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INTERNATIONAL JOURNAL OF WOOD CULTURE
3 (2022) 1–37

The International Journal of Wood Culture
brill.com/ijwc

Wood Used in Brussels' Old Buildings: Origin, Characterisation, and Use (12th–19th Centuries)

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 | DOI:10.1163/27723194-BJA10010

Abstract

Since 1990 archaeologists, historians and dendrochronologists have worked on 128 sites in the Brussels-Capital Region. In addition to producing a typo-chronological inventory of wooden roof structures (12th–19th centuries), the studies have now extended to finishings and floor coverings, with an increasing focus being placed on the types of wood used. Although oak was the predominant material, especially before the 17th century, the resources used in Brussels and the surrounding villages were local. They came from three wooded areas, cleared or degraded to varying degrees: the Sonian Forest, state-owned forests, and hedgerows. Oak grows rapidly, with wide rings which make dendrochronological dating difficult, although this can be overcome by utilising more comparative data, employing carbon-14 dating, or knowing the historical context. The use of green wood has been confirmed, with unusual felling periods spread over two years. The sinuous profile of the fast-growing oaks was used to cut the knee braces in roofs over knee walls and porticoed wooden structures of monuments, urban housing, and vernacular architecture. Mediocre oak, or even wood from fruit trees, elm, or ash, was used for this kind of architecture. Moreover, from the 17th century onward, species other than oak began to appear in the roof frames of all buildings, especially after the centre of Brussels was bombarded in 1695. The typology of the reconstructed roof frames is the same as that prior to 1695, but a wider variety of woods were used to meet the high demand at the time of reconstruction. This diversity of species is more evident among floorboards, with poplar, elm, Scots pine, fir, and spruce being used. This may have been due to technical reasons, but, in the local context, it would also have been a question of using the precious oak of the Sonian Forest frugally.

Keywords

archaeology – carpentry – dendrochronology – forest exploitation – joinery – wood species

1 Introduction

The regional administration responsible for managing and conserving the immovable heritage of the Brussels-Capital Region, set up from 1989–1990, immediately recognised dendrochronology as a tool for analysing the area's historic built heritage in the context of preventive archaeology operations (Modrie *et al.* 2021, p.133). The idea was to link dendrochronology with a typo-chronological inventory project involving the historic wooden roof structures

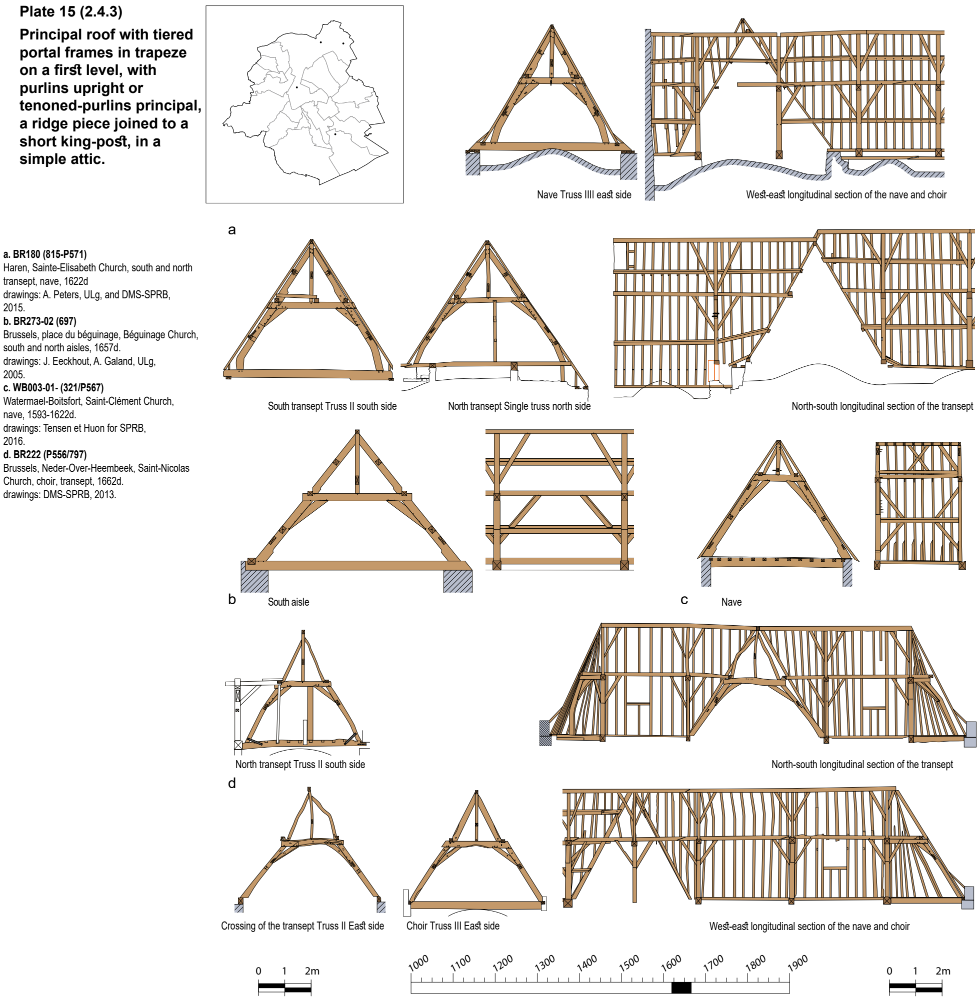

FIGURE 1 One of the typological plates of the inventory of the frameworks in the Brussels region © ULIÈGE, KIK-IRPA, URBAN.BRUSSELS

in Brussels with the aim of understanding how they evolved while taking inspiration from the methodology used in projects in northern France and Belgium (Hoffsummer 2002) (Fig. 1).

