), Colfiorito (Brugiapaglia & de Beaulieu, 1995), Pian Piccolo of Castelluccio of Norcia (Venanzoni & Brugiapaglia, 2007), Lago Trasimeno (Drescher-Schneider, 1994; Drescher-Schneider, 2006), Pantano Zittola (Brugiapaglia, unpublished data) (Fig. 1).

The purpose of the work is to contribute to the implementation of data on the distribution area of the genus *Pinus* in the central Apennines during the Lateglacial and Holocene period.

Most palaeoenvironmental reconstructions are based on pollen analysis, but *Pinus* pollen (Fig. 2) has extreme volatility due to its conformation which allows it to float in the air; low percentages of pollen in the diagrams are not always indicative of the presence of the plant in the surrounding areas, but could be linked to a distant wind transport. The only possibility of confirming its presence *in situ* is the search for macroremains plants (needles, wood, cones).

## Materials and methods

During the construction of a tunnel in the locality Macchia del Pozzo, near Nocera Umbra, in the Umbria-Marche Apennines (Fig. 1), a fossil wood was found in a good state of conservation and with a still

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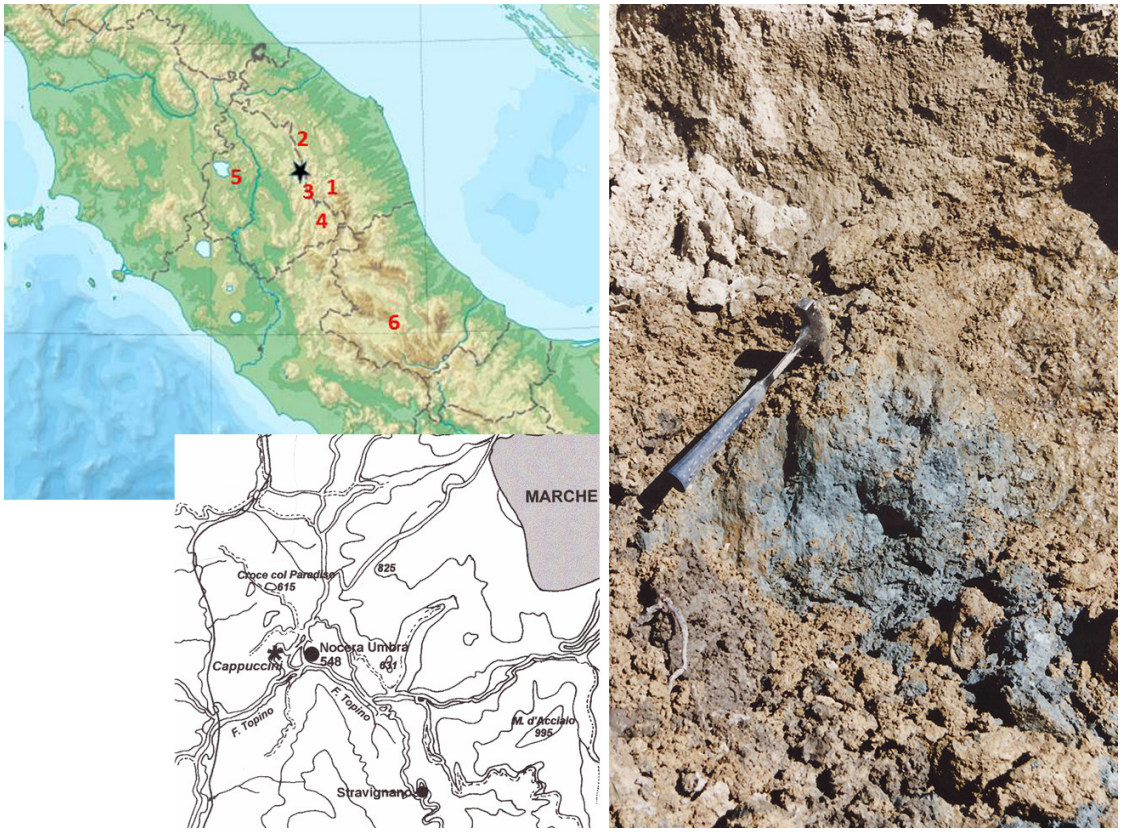


Fig. 1 - Location of the sites mentioned in the text. 1) Monte Cavallo, Gelagna Bassa, Muccia and Polverina (Paganelli, 1982); 2) Montelago of Sassoferrato (Savelli *et al*., 2013); 3) Colfiorito (Brugiapaglia & de Beaulieu, 1995); 4) Pian Piccolo of Castelluccio of Norcia (Venanzoni & Brugiapaglia, 2007); 5) Lago Trasimeno (Drescher-Scheneider, 2006); 6) Pantano Zittola (Brugiapaglia, unpublished data). ★ location of the find. Clay lens containing the *Pinus* trunk.

woody consistency, about 20 cm in diameter.

