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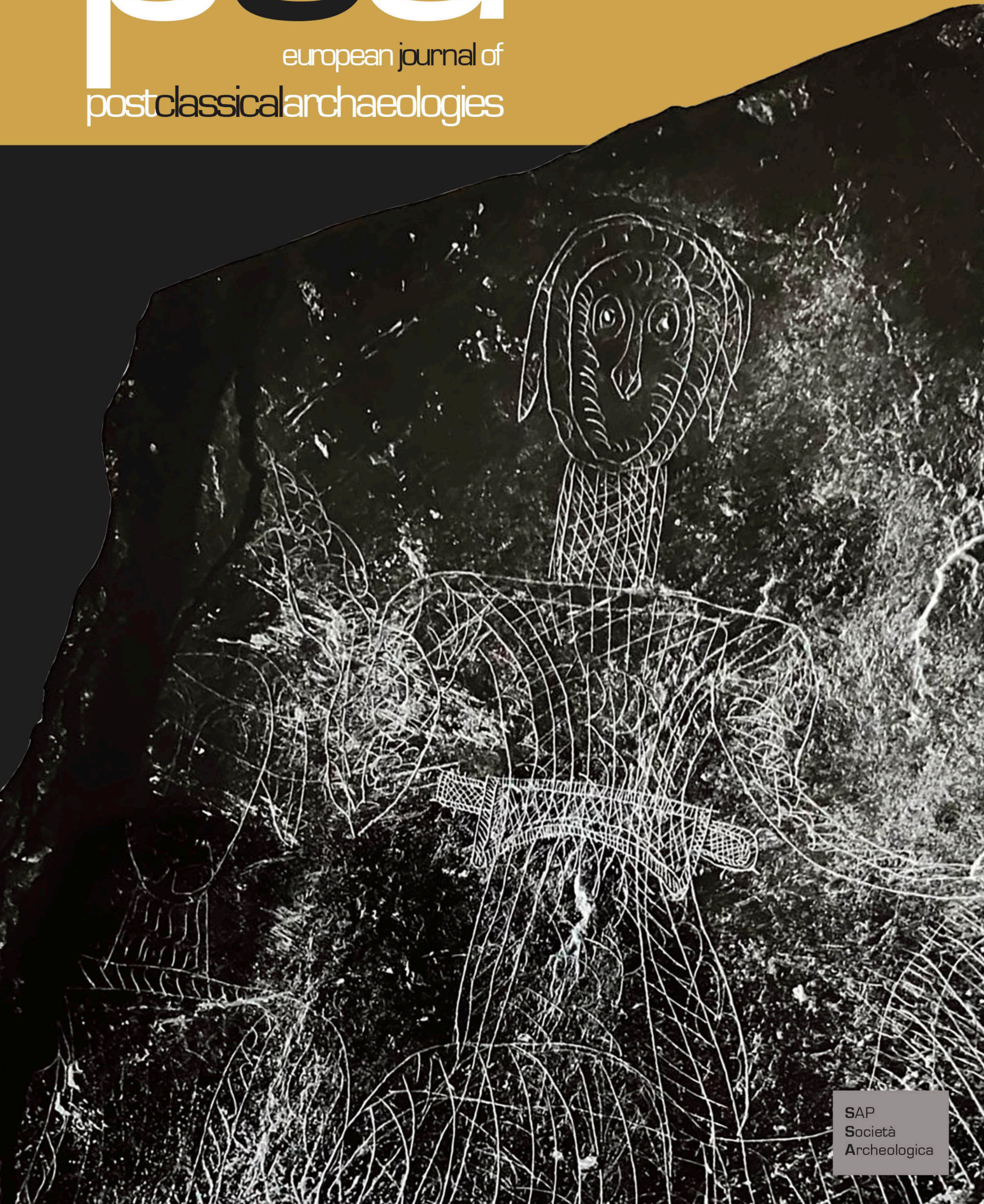

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CONTENTS PAGES

Roberta D'Andrea*, Léa Gérardin-Macario**, Vincent Labbas***, Mélanie Saulnier*, Nicolas Poirier****

Roofing at the crossroads: timber procurement for historical roof construction at the confluence of two major waterways in Occitania (France)

1. Introduction

Understanding the relationship between humans and their surrounding landscapes is essential for building a sustainable future (Massaro *et al*. 2025). Among all landscapes, forests hold a central place in human history, not only because they provide oxygen and shelter, but also because they have always supplied one of the most sustainable and vital materials: timber. Throughout history, forests and their timber resources have indeed participated in the socio-economic development of some of the greatest civilizations (Lazzarini 2021). Decoding these complex dynamics requires interdisciplinary approaches that, through the study of the material and written record, are capable of revealing how the human-forest relationship evolved over time.

In recent decades, scientific methods have been developed to study archaeological wood, including dendrochronology (i.e., the analysis of tree rings). Tree rings not only capture regional climate signals but also reflect ecological and human-induced disturbances experienced by trees over time (Schweingruber 1989). By matching growth curves derived from ring-width measurements – a process known as "crossdating" – the exact felling date of trees can be determined, and their provenance traced through the use of regional reference chronologies (Domínguez-Delmás 2019).

The Bosca project[1] uses an interdisciplinary approach combining documentary sources, epigraphic evidence, and dendrochronological data to examine

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[1] Bois d'Oeuvre, SylviCulture et Acheminement. PI: Nicolas Poirier (TRACES, University of Toulouse).

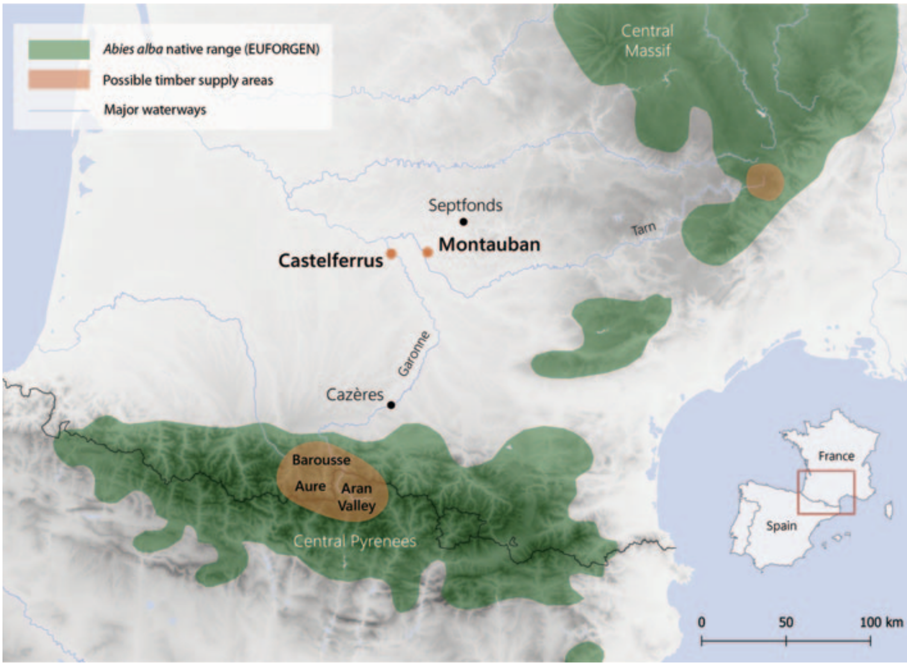


Fig. 1. The study area. The orange dots refer to the location of the buildings included in this study, while the black dots refer to further sites mentioned in the text.

timber production, transport, and use in medieval and modern Occitania (south-western France; fig. 1), seeking to shed light into the relationship between past societies and forests in this region. Here, construction timber transport along the Garonne River has been documented since the Middle Ages (Minovez 1999; Fabre 2021), leading to the common assumption that silver fir (*Abies alba* Mill.) timber originated exclusively from the Pyrenees. In contrast, the role of the Tarn River in timber supply remains poorly understood. Within the Bosca project, we therefore focused our study on high-profile religious and secular buildings located at the confluence of the Garonne and Tarn rivers to examine timber transport dynamics and procurement strategies between these waterways and consequently, the exploitation of Occitania's high-elevation forests in the past. The documentary research offered the most comprehensive and detailed information, which was supported by epigraphic and dendrochronological findings. The selection of buildings was guided by their historical significance, allowing the analysis to capture the key networks of timber procurement in the region. Indeed, all the selected structures are listed as *Monuments Historiques*, an official French designation indicating that they are protected by the homonymous French institution dedicated to cultural heritage conservation.

2. Materials and methods

2.1. Studied roof structures

The Castelferrus Castle

Located at approximately one kilometre from Garonne River, the Castelferrus Castle (France) was historically owned by the Counts of Toulouse. Originally built in the 14th century as a fortified manor house with square towers at the corners, it was redesigned in the 17th century into a large two-story castle, and it is known today for its 18th-century stucco-decorated fireplaces and painted beams in the main room at the first floor[2]. In 2022, it was acquired by two artists aiming to establish a contemporary art centre. Consequently, restoration works were undertaken, providing us with the opportunity to collaborate with the architects and archaeologists involved in the project and to collect data on the timbers of the roof. Their preliminary observation revealed that the roof structure, which is relatively homogeneous, is primarily composed of silver fir (hereafter referred as "fir") timbers, with the exception of four transverse oak (*Quercus* sp.) beams assembled between the wall plates and the rafters (fig. 2a). These beams are not consistent with the rest of the roof structure and may therefore have been reused from the original 14th-century building (Duchêne, Rousset 2024).