The wood, embedded in a clay layer outcropping 2 m thick, was covered by a layer of 3-4 m of sandy-clay colluvial material coming from the surrounding slopes where the marly-arenaceous umbria series, comes through.

The following analyzes were performed on the wood:

1 - Xylotomic analysis according to the classical method: two cubes of 0.5 cm on each side were cut from the sample; immersed in water; immersed in the fixative (formalin solution, 50% ethyl alcohol and glacial acetic acid); dehydration to alcohols with increasing concentration (40°, 60°, 80°, 90°, and 100°), passages to methyl benzoate, benzene and paraffin inclusion. The samples were cut to the microtome with variable thicknesses from 10 to 18 µ according to the transversal, longitudinal and tangential radial sections. The observations were made with the Leitz Diaplan trasmission microscope with objective x 25 and x 40.

For the determination of the wood the following dichotomous keys and photographic atlas were used: Rol (1932), Greguss (1955), Jacquiot (1955), Greguss (1972), Gellini *et al*. (1979), Schweingruber (1990).

2 - Dating through 14C was performed at the Geochemical Laboratory of the "La Sapienza" University of Rome.

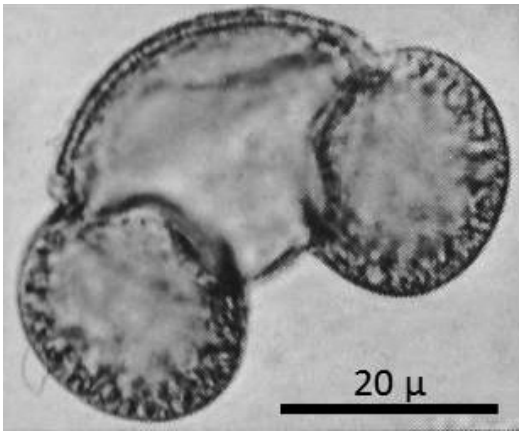


Fig. 2 - Pollen of *Pinus sylvestris* (after Reille, 1992).

## Results

### *Anatomical study of wood*

*Trasversal section*

Homoxyl wood, with clear growth rings (Fig. 3).

The fibretracheids of the early wood have a quadrangular-polygonal shape, while those of the late wood are rectangular.

In the radial direction the number of fibretracheids in the early wood is between 12 and 18 rows, in the late wood it varies between 2 and 11 rows.

The diameter (tang. x rad.) of the fibretracheids is 18 (35) µm x 20 (35) µm in the early wood while is 15 (30) µm x 12 (15) µm in the late wood. The lumen of the fibretracheids (diameter tang. x rad.) is 15 (25) µm x 18 (30) µm in the early wood and 10 (25) µm x 8 (10) µm in the late wood.

The thickness of the radial and tangential walls in the early wood is 3-4 µm, in the late one it is 3 µm.

The rays are separated by 8 to 18 rows of fibretracheids in the radial direction.

The longitudinal resin canals are located in the contact zone between the early and late wood with prevalence in the latter, whose diameter is on average 116 µm.

*Tangential section*

On the tangential walls of the fibretracheids, of both the late and early wood, the presence of pits is not noticed (Fig. 4).

The rays are uniseriate, with the exception of those enclosing the transverse resin canals which are biseriate. They are composed of elliptic-round cells in the central part, while those placed at the ends are tapered. The height of the rays varies from 2 to 15 (18) overlapping cells, corresponding to 55 µm-330 µm. Their width is 15-20 µm. There are 30 to 40 rays per $mm^2$. The diameter of the horizontal resin canal is on average 50 µm.