The Episcopal Palace of Montauban

The Episcopal Palace of Montauban, now housing the Ingres Bourdelle Museum, was commissioned by bishop Pierre de Bertier during the second half of the 17th century. It was constructed on the remains of a fortress originally built by Edward III of England during the Hundred Years' War (1337-1453). Its overall layout corresponds to a squared structure, with four corner pavilions enclosing a central courtyard.[3] The two western pavilions are distinguished by their steeply pitched roofs, which appear to retain their original framework made of fir wood. According to historical records, the roof structure of the northwest pavilion was completed in 1665, followed by that of the southwest pavilion in 1666 (Garric 1994). Our study focused on the roof of the southwest pavilion (fig. 2b). In 1790, the suppression of the Diocese of Montauban provided the municipality with an excellent opportunity to acquire the episcopal palace at little cost. Converted into the Town Hall, the building has hosted a museum dedicated to the artists Jean-Auguste-Dominique Ingres and Émile-Antoine Bourdelle since 1843. The Tarn River flows along the west side of the building.

[2] Entry: https://pop.culture.gouv.fr/notice/merimee/PA00095916.

[3] Entry: https://pop.culture.gouv.fr/notice/merimee/IA82100044.

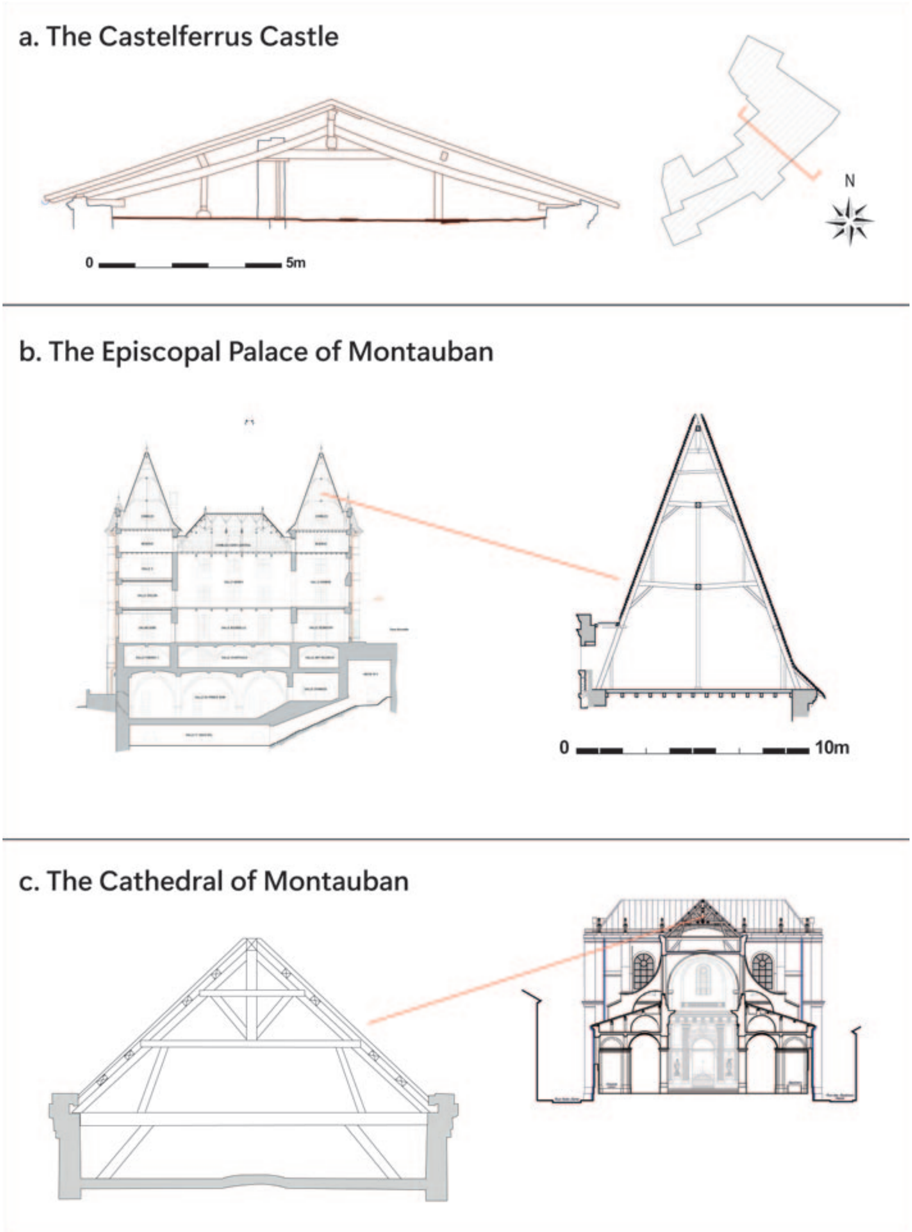


Fig. 2. Plans and sections of the buildings and the roofs included in this study. (a) The Castelferrus Castle: plan of the building and transverse section through the studied roof (Duchêne, Rousset 2024); (b) the Episcopal Palace of Montauban: transverse section through the pavilions and the main body of the palace (credits: Jean-Louis Rebière, ACMH); (c) the Cathedral of Montauban: transverse section through the nave facing the choir (credits: Jean-Louis Rebière, ACMH).

The Cathedral of Montauban

The construction of the Cathedral of Montauban began in 1692 by initiative of Louis XIV and symbolises the conversion of the city from Protestantism to Catholicism. It is characterised by a Latin cross plan and a Neoclassical style; it is mostly made of bricks, while the façade is entirely made of white stone[4]. Its current roof structure differs from the 18th-century drawings signed by the architect in charge of the construction (Huillet 1950). This discrepancy raises the issue of whether the current structure reflects a change of design during the 18th century or whether it has undergone later alterations that modified its structure (fig. 2c). The first dendrochronological campaign involving this roof structure was carried out in 2011, when C. Perrault collected 14 core samples primarily from the nave and transept. Of these, 10 were identified as fir, while the presence of oak and pine (*Pinus* sp.) was also recorded, highlighting a certain degree of diversity in the choice of construction materials. However, because the individual ring-width series showed no significant correlations, it was not possible to establish a reliable site chronology (Perrault 2011). The general scarcity of fir reference chronologies available at the time further limited the possibility of dating the individual samples. Despite these methodological constraints, this first campaign revealed the complexity of the Cathedral's roof structure and suggested the existence of multiple construction phases. Access to the building is now restricted to the public, as the construction of an underground parking facility has compromised the stability of the building. Restoration works are currently underway to address the problem, and they have fuelled a growing interest in this building, which in turn has allowed us to obtain permission to carry out additional sampling in the roof structure included in this study.

2.2. Documentary research

Among the three sites investigated, only the Episcopal Palace and the Cathedral of Montauban have been subject to archival research, as no records about timber supply have yet been identified for the Castelferrus Castle. To reconstruct timber supply networks, we consulted the archival collections described by Huillet (1950), Garric (1994), and Fau (1994), preserved at the *Archives départementales de Tarn-et-Garonne* (AD 82; Montauban, France). For the Episcopal Palace, the available evidence is limited to a quotation dated to 1665[5]. By contrast, the documentation concerning the Cathedral of Montauban is far more extensive, with several hundred accounting records, quotations, and letters preserved, covering the fifty years of construction of the building (1692-1739). Our analysis focused on documents referring to carpentry work and timber suppliers,

4 Entry: https://pop.culture.gouv.fr/notice/merimee/PA00095799.

5 AD 82, series E, file E 442.

leading to the selection of seven quotations and approximately 200 mentions to carpenters and timber deliveries recorded[6]. To pursue this inquiry into the supply of timber for the restoration of the Cathedral's roof in the 1840s, we also consulted the records of works preserved at the *Médiathèque du Patrimoine et de la Photographie* (Paris, France).

2.3. Inspection and selection of timbers

For each of the three roof structures, an initial survey was carried out with the aim of (i) observing and understanding the overall timber assemblages to help us decide the number of samples to collect from each structural unit (Tegel *et al.* 2022), (ii) recording the characteristics of individual timbers, and (iii) identifying the most suitable timbers for the dendrochronological analysis.

The characteristics of timbers are particularly important as they can provide valuable information on timber provenance and transport (e.g., trademarks and evidence of timber rafting), on the phases of construction of the building (e.g., woodworking techniques and evidence of reuse) and on the type of forest exploited (e.g., type of timber employed, quality of wood, dimensions of timbers, etc.). Therefore, these characteristics have been meticulously recorded through photographs and manual sketches on tracing paper before sampling.

The selection of timbers for dendrochronological analysis was guided primarily by three criteria: (i) the accessibility of timbers, (ii) the wood species, ensuring that the study focused on taxa with established dendrochronological reference datasets, and (iii) the presence of bark or partially preserved sapwood, which allows a more precise determination of the felling dates and, consequently, a finer interpretation of the construction phases.