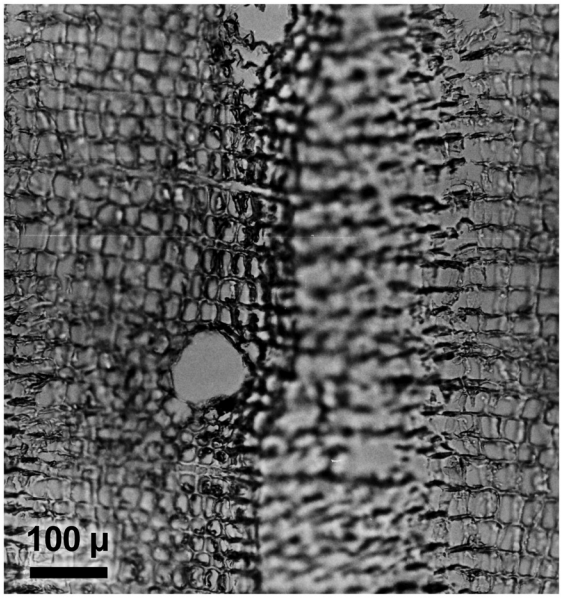


Fig. 3 - Transversal section: homoxyl wood with evident resin canals locateted in the contact zone between the early and late wood.

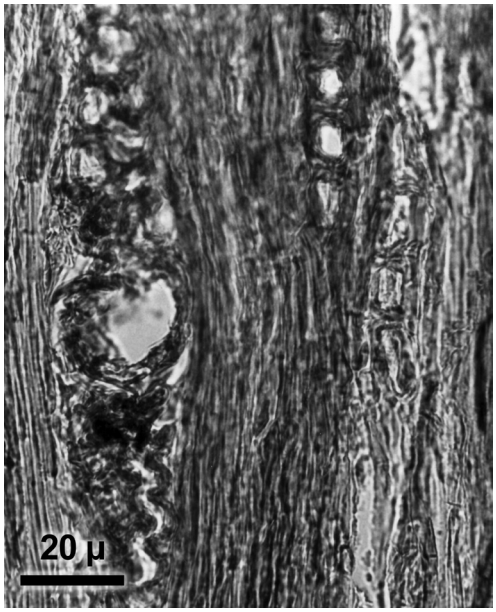


Fig. 4 - Tangential section: the rays are uniseriate, with the exception of those enclosing resin canals which are biseriate.

The length of the fibretracheids is between 120 and 200 µm, width of 21 µm on average in the early wood, and on the late wood of 14 µm on average.

*Radial section*

The pits present on the radial walls of the early wood fibretracheids are always uniseriate, spaced, only rarely in contact (Fig. 5). Crassulae are exceptionally present. The size of the pits of the fibretracheids (rad. x tang.) is 15 (22) µm x 15 (18) µm in the early wood and 10 (15) µm x 10 (15) µm in the late wood. The pore has a diameter between 5 µm and 12 µm and di 4-5 µm respectively in the pits of early and late wood.

The rays are uniseriate, heterogeneous; the parenchyma cells have smooth walls, with a thickness of 2 µm the horizontal ones and approximately 4 µm the vertical ones. The cell height is between 12 µm and 20 µm while the average length is 135 µm.

In the cross-field of the early wood the pits, of the pinoid type, are one or rarely two per field (Fig. 6). Their dimensions (length x width) are 15 (50) µm x 12

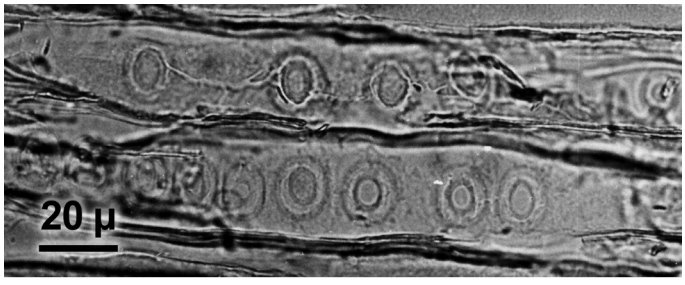


Fig. 5 - Radial section: uniseriate pits on the radial walls of the fibretracheids.