2.4. Dendrochronological sampling and analysis

15 to 17 core samples per roof structure were extracted using a Rinntech drywood borer coupled to an electric drill. In the laboratory, samples were prepared using standard dendrochronological methods (Schweingruber 1989). Samples were mounted on plastic supports and carefully sanded with progressively finer sandpaper (from 120 to 600 grit) in order to make the annual growth rings clearly visible. High-resolution scans (2400 DPI) were then produced using an Epson 10000 XL flatbed scanner to obtain suitable images for ring-width analysis. Ring widths were measured using the CooRecorder software, and resulting series were compared visually and statistically using the CDendro software (Larsson 2013).

[6] AD 82, series C, files C 50 to C 67.

The dendrochronological analysis followed a staged procedure. First, ring-width (RW) series belonging to the same roof structure were compared to identify common growth patterns, which may indicate that the timbers were contemporaneous or originated from the same woodland source. Secondly, individual RW series that showed a statistically significant match were averaged into floating (i.e., undated) mean RW series. Finally, we crossdated the obtained series against existing site and regional reference chronologies to establish absolute calendar dates. For fir, we used a local reference (Labbas *et al.* 2024; Saulnier *et al.* 2025) covering the period 1049-2023 and composed of 27 site chronologies, with Alpine and Central Massif chronologies (Shindo *et al.* 2017; F. Blondel, unpublished) for crossdating validation. For oak, we used a set of reference site chronologies (n. 110) from Occitania (Béa *et al.* 2008) covering the period 1012-1794; a chronology from Nouvelle-Aquitaine (C. Belingard, unpublished) was also consulted to confirm the dating results.

When the waney edge (i.e., last ring below the bark) was present on the timber and preserved on the core sample, a precise felling date could be indicated for both fir and oak. In oak, when sapwood was present and could be distinguished from heartwood based on colour, the number of missing sapwood rings was estimated using the sapwood model developed by Lambert (1998). In cases where only heartwood was preserved, only a *post-quem* date could be provided.

3. Results

As mentioned, archival research has been carried out solely on the Episcopal Palace and on the Cathedral of Montauban, as no historical documents on timber supply have been identified for the Castelferrus Castle. As regards the Cathedral, we incorporated the undated dendrochronological dataset developed by Perrault (2011) on the same building. These data were used alongside our own tree-ring measurements to support the analyses presented here.

3.1. The Castelferrus Castle

Assemblages and timbers

Observations and sampling were carried out in the accessible areas of the roof structure in the southeast side of the building. The structure is a portico-style roof with raised tie beams and rafters supported by vertical posts (fig. 2a). As previously suggested by the architects and archaeologists in charge of the restoration project (see paragraph 2.1), two assemblages were noticed: the main roof structure made of fir wood, likely corresponding to the modern phase, and four oak timbers that appear unrelated to the rest of the structure and that could have belonged to the medieval phase of the roof construction (fig. 3a).

Evidence of rafting was identified on fir timbers. Most notably, we observed wooden pegs with rope remnants (fig. 3c) comparable to examples elsewhere in Europe (e.g., Eissing, Dittmar 2011). The wooden pegs vary in size, measuring 2-3 cm in diameter and 9-11 cm in length, with pointed, quadrangular shapes as those reported by Labbas *et al*. 2021. Ropes were crafted from common hazel (*Corylus avellana* L.) branches. Some purlins and joists retain peg holes, and their shaped ends correspond to typical raft construction (fig. 3b). Moreover, the fir beams show a distinctive woodworking pattern: one well-squared face (likely used as the raft decking) bears different trademarks, the opposite face is unsquared (presumably the water-facing side of the timber), and the two lateral faces are less precisely finished. The trademarks observed consist of letters or alphanumeric codes, typically inscribed within geometric symbols such as circles, squares, or hearts (fig. 3d). Some recurring marks, such as the D and the BF inscribed in heart-shaped symbols, were identified (table S1).

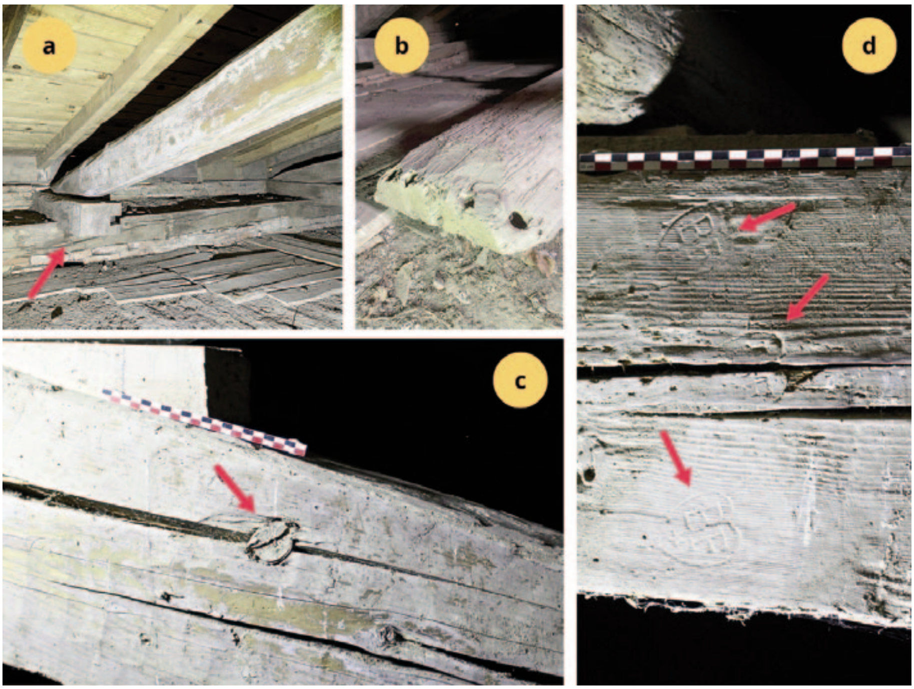


Fig. 3. The Castelferrus Castle. (a) The fir roof structure with reused oak timbers; (b) joist with peg holes; (c) wooden pegs with rope remnants; (d) trademarks.

			Occitania 1012-1794	Nouvelle-Aquitaine 1083-1876	Frequency
CAS_QUSP	1123-1256	*Quercus* sp.	**R = 0.40** **T = 5.0** **Glk = 0.63** **Ovl = 133**	R = 2.8 T = 3.3 Glk = 0.59 Ovl = 133	**33.3%**

Table 1. Dating of the mean chronology CAS_QUSP. Crossdating statistics were calculated using the 'Proportion of last two years growth' (P2Yrs) normalization method implemented in CDendro (Larsson 2013). R = Person correlation coefficient; T = Student's t value; Glk = Gleichläufigkeit score (Buras 2015); Ovl = Overlap. The best match is highlighted in bold. The frequency indicates the statistical reliability of the assigned date based on how many times the crossdating analysis suggest it (against how many reference site chronologies; Lambert *et al.* 2010).

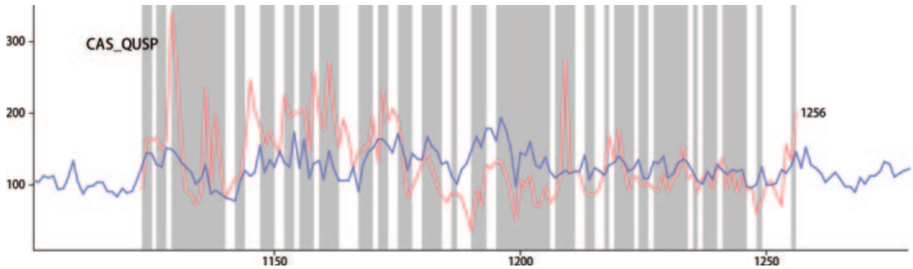


Fig. 4. Dating of the mean chronology CAS_QUSP. Y axis: tree-ring widths (x0.01 mm); X axis: calendar years. The blue curve represents the oak master chronology from Occitania. The grey bars represent the percentage of parallel variation (Glk).

Dendrochronological analysis

We sampled all four timbers of the oak assemblage and eleven timbers for the fir assemblage. Both groups of timbers showed significant inter-series correlations, which allowed the creation of two mean site chronologies, namely CAS_QUSP for oak (MR: 0.55; SDI: 0.48-0.63)[7] and CAS_ABAL for fir (MR: 0.61; SDI: 0.51-0.71). The comparison of these chronologies with the reference datasets available allowed to date the oak assemblage to the 13th century (table 1; fig. 4) and the fir assemblage to the first half of the 18th century (table 2; fig. 5). Only samples CAS_04 and CAS_11 could not be incorporated into the site chronology CAS_ABAL; they were instead compared individually with the reference chronologies, but no significant match was obtained. Therefore, we achieved a 100% dat-

[7] MR = mean Pearson's correlation; SDI = standard deviation interval.