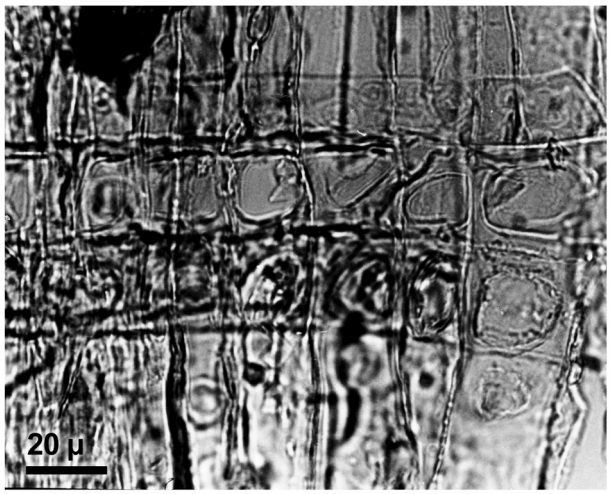


Fig. 6 - Radial section: cross-fields with pits pinoid type in the early wood and in the shape of an oblique fissure in the late wood.

µm. In the late wood there is a pit per field, narrower, oblique-shaped, of 15-18 µm x 6 µm.

The transversal tracheids are almost exclusively localized at the end of the rays, the average height of these is 22.5 µm. They have horizontal walls with indentures with mostly rounded apex.

The indenture sizes (base x height) are on average 4.7 µm x 7.7 µm (Fig. 7). The transversal walls, with vertical or oblique lines, are smooth. The transversal tracheids have irregularly arranged areolate pits, their diameter is on average 9.3 µm while the pore diameter is 3.1 µm.

The dating of the woody find, with the 14C method, gave the result of 14100 ± 140 B.P.

**Determination and paleoecological considerations**

The anatomical study of wood highlighted the presence of pinoid pits in the cross-fields, a characteristic that allows to attribute the sample to the genus *Pinus* L.

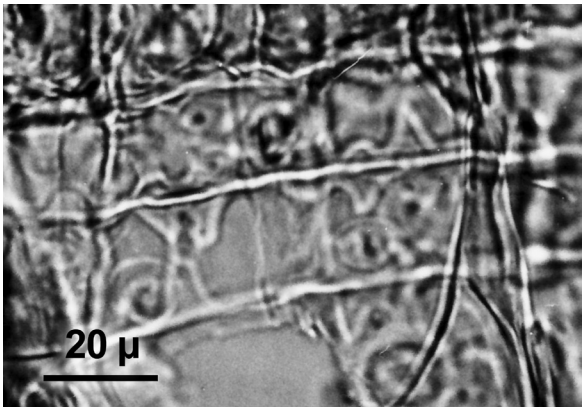


Fig 7 - Radial section: indentures with apex on the longitudinal walls of the transversal tracheids.

Based on the following characteristics:

1- transverse tracheids of the rays with indentures;

2- cross-fields including one or very rarely two rectangular-shaped pinoid pits;

3- lack or rare presence of pits of the tangential fibretracheids.

The wood under examination is attributable to the *P. sylvestris* section, which includes the following species: *P. sylvestris* L., *P. laricio* Poiret, *P. montana* Mill., *P. resinosa* Soland and *P. densiflora* Sieb. et Zucc. It is impossible to recognize the species anatomically within this section.

The xylological analysis carried out on the find discovered in Nocera Umbra does not seems to be in agreement with the conclusions of Marchesoni (1957) according to whom *Pinus nigra* var. *austriaca* lived on the Umbria-Marche Apennines during the Lateglacial, while *Pinus sylvestris* was present in the North Apennines. These conclusions, based only on the morphometry of pollen grains, appears to contrast with the results obtained from the xylotomic analysis that would extend the area of *Pinus sylvestris* up to the Umbria-Marche Apennines. *Pinus nigra* var. *austriaca* and *Pinus sylvestris* differ, according to Gellini *et al*. (1979), for the indentures present in the walls of the radial tracheids: in the first species they are pointed, while in the second species they are rounded. Instead according to Schweingruber (1990) *Pinus nigra* and *Pinus sylvestris* cannot be distinguished except for a difference detectable in correspondences of the early wood/late wood transition that would be more abrupt in *Pinus nigra* than in the other species.

The macroremains that testify the presence of *Pinus sylvestris* or *Pinus nigra* were determined for the Conca river (Biondi, 1983) in Emilia-Romagna on the basis of the discovery of a cone included in the fluvial – lacustrine sediments of the Riss (Conti *et al*., 1982).