			Occitania 1049-2023	Alps 1214-1933	Central Massif 1118-2022	Frequency
CAS_ABAL	1581-1741	*Abies alba* Mill.	**R = 0.46** **T = 6.5** **Glk = 0.67** **Ovl = 160**	R = 0.41 T = 5.6 Glk = 0.59 Ovl = 160	R = 0.34 T = 4.5 Glk = 0.58 Ovl = 160	**71.4%**

Table 2. Dating of the mean chronology CAS_ABAL. Additional details are provided in the caption of Table 1.

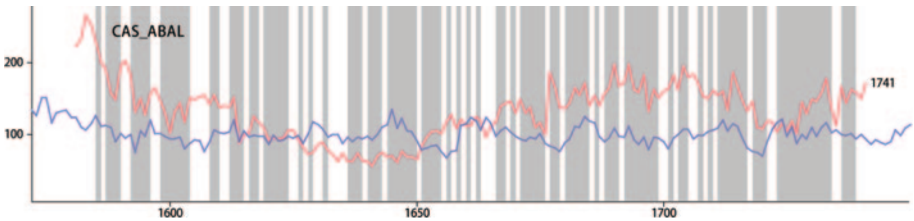


Fig. 5. Dating of the mean chronology CAS_ABAL. Y axis: tree-ring widths (x0.01 mm); X axis: calendar years. The blue curve represents the fir master chronology from Occitania. The grey bars represent the percentage of parallel variation (Glk).

ing success rate for oak and 81.8% for fir. As regards the 13th-century phase, neither bark nor sapwood were preserved on the four oak timbers. Consequently, only *post-quem* dates were established for the felling of these trees (table S1). For the modern phase, the presence of bark on CAS_05 and CAS_09 allowed to date the felling of these two trees to 1741 and 1740, respectively. The observation of the anatomical features of the last rings preserved on CAS_05 and CAS_09 revealed the presence of latewood (i.e., the portion of xylem formed at the end of the growing season) on both samples, indicating that the trees were felled between the summer of the last ring preserved and the following spring (prior to the formation of the next year's ring; table S1). The occurrence of timbers from different felling seasons within a single building could indicate that the trees were initially taken to a storage location prior to being used in construction (Eckstein 2007).

3.2. The Episcopal Palace of Montauban

Documentary research

The documentary research conducted at the *Archives départementales de Tarn-et-Garonne* showed that fir and larch (*Larix decidua* Mill.) were used for flooring, fir or oak for planks and staircases, and linden (*Tilia* sp.) for secondary elements such as cornices and panelling. Within the main roof structure, fir seems to predominate, while oak was reserved for specific components, including ridge beams and king posts.

The sources of the timber employed in the main roof structure are not explicitly mentioned. The documents analysed state that fir wood was supplied by the bishop, that it was stocked in a barn at Villebourbon – a district of Montauban located near the Tarn River – and that it was delivered directly to the construction site. In these documents, the word "bishop" likely denotes the episcopal institution rather than the individual, indicating that the bishopric was responsible for acquiring and stocking the timber. The carpenters involved were based in Montauban. The records also mention a port on the Tarn River – at Sapiac, a suburb of Montauban – where poplar (*Populus* sp.) wood for scaffolding was delivered[8].

Two supply scenarios can be proposed: (i) timber may have been sourced from ecclesiastical lands or from the bishop's personal estates, as bishops were often landowners; (ii) alternatively, it may have been procured from merchants and stored in episcopal properties before being delivered to the site.

Assemblages and timbers

We focused on the southwest pavilion, as it was the only one accessible for study (fig. 2b). The roof structure is a common rafter roof made entirely of fir timber (fig. 6a). Evidence of later interventions, such as repairs and chimney insertions, is also visible. Because of the insulation, the wall plates and the lower portions of the rafters could not be examined. The upper part of the roof could be closely inspected by means of a ladder, allowing access to roughly three-quarters of the total height of the structure, but only when the ladder could be placed in the narrow spaces between the rafters. For safety reasons, samples were taken from the lower portions of the rafters (fig. 6b).

As for the Castelferrus Castle, several indications of rafting were observed on the fir timbers of this roof structure, including several trademarks stamped on wood. In particular, several *fleur-de-lys* marks were identified (fig. 6c; table S2, see samples MIB_01 and MIB_03), suggesting that the timber may have originated from ecclesiastical properties. Another recurring mark is the double "D" one, observed on timbers MIB_08, MIB_12 and MIB_14 (table S2). Wooden pegs with rope remnants, as well as peg holes like those reported at the Castelferrus Castle, were also documented (fig. 6d).

Dendrochronological analysis

We sampled fifteen rafters belonging to the roof structure of the southwest pavilion. Five out of fifteen samples showed significant inter-series correlations and could be averaged into a mean site chronology named MIB_ABAL (MR:

[8] AD 82, E 442, n. 5.

Fig. 6. The Episcopal Palace of Montauban. (a) The roof structure; (b) the sampling campaign; (c) trademarks on timber; (d) wooden peg with rope remnants.

0.64; SDI: 0.58-0.70)[9]. The comparison of the MIB_ABAL chronology with the master chronology of fir from the Occitania Region allowed to date the felling of the five trees to the second half of the 17th century (table 3; fig. 7), which confirm the information reported by Garric (1994). Because no bark was preserved, only *post-quem* dates could be established. The remaining ring-width series were individually compared with the reference chronology, but no significant correlation was identified. The relatively low dating success rate (33.3%) may be explained by the short length and limited variability of several series (e.g., MIB_14 with only 41 rings), which reduces the statistical reliability of the cross-dating analysis. Conversely, MIB_04 and MIB_05, the longest series (203 and 144 rings, respectively), could not be dated, likely due to the pronounced suppression and release events that characterise their growth patterns (fig. 8). These events are generally linked to natural hazards (e.g., storms, insect outbreaks, etc.) or silvicultural practices (e.g., intensive cutting, trimming, etc.), which can trigger an abrupt growth reduction (i.e., in damaged trees) or acceleration (i.e., in the trees that are left standing after their neighbours are re-

[9] MR = mean Pearson's correlation; SDI = standard deviation interval.

			Occitania 1049-2023	Alps 1214-1933	Central Massif 1118-2022	Frequency
MIB_ABAL	1551-1655	*Abies alba* Mill.	**R = 0.45** **T = 5.1** **Glk = 0.58** **Ovl = 104**	R = 0.27 T = 2.8 Glk = 0.67 Ovl = 104	R = 0.38 T = 4.1 Glk = 0.63 Ovl = 104	**75%**

Table 3. Dating of the mean chronology MIB_ABAL. Additional details are provided in the caption of Table 1.

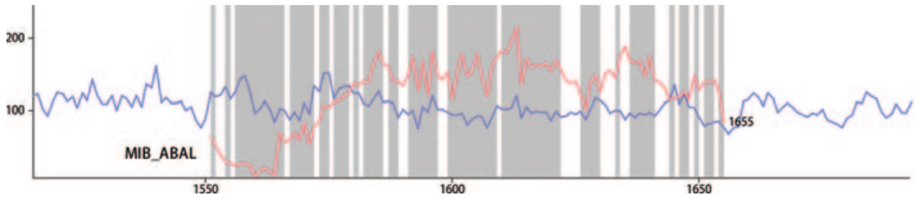


Fig. 7. Dating of the mean chronology MIB_ABAL. Y axis: tree-ring widths (x0.01 mm); X axis: calendar years. The blue curve represents the fir master chronology from Occitania. The grey bars represent the percentage of parallel variation (Glk).

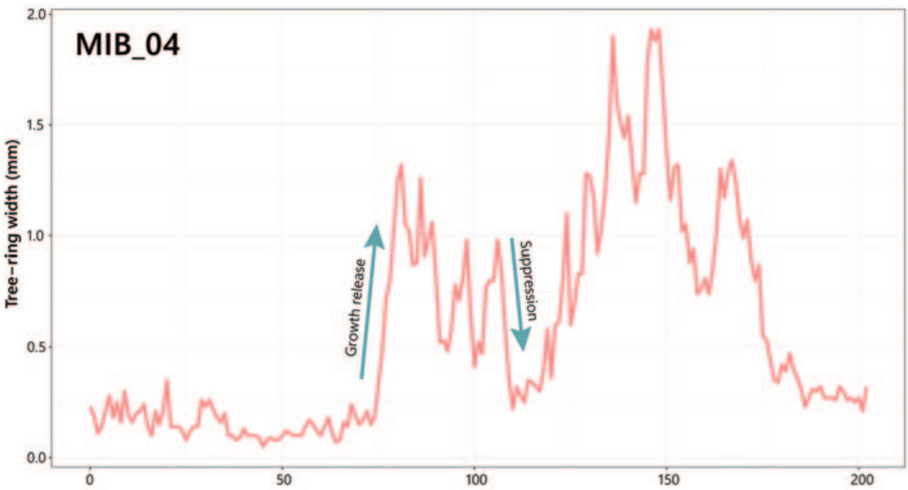


Fig. 8. Undated tree ring-width series MIB_04.

moved). Such trends can blur the climate signal and hinder the crossdating analysis despite standardisation but can inform on past tree growth conditions. Broadly speaking, the high difference in tree age could reflect the use of different forest stands for timber procurement.

3.3. The Cathedral of Montauban

Documentary research

Rich documentation exists for the 18th century regarding timber transport and use in carpentry for the Cathedral of Montauban. The most relevant information comes from the *Archives départementales de Tarn-et-Garonne* and paints a very complex timber supply system.

Excluding planks, scaffolding, and machinery – where poplar was commonly used – only oak and fir emerge as the primary species for the construction of the main framework. In the 18th-century structure, fir and oak were distributed according to their structural properties: fir timber was primarily chosen for large horizontal elements such as tie beams, whereas oak was used for smaller components such as king posts. Broadly speaking, fir predominates, and it is generally less expensive than oak, despite being sourced from considerably greater distances and transported by rafting on the Garonne River[10]. Indeed, the accounts indicate that it originated from the Pyrenean valleys with the exception of the Aran valley, which was considered to yield wood of inferior quality[11]. The only mention of rafting on the Tarn River regards poplar wood used for scaffolding[12]. Timber was distributed through merchants, many from Montauban, who acted as intermediaries. A Toulouse-based merchant, *sieur* Daure, is also recorded as delivering timber by rafting to the port of Bourret on the Garonne River, approximately 20 kilometres southwest of Montauban[13]. Oak, in contrast, appears to have been sourced locally. The accounts refer to oak obtained from nearby fairs, often specifying the suppliers' origins: the most notable provider was François Delpech of Septfonds, located 30 kilometres northeast of Montauban (fig. 1), who undertook the supply of large oak structural elements such as king posts[14].

For timber supply, architects relied on adjudications, contracts guaranteeing the delivery and payment of a specified quantity of wood over several years. Nevertheless, these contracts did not cover all needs, so architects often turned to carpenters themselves, who also provided timber with the merchants acting

[10] AD 82, C 54, n. 11.

[11] AD 82, C 54, n. 11.

[12] AD 82, C 50, n. 2.

[13] AD 82, C 54, n. 18.

[14] AD 82, C 63, n. 92.

as guarantors. Batches of timbers were sometimes purchased directly from various providers on local markets[15].

Regarding the 19th-century restoration of the Cathedral, no information has been found in the archives of the *Médiathèque du Patrimoine et de la Photographie* in Paris concerning timber transport and use for the restoration of the roof structure in the 19th century.

Assemblages and timbers

We observed that the present roof structure follows the 18th-century design. However, its reduced height and the presence of reinforcements indicate substantial modifications that altered the original plan while preserving its fundamental structure: a crown-post roof (fig. 2c; fig. 9a; Hoffsummer *et al.* 2011; see paragraph 2.3). Our observations focused on a number of accessible key elements, such as the tie beams of the nave and the transept and the trusses of the crossing framework (fig. 9b). As previously recorded by C. Perrault, three main species of wood are employed in the construction: fir is the dominant species; oak is mostly used for short vertical and diagonal elements such as king posts and braces; and Scots pine (*Pinus sylvestris* L.) is only employed in the axial chapel. Two types of fir timbers could be distinguished: those likely belonging to the original construction phase (beginning of the 18th century) and those resulting from a major 19th-century restoration campaign (fig. 9c).

The fir elements attributed to the initial phase share several common features: they are regularly squared on three faces and left unsquared on the fourth one; one well-squared face almost invariably bears stamped trademarks. Marks of broadaxe are clearly distinguishable on the well-squared faces (*timber typology 1*; fig. 9d). Evidence of rafting was also observed, including groups of peg holes, as well as wooden pegs with rope remains like those reported at the Castelferrus Castle and at the Episcopal Palace. Trademarks reveal a highly heterogeneous timber supply system (fig. 10). While some marks appear on multiple pieces, often within the same area, no consistent pattern or major supplier could be identified. The "CH" mark is noteworthy, as it appears on both fir and oak pieces (table S3).

The timbers belonging to the second phase are mechanically sawn on all four faces and show no evidence of rafting (*timber typology 2*; fig. 9e). These timbers also bear several dates ranging from 1817 to 1847, which align with a major roof restoration project that appears to have begun in the first half of the 19th century (fig. 9c).

Most likely during the 20th century, the sapwood of all the fir timbers was partially and sometimes completely removed to mitigate the risk of insect infestation.

[15] AD 82, C 52, n. 27.

Fig. 9. The Cathedral of Montauban. (a) The roof structure; (b) sampling and recording trademarks; (c) evidence of restoration; (d) timber typology 1; (e) timber typology 2.

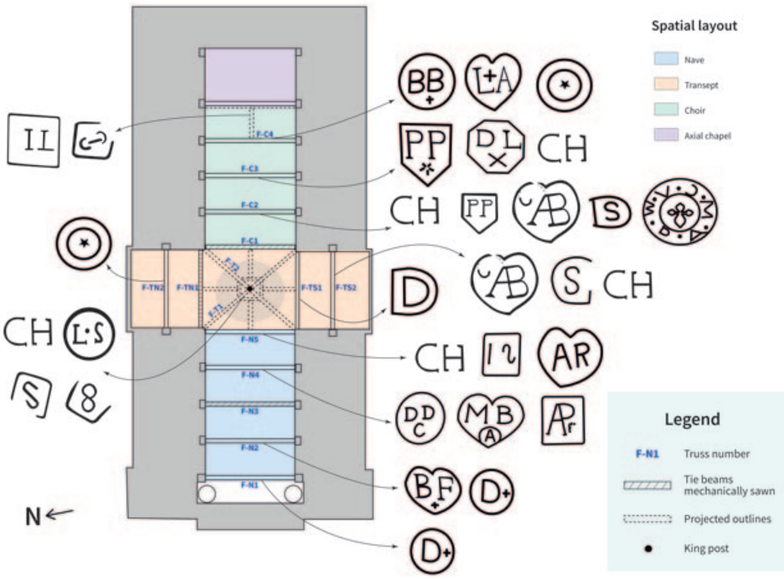


Fig. 10. Diversity of trademarks at the Cathedral of Montauban.

Dendrochronological analysis

We focused our dendrochronological analysis on the frameworks of the nave, the transept, and the crossing. Fir and oak elements from both construction phases were sampled, and the new dataset was combined with that of C. Perrault. For consistency, ring-width series belonging to the same timbers were averaged: sample CAT_RD05 with Perrault's sample 09 (CAT_RD05_CP09; crossing, principal rafter), and sample CAT_RD13 with Perrault's sample 01 (CAT_RD13_CP01; nave, tie beam). Series from both datasets did not exhibit significant inter-individual correlations – which may suggest that the timbers were obtained from different forest sources –, preventing the construction of a mean site chronology. The series were therefore compared individually to the regional fir and oak master chronologies from Occitania. No significant match has been identified for oak samples, likely because of the short length of their series (e.g. CAT_RD03 is characterised by 28 rings). As for fir timbers, three main groups of timbers were identified. The first consists of four samples from the original construction phase: CAT_RD01 and Perrault's samples 02, 04 and 12 (renamed CAT_CP02, CAT_CP04 and CAT_CP12). All these timbers present the characteristics of *timber typology 1* (fig. 9d), and their outermost rings date to the second half of the 17th century (table 4; fig. 11). Nevertheless, as a significant portion of sapwood had been removed (see paragraph 3.3.2), these trees were probably felled in the early 18th century, as also suggested by the archival documents analysed. The second group includes three samples from the 19th-century restoration phase (table 5; fig. 12). Finally, the last rings of samples CAT_RD16 and CAT_RD17 were dated to 1562 and 1630, respectively (table 6; fig. 13). These timbers present the characteristics of *timber typology 2* (fig. 9e) and bear 19th-century painted dates (fig. 9c; table S3), suggesting they may have been reused during the restoration phase. In conclusion, out of 23 fir samples (13 from our dataset and 10 from Perrault's), only eight could be dated (34.7% dating success rate). Felling dates could not be estimated due to the lack of the waney edge on all samples.

4. Discussion

4.1. Modern-period roof structures in southwestern France

Although research on roof structures is well established elsewhere in France for both the medieval (Épaud 2007) and the modern periods (Hoffsummer *et al.* 2011), investigations in southern France are still comparatively limited and have focused on the Mediterranean region (Guibal, Bouticourt 2010; Bouticourt 2016). In Occitania, dendrochronological investigations funded by regional authorities

			Occitania 1049-2023	Alps 1214-1933	Central Massif 1118-2022	Frequency
a/ CAT_CP02	1545-1655	*Abies alba* Mill.	**R = 0.38** **T = 4.2** **Glk = 0.63** **Ovl = 110**	R = 0.23 T = 2.4 Glk = 0.61 Ovl = 110	NS	**16.7%**
b/ CAT_CP04	1580-1658	*Abies alba* Mill.	**R = 0.44** **T = 4.2** **Glk = 0.62** **Ovl = 78**	R = 0.32 T = 2.9 Glk = 0.56 Ovl = 78	R = 0.37 T = 3.5 Glk = 0.52 Ovl = 78	**80%**
c/ CAT_RD01	1572-1666	*Abies alba* Mill.	**R = 0.32** **T = 3.2** **Glk = 0.63** **Ovl = 94**	R = 0.19 T = 1.9 Glk = 0.55 Ovl = 94	NS	**40%**
d/ CAT_CP12	1593-1687	*Abies alba* Mill.	**R = 0.21** **T = 2.1** **Glk = 0.57** **Ovl = 94**	R = 0.08 T = 0.8 Glk = 0.52 Ovl = 94	NS	**75%**

Table 4. Dating of the individual samples of "Group 1" collected at the Cathedral of Montauban. Additional details are provided in the caption of Table 1. NS = non-significant.