A wood sample found in the Gran Sasso d'Italia in Abruzzo was determined as *Pinus sylvestris* (Tammaro *et al*., 1979). It was dated by C14 and gave a result at 37.000 years BC, then in full glacial period.

Along the Esino river, in the Marche, for the period between 40.000 and 30.000 BP the presence of *Pinus* sp. and of *Betula* sp. was shown with *Cyperaceae* and *Graminaceae* which constituted a taiga environment (Evans in Calderoni *et al*., 1991).

The presence of *Pinus sylvestris* older than 41,000 has been highlighted by Alessio *et al*. (1987) also for the Metauro river in the Marche.

Other testimonies on the presence of *Pinus* in central Italy are offered by the study of fossil pollens in deposits of Lazio, Umbria and Marche. In the deposits of Monte Cavallo, Gelagna bassa, Muccia and Polverina, Paganelli (1982) always recognizes *Pinus* pollen. These deposits, based on their floristic composi-

tion, according to Paganelli (1982), are attributed to the interglacial Riss-Würm while from a stratigraphic point of view the deposits were attributed to the Würm 3 (Damiani & Moretti, 1968). For the Vico lake, in Lazio, the presence of *Pinus* pollen with relative frequencies of 10% was highlighted in the Lateglacial period (Frank, 1969). Magri and Follieri (1989) for the Piana of Fucino indicate for *Pinus* pollen an average of 30% for the Lateglacial. In Valle di Castiglione (Alessio *et al*., 1986), in Lazio, in deposits dated 14220 BP the same frequencies are of the order of 30%. The study of the Trasimeno lake (Drescher-Schneider, 1994), highlighted an older Dryas characterized by 10% of *Pinus*. At the swamp of Colfiorito (Brugiapaglia & de Beaulieu, 1995), during the older Dryas, the frequency of *Pinus* was on average 30%.

In the pollen diagrams of Lateglacial, and in particular the older Dryas, is a period characterized by poor tree vegetation even if the arboreal pollen is always present with frequencies even greater than 50%. It should be only a distant contribution because the herbaceous vegetation, consisting mainly of *Artemisia*, *Chenopodiaceae*, *Thalictrum* and *Helianthemum* did not represent an obstacle for the long distance transport of the pollen.

In all these diagrams the frequencies of *Pinus* so low, do not allow to affirm with certainty the presence *in situ* of the *taxon* since none of these works take into consideration the study of macroremains able to confirm the presence of the species recorded by the pollen rain.

In Nocera the presence of a wood sample referable to the *Pinus sylvestris* section, confirms the results of the first palynological analysis that highlight the presence of *Pinus* pollen as well as of herbaceous *taxa* such as *Asteroideae*, *Rumex*, *Chenopodiaceae*, Spore trilete, *Campanulaceae* and *Linum* (Biondi & Brugiapaglia, 1999).

During the last phase of the wurmian period, the dry and cold continental climate would have favored the survival of *Pinus sylvestris*, which is able to withstand dry climatic conditions.

As far as the altitudinal limits are concerned, it is not possible to define them due to the lack of research on macroremains.

The study carried out showed that in central Italy during the older Dryas there were islands of arboreal vegetation with species of pines with anatomical characteristics of the wood similar to the current *Pinus sylvestris*. Since it is not possible to quantitatively evaluate the presence of *Pinus*, we cannot estimate whether they were isolated individuals or large populations.

From a temporal point of view, the finding of Nocera Umbra is the youngest discovered in central Italy. We can therefore state that the populations of *Pinus* were present at least up to 14000 B.P. Findings of a more recent age have not yet been found even if from the pollen diagram of Colfiorito (Brugiapaglia & de Beaulieu, 1992) a peak of *Pinus* pollen is found at about 3,000 B.P. Probably there were also other individuals as shown by the percentages found in the pollen diagram of Montelago di Sassoferrato (Savelli *et al*., 2013). Further investigations currently being published at Montelago di Sassoferrato, have highlighted the presence of flakes of the *Pinus* cone at 2,500 BP (Coccioni *et al*., in press). It therefore appears that the populations of *Pinus*, quite widespread in the Lateglacial in the central Apennines, have been present up to 2,500 BP at least in the northern part of this sector of the Apennines. However, further research into macroremains will be necessary to define the temporal limit of rarefaction or disappearance from the natural vegetation of this species in the central Apennines.

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