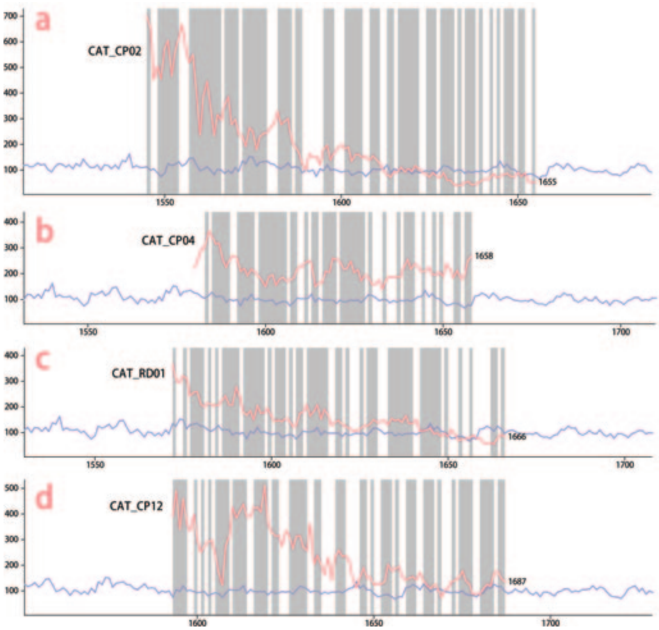


Fig. 11. Dating of the individual series of "Group 1". Y axis: tree-ring widths (x0.01 mm); X axis: calendar years. The blue curve represents the fir master chronology from Occitania. The grey bars represent the percentage of parallel variation (Glk).

			Occitania 1049-2023	Alps 1214-1933	Central Massif 1118-2022	Frequency
a/ CAT_RD05_CP09	1704-1810	*Abies alba* Mill.	R = 0.4 T = 4.2 Glk = 0.69 Ovl = 106	**R = 0.45** **T = 4.8** **Glk = 0.66** **Ovl = 94**	R = 0.37 T = 4.1 Glk = 0.58 Ovl = 106	**57.1%**
b/ CAT_RD13_CP01	1752-1845	*Abies alba* Mill.	**R = 0.51** **T = 6.1** **Glk = 0.66** **Ovl = 93**	R = 0.38 T = 4.1 Glk = 0.69 Ovl = 105	R = 0.34 T = 3.5 Glk = 0.61 Ovl = 93	**33.3%**

Table 5. Dating of the individual samples of "Group 2" collected at the Cathedral of Montauban. Additional details are provided in the caption of Table 1.

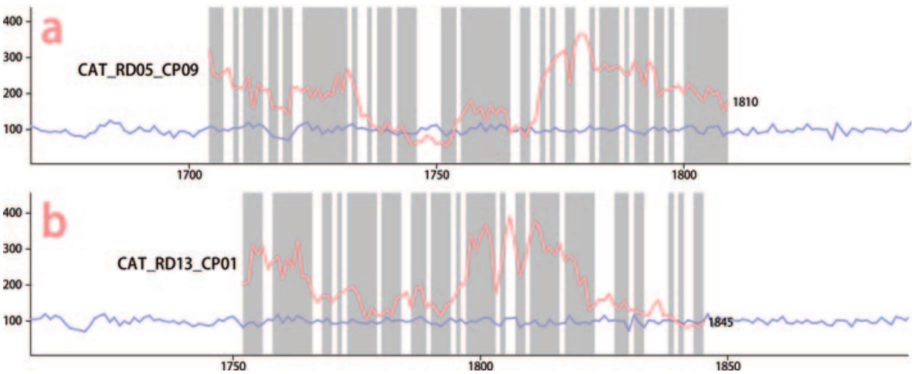


Fig. 12. Dating of the individual series of "Group 2". Y axis: tree-ring widths (x0.01 mm); X axis: calendar years. The blue curve represents the fir master chronology from Occitania. The grey bars represent the percentage of parallel variation (Glk).

and carried out within the framework of a heritage inventory program[16] have so far enabled the survey and dating of a number of roofs. Moreover, Labbas *et al.* (2021) and François (2023) reported the first evidence of rafting marks on fir timbers felled at the beginning of the 19th century for the construction of the roof of the La Grave Hospital in Toulouse (France).

In this context, the present study provides a more exhaustive foundation for future research on this subject in southwestern France. Although these timber structures differ in type, they are all comparable in terms of material selection and supply networks. Indeed, fir was preferred for large horizontal elements (e.g., tie beams) owing to its tensile and bending strength and to the long, straight stems typical of the species. Oak, on the other hand, was reserved for

[16] https://inventaire.patrimoines.laregion.fr/.

			Occitania 1049-2023	Alps 1214-1933	Central Massif 1118-2022	Frequency
a/ CAT_RD16	1458-1562	*Abies alba* Mill.	R = 0.44 T = 4.9 Glk = 0.69 Ovl = 104	R = 0.12 T = 1.2 Glk = 0.56 Ovl = 104	**R = 0.45** **T = 5** **Glk = 0.71** **Ovl = 104**	**80%**
b/ CATRD17	1559-1630	*Abies alba* Mill.	**R = 0.52** **T = 5** **Glk = 0.65** **Ovl = 71**	R = 0.07 T = 0.5 Glk = 0.51 Ovl = 71	NS	**100%**

Table 6. Dating of the individual samples of "Group 3" collected at the Cathedral of Montauban. Additional details are provided in the caption of Table 1. NS = non-significant.

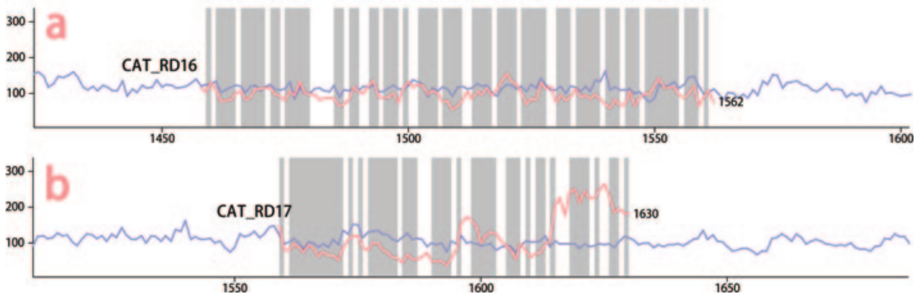


Fig. 13. Dating of the individual series of "Group 3". Y axis: tree-ring widths (x0.01 mm); X axis: calendar years. The blue curve represents the fir master chronology from Occitania. The grey bars represent the percentage of parallel variation (Glk).

vertical components like king posts, where its superior compressive strength was advantageous. The two timbers were also sourced differently: fir was transported over long distances as its low density allows it to be floated, whereas oak was procured locally due to its higher density, which makes floating impractical. It is important to stress that all of the studied buildings are situated in close proximity to waterways, which facilitated the long-distance transport of timber. Another example of this building practice is the Church of *Notre-Dame-de-l'Assomption* in Cazères, also located along the Garonne River (fig. 1). Its roof was dated as part of the Bosca project to the early 16th century (D'Andrea, unpublished) and presented the same characteristics: fir as the main material, oak for the king posts, and evidence of timber rafting for the fir elements[17]. In contrast, during the same period, fir is entirely absent in comparable structures located far from the

[17] https://doi.org/10.5281/zenodo.17423788.

Garonne River. Ongoing dendroarchaeological research, conducted in the framework of an inventory initiative of the Region Occitania, has indeed revealed the exclusive use of oak timber for carpentry in high-profile buildings located far from the Garonne and the Tarn rivers (Bongiu, Gérardin-Macario 2024). Finally, it is worth noting that the roofs examined in this study belong to high-profile construction projects, where high-quality or non-local timber was easier to obtain. Future research focusing on more modest contexts along the Garonne River could reveal contrasting trends, such as the predominance of locally sourced timber, the re-employment of timber, or the use of less common taxa.

4.2. Dendrochronology of fir

Overall, this study highlights both the significant role of fir in modern roof construction in Occitania and the need for further dendrochronological research on this species. Although recent progress has been made with the acquisition and publication of two databases – a dendroarchaeological one (Labbas *et al.* 2024) and another one based on living trees (Saulnier *et al*. 2025) – the master chronology for dating fir in Occitania, and more specifically in the Central Pyrenees, is still under development. This is likely the reason for the relatively modest dating results obtained in this study: we achieved a dating success rate of 81.8% at Castelferrus Castle, 33.3% at the Episcopal Palace, and 34.7% at Montauban Cathedral. With the exception of Castelferrus, the dating scores from the two sites in Montauban are relatively low when compared to other studies in France and Europe, particularly those based on oak timber (Haneca *et al.* 2020; D'Andrea *et al*. 2024). Another possible explanation is that some of the timber did not originate in the Pyrenees but came instead from regions for which no reference chronology is currently available.

The other main references for fir in France the one developed by Shindo *et al.* (2017) – which assembles historical ring-width series from the French Alps and in the Mediterranean – and the one developed for the Central Massif (Blondel, unpublished). These references were used here to validate our results and sometimes provided stronger correlations with our tree-ring database: for instance, CAT_RD05_CP09 exhibits a more significant match with the Alpine chronology (table 5). This is not necessarily an indication of provenance – as it has been demonstrated that fir trees show strong correlations over long distances (Bernabei, Franceschi 2024) – but stresses the need for a refined dendro-methodological approach to apply to fir specifically in dating and provenance studies. Notably, Dittmar *et al*. (2012) identified elevation-specific signatures in Norway spruce and fir ring-width series in Southern Germany, emphasising the potential need to compile elevation-specific master chronologies for dating fir. Moreover, recent methodological advances – such as the application of oxygen isotopes (Loader *et al*. 2019) and blue intensity measurements (Wilson

2025) – offer promising avenues for increasing the precision of both dating and provenancing. Statistical approaches that use advanced spatial correlation analysis (Bridge, Fowler 2019; Visser 2021; Bernabei, Franceschi 2024) and couple multiple proxies (D’Andrea *et al*. 2023) might help expand the dendrochronological research on fir and improve the reliability of its provenancing.

These research avenues are particularly important, as they could shed light on past timber supply networks, as well as on the management and exploitation of high-elevation forests in France (Shindo *et al*. 2022). Moreover, they could contribute to a better understanding of how past forest use has influenced present-day forest cover and health (Oliva, Colinas 2007; Camarero *et al*. 2011).

4.3. Timber sources and supply chains from the 17th to the 19th century

The wood species selection for historical construction can offer valuable insight into past economy, forest resource management and supply practices. Here, the use of oak and fir is particularly significant, as it shows that builders relied on two separate trade networks: a local one for oak and a long-distance one for fir. Fir emerges as the preferred construction material, owing to its lower cost relative to local oak. This case study thus reveals how economic considerations impacted construction practices in the past, as the builders took advantage of the commercial potential offered by rivers.

The opportunities offered by the long-distance fir trade attested on the Garonne River for the 17th-18th century had varying impacts on projects according to their scale. For smaller projects, such as the roofs of the Castelferrus Castle or the Episcopal Palace, timber procurement appears relatively uniform. By contrast, large-scale projects like the Cathedral of Montauban present a markedly different scenario, involving complex supply chains and multiple intermediaries. Our dendrochronological and epigraphic results confirm the information provided by the documentary research: on the one hand, the absence of correlation among individual tree-ring-width series of the Cathedral shows that timber came from multiple forests, and on the other hand the diversity of trademarks suggests that timber was obtained through the involvement of numerous merchants.

In this context, a more attentive analysis of trademarks allowed us to identify the influence of the same merchant (or family of merchants) across different buildings: for example, the “BF” mark – inscribed within a heart-shaped motif – occurs both at the Cathedral and at Castelferrus, while the double “D” is attested at the Cathedral and at the Episcopal Palace. Such recurrences may suggest that certain timbers circulated through the same supply networks. Conversely, the “CH” mark appears on both oak and fir at the Cathedral. Knowing from archival records that the oak and fir timbers came from different supply networks, the “CH” could indicate a merchant who supplied all of these timbers but acquired them from different areas. This highlights the key issue of the geographical range of a merchant's influence and calls into question the reliability of trademarks as indicators of wood provenance. The direct participation of carpenters in sourcing timber for the Cathedral – with the involvement of merchants as guarantors – points in the same direction, as their presence on site suggests possible access to ports not only along the Garonne but also the Tarn, and therefore to different supply chains. A systematic documentation of trademarks, combined with the analysis of related archival records, will be essential for clarifying these dynamics.

Another clear indication of long-distance trade revealed by our results is the presence of rafting pegs with rope remnants. Rafting techniques have been extensively documented in several Western and Northern European regions, notably by Eißing and Dittmar (2011) in Thuringia and Bavaria (Germany), and by Zunde (2011) in Latvia. Such methods were commonly employed across Europe to transport timber for roof construction of high-profile religious and secular buildings. For instance, Haneca *et al*. (2012) provided evidence of rafting for the oak timbers of the Church of Our Lady in Damme (Belgium) likely transported along the Meuse River. Similarly, Domínguez-Delmás *et al.* (2018) demonstrated that rafting was used to move pine timbers for the Cathedral of Jean and the *Colegial del Salvador* in Sevilla via the Guadalquivir River. Shindo *et al*. (2019) reported that fir timbers employed in the Grand-St-Jean Castle (Aix-en-Provence, France) were rafted down the Rhône from the Alps. More recently, Grabner *et al*. (2021) documented comparable rafting practices at the Castle of Vienna and the Capuchin Church, where spruce timbers were transported along the Danube River. These studies collectively highlight the widespread use of river-based timber transport in the construction of high-profile buildings across Europe. Our archival and archaeological research now extends this knowledge to the Occitania Region, where timber rafting on the Garonne River – previously suggested by archival research for the late Middle Ages (Fabre 2021) – persisted into the 17th and 18th centuries. Although the Aran Valley (fig. 1) is documented as the principal supply area in the Central Pyrenees (Galy 2018), archival records concerning the Cathedral state that the timber from this valley was of poor quality, suggesting that it may have been overexploited in the centuries prior to the 18th. It is therefore plausible that the fir employed originated instead from the Barousse or Aure valleys (fig. 1), also cited as the most important supply areas by Galy (2018) and Fabre (2021).

Based on our results, we hypothesise that timber transport dynamics in Montauban underwent significant changes in the 19th century. Timbers from this period appear markedly different from earlier ones: they show no evidence of rafting or trademarks and were mechanically sawn. Since the first railway line reaching Montauban was built in 1858 (Suret-Canale 1942), therefore after the restoration of the Cathedral (1840s), it is likely that timber were transported by ship to the construction site. Future studies aimed at expanding dendrochronological sampling of 19th-century timbers – in Montauban and elsewhere in the region – will help determine whether the wood still originated from the Central Pyrenees or came from other regions, thereby contributing to a better understanding of forest exploitation and timber supply practices across centuries.

Finally, the documented presence of fir in medieval and modern buildings of the low Languedoc-Roussillon Region (e.g., the Malves-en-Minervois Castle; Decottignies, Chabbert 2023; Bouticourt 2016) attests to the circulation of timber from the Eastern Pyrenees down the Aude River as far as the ports of Trèbes et Villedubert (Fabre 2023). From the late 17th century onward, rafts were dismantled in these ports and reassembled before being floated further along the so-called *Canal du Midi* – an artificial canal linking Toulouse to the Mediterranean – as far as Sète (Fabre 2023). Furestier (2025) reports that timber from the Alps was also shipped to Sète after being rafted down the Rhône River, suggesting that the timber assemblages preserved in today's buildings of southern France may be more complex than previously assumed. Moreover, since the *Canal du Midi* was navigable in both directions, it is reasonable to suppose that from the late 18th century fir timber from the Eastern Pyrenees could also have reached Toulouse, and, after 1844 – when the canal was extended further north to reach Montech and Montauban – Montauban as well (fig. 14). This implies the presence of a third supply network reaching the study area, which opens new promising avenues for research.

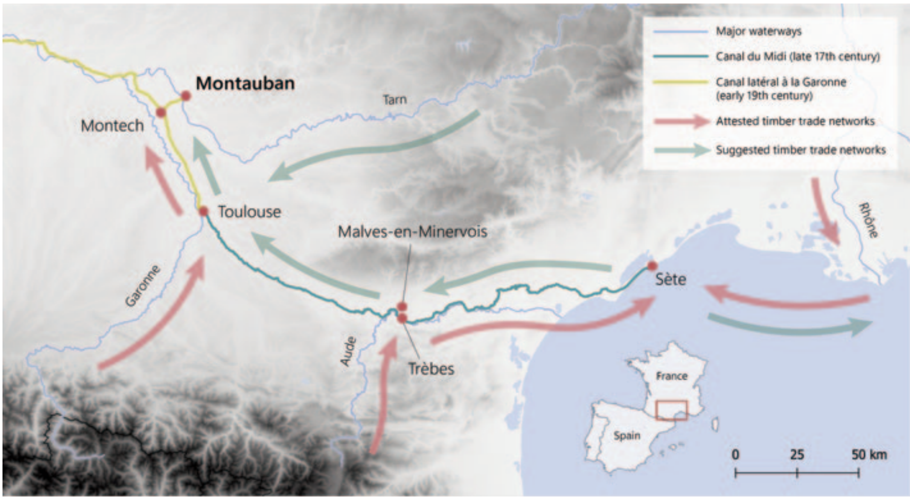


Fig. 14. Attested and suggested timber trade networks in southern France. In 1844, the *Canal du Midi* was extended to reach Montech and Montauban. This new section of the canal was called *Canal latéral à la Garonne*. In 1856, the canal reached Castets-en-Dorthe, near Bordeaux.

5. Conclusions

The study of roof frameworks in southwestern France has long remained largely unexplored, and this research represents a pioneering work in addressing that gap. The analysis of timber from modern-period constructions has revealed the predominant use of fir in roof-building practices in Occitania during this period. Beyond contributing to architectural and historical knowledge, our analysis has refined the regional master chronology for fir, which will strengthen the future dendrochronological studies. These findings emphasise the continuing need for detailed investigation of timber species, their provenance, and the networks through which they circulated, offering new insights into construction techniques, material selection, and trade patterns in France and Europe. Whether fir timber was also rafted along the Tarn River and sourced from the Central Massif remains uncertain; so far, the only identified record concerns poplar wood delivered at the Sapiac port in Montauban. Further archival and dendroarchaeological analyses of 19th-century timbers may clarify this issue.

Acknowledgments

We especially thank the Bosca project for funding this research and all its members for their valuable insight and contributions. We acknowledge Christophe Perrault, François Blondel, Lisa Shindo, Christelle Belingard, and the Region Occitania for providing the reference data. We also express our gratitude to the *Musée Ingres Bourdelle*, the *Direction Régionale des Affaires Culturelles*, and the owners of Castelferrus Castle for granting access to the buildings, thereby enabling this study. We extend our sincere thanks to Marc Galy and Michel Bartoli for sharing their knowledge on the use of fir in southwestern France and for engaging in enriching discussions.

ID	Localisation and type of timber	Species	NR (NSR)	First year	Last year	Waney edge?	Felling	Marks
CAS_01	Roof, transverse beam	*Quercus* sp.	112 (0)	1142	1253	-	After 1253	-
CAS_02	Roof, purlin	*Abies alba* Mill.	61	1677	1737	-	After 1737	
CAS_03	Roof, principal rafter	*Abies alba* Mill.	44	1677	1720	-	After 1720	
CAS_04	Roof, tie beam	*Abies alba* Mill.	56	ND	ND	-	ND	-
CAS_05	Roof, principal rafter	*Abies alba* Mill.	48	1694	1741	Yes	Summer 1741/ spring 1742	-
CAS_06	Roof, post	*Abies alba* Mill.	130	1606	1735	-	After 1735	
CAS_07	Roof, purlin	*Abies alba* Mill.	134	1581	1714	-	After 1714	
CAS_08	Roof, post	*Abies alba* Mill.	140	1596	1735	-	After 1735	
CAS_09	Roof, principal rafter	*Abies alba* Mill.	111	1630	1740	Yes	Summer 1740/ spring 1741	-
CAS_10	Roof, principal rafter	*Abies alba* Mill.	47	1688	1734	-	After 1734	-
CAS_11	Roof, principal rafter	*Abies alba* Mill.	33	ND	ND	-	ND	
CAS_12	Roof, transverse beam	*Quercus* sp.	96 (0)	1123	1218	-	After 1218	-
CAS_13	Roof, transverse beam	*Quercus* sp.	120 (0)	1137	1256	-	After 1256	-
CAS_14	Roof, transverse beam	*Quercus* sp.	98 (0)	1132	1229	-	After 1229	-
CAS_15	Roof, purlin	*Abies alba* Mill.	79	1651	1729	-	After 1729	

Table S1. The Castelferrus Castle. Sampled timbers. NR = Number of rings; NSR = number of sapwood rings.

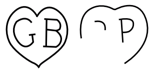
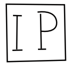
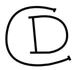
ID	Localisation and type of timber	Species	NR (NSR)	First year	Last year	Waney edge?	Felling	Marks
MIB_01	Southwest pavilion, rafter	*Abies alba* Mill.	57	1592	1648	-	After 1648	
MIB_02	Southwest pavilion, rafter	*Abies alba* Mill.	58	ND	ND	-	-	
MIB_03	Southwest pavilion, rafter	*Abies alba* Mill.	40	ND	ND	-	-	
MIB_04	Southwest pavilion, rafter	*Abies alba* Mill.	203	ND	ND	-	-	
MIB_05	Southwest pavilion, rafter	*Abies alba* Mill.	144	ND	ND	-	-	-
MIB_06	Southwest pavilion, rafter	*Abies alba* Mill.	90	ND	ND	-	-	-
MIB_07	Southwest pavilion, rafter	*Abies alba* Mill.	34	ND	ND	-	-	
MIB_08	Southwest pavilion, rafter	*Abies alba* Mill.	84	1565	1648	-	After 1648	
MIB_09	Southwest pavilion, rafter	*Abies alba* Mill.	67	1551	1617	-	After 1617	-
MIB_10	Southwest pavilion, rafter	*Abies alba* Mill.	81	1575	1655	-	After 1655	-
MIB_11	Southwest pavilion, rafter	*Abies alba* Mill.	60	ND	ND	-	-	
MIB_12	Southwest pavilion, rafter	*Abies alba* Mill.	50	ND	ND	-	-	
MIB_13	Southwest pavilion, rafter	*Abies alba* Mill.	71	1584	1654	-	After 1654	-
MIB_14	Southwest pavilion, rafter	*Abies alba* Mill.	31	ND	ND	-	-	
MIB_15	Southwest pavilion, rafter	*Abies alba* Mill.	37	ND	ND	-	-	-

Table S2. The Episcopal Palace of Montauban. Sampled timbers. NR = Number of rings; NSR = number of sapwood rings.

ID	Localisation and type of timber	Species	NR (NSR)	First year	Last year	Waney edge?	Felling	Marks
CAT_RD01	Crossing, tie beam	*Abies alba* Mill.	95	1572	1666	-	After 1666	
CAT_RD02	Crossing, bracing beam	*Abies alba* Mill.	114	ND	ND	-	ND	-
CAT_RD03	Crossing, king post	*Quercus* sp.	28	ND	ND	-	ND	
CAT_RD04	Transept, tie beam	*Abies alba* Mill.	79	ND	ND	-	ND	-
CAT_RD05	Crossing, principal rafter	*Abies alba* Mill.	103	1708	1810	-	After 1810	-
CAT_RD06	Crossing, bracing beam	*Abies alba* Mill.	59	ND	ND	-	ND	
CAT_RD07	Crossing, post	*Abies alba* Mill.	31	ND	ND	-	ND	
CAT_RD08	Crossing	*Quercus* sp.	30	ND	ND	-	ND	-
CAT_RD09	Crossing, brace	*Quercus* sp.	53	ND	ND	-	ND	-
CAT_RD10	Crossing, brace	*Quercus* sp.	33	ND	ND	-	ND	-
CAT_RD11	Crossing	*Abies alba* Mill.	28	ND	ND	.	ND	-
CAT_RD12	Crossing	*Abies alba* Mill.	39	ND	ND	-	ND	-
CAT_RD13	Nave, tie beam	*Abies alba* Mill.	94	1752	1845	-	After 1845	-
CAT_RD14	Nave, tie beam	*Abies alba* Mill.	64	ND	ND	-	ND	-
CAT_RD15	Transept, tie beam	*Abies alba* Mill.	69	ND	ND	-	ND	-
CAT_RD16	Transept, common rafter	*Abies alba* Mill.	105	1458	1562	-	After 1562	1817
CAT_RD17	Transept, purlin	*Abies alba* Mill.	72	1559	1630	-	After 1630	1842

Table S3. The Cathedral of Montauban. Sampled timbers. NR = Number of rings; NSR = number of sapwood rings.

Abstract
Research on historical roof structures and timber supply networks in southwestern France remains scarce. Combining archival sources and epigraphic evidence with dendrochronological data, we examined three roofs located at the confluence of the Garonne and Tarn rivers to better understand timber procurement in modern-period Occitania (France). We identified two distinct systems: a long-distance supply for fir (*Abies alba* Mill.) and a local one for oak (*Quercus* sp.). In the 17th and 18th centuries, rafting was the main transport method, while the 19th century shows changes in long-distance procurement methods and possibly supply regions. Our research highlights the need to refine fir tree-ring chronologies to strengthen future provenance studies.
Keywords: dendroarchaeology, modern-period timber supply, roof structures, *Abies alba*, Pyrenees.

*Le conoscenze sulle strutture storiche dei tetti e sulle reti di approvvigionamento del legname nella Francia sud-occidentale sono ancora limitate. Questo studio combina fonti d'archivio, evidenze epigrafiche e dati dendrocronologici per analizzare le coperture di tre edifici situati alla confluenza dei fiumi Garonna e Tarn, con l'obiettivo di approfondire la comprensione delle dinamiche di approvvigionamento del legname in Occitania (Francia) in età moderna. L'indagine ha permesso di distinguere due sistemi di rifornimento: uno a lunga distanza per l'abete bianco (*Abies alba *Mill.) e uno locale per la quercia (*Quercus *sp.). Nel XVII e XVIII secolo il trasporto del legname avveniva prevalentemente per via fluviale, tramite zattere, mentre nel XIX secolo si osservano trasformazioni nei metodi e, probabilmente, nelle aree di provenienza del legname. I risultati sottolineano la necessità di affinare le cronologie di anelli dell'abete bianco in Occitania, al fine di consolidare futuri studi sulla provenienza del legname storico da costruzione.*
***Parole chiave**: dendroarcheologia, approvvigionamento di legname nel periodo moderno, strutture dei tetti,* Abies alba, *Pirenei.*

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