Moreover, since 2013, urban.brussels has funded a dendrochronology and archaeological wood study group in the Brussels region. This working team brings together the dendrochronology laboratories of the University of Liège and the Royal Institute for Cultural Heritage. This group is responsible for the dendro-archaeological analyses of buildings and archaeological sites in

Brussels. A substantial portion of the results is fed into the database of the inventory project for roof frames. Archaeologists and historians from the University of Liège, the University of Brussels, and the Museum of Art and History make up this multidisciplinary team, along with regional archaeologists. The research, initially limited to wooden roof structures and some excavated finds, has been extended to include finishings and floors. During this dendro-typological inventory, 128 sites in Brussels were studied, corresponding to 266 occurrences (objects, buildings, or chronological phases) (i.e., 1,960 dendrochronological samples) (Fig. 2).

The material documentation is added to a corpus which covers the period from the end of the 12th century to the end of the 19th century. Regarding preventive archaeology, the collection work presents various opportunities. Programmed archaeological campaigns would probably make it possible to document the Middle Ages more effectively, as this period is under-represented compared to the modern era. Despite this fact, the sites in our corpus are varied — rural and urban sites, prestigious and ordinary dwellings, pieces of monumental religious architecture, public buildings, military sites, etc. — and

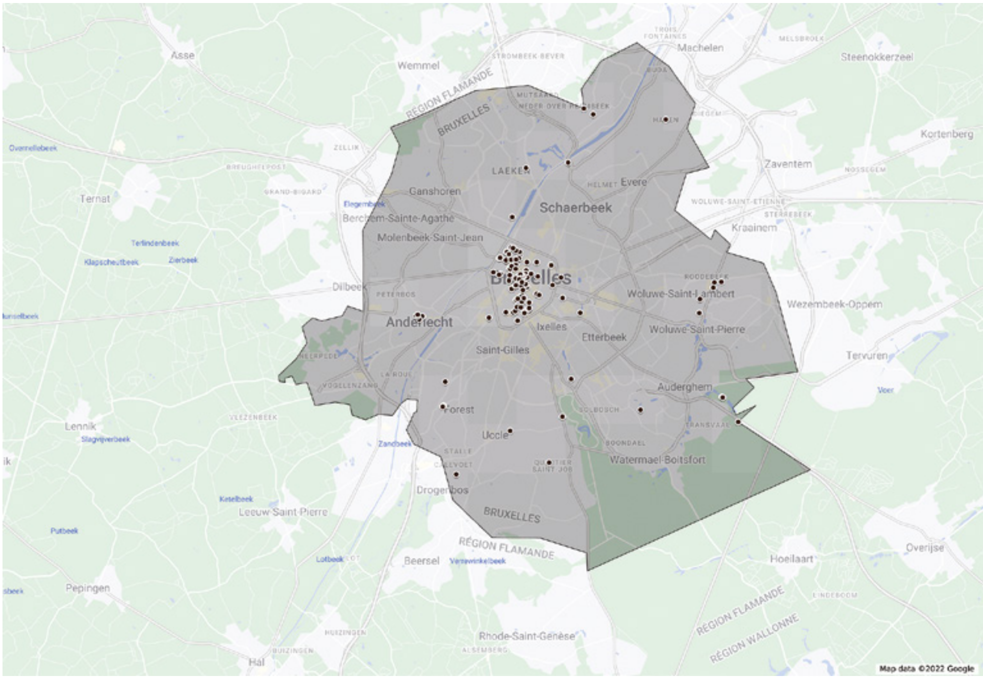

FIGURE 2 Location of the sites studied by dendrochronology in the Brussels region
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they offer a glimpse of the richness of Brussels' historic heritage. Districts with a high level of urban dynamism, where there is a strong political will to restore protected heritage sites, as is the case in the area around the Grand-Place (classified as a UNESCO World Heritage site), have provided more case studies compared to, for example, sites in rural areas. In the case of the area around the Grand-Place, history and archaeology intersect around a significant event — the bombardment of the city by Louis XIV in 1695 — in a site covering 21 hectares where housing was rebuilt (see below).

During these studies, wood, as a resource, emerged as a research topic in its own right, and the results of this research can contribute to the broader study of construction history. Since 2011, species other than the primary one, i.e., oak, have been almost systematically inventoried, and they were used for structural timber or for building components. Some examples detailed in the article illustrate this variety. While the material analysis presented here gives a more nuanced picture than that provided by some theoretical prescriptions in the texts, it remains a partial overview, since not all types of wooden constructions are known presently.

In this article, the team of researchers focused on structural work, particularly timber roofs, while finishing work was only examined through flooring. A historical approach combining the material studies was employed by focusing on a few representative buildings of the corpus and paying particular attention to the nature and the origin of the wood.

2 Forest Exploitation in the Brussels Region before the Industrial Revolution: Landscape, Management and Market

The present-day Brussels region roughly corresponds to the historical city and several villages in its vicinity (a radius between 5 and 10 kilometres). Brussels appeared at the turn of the millennium as a *portus*. The city was established inland, 40 kilometres south of the North Sea, at the crossroads of two important trade routes: the Senne, a sub-tributary of the Scheldt flowing from south to north, and an east-west road route connecting Flanders and the Rhineland. In the west, the city bordered an important woodland, the Sonian Forest (almost 10 000 hectares at the beginning of the 16th century) (Fig. 3). Together with several coppiced woods, high trees, and hedgerows (along rivers and roads) around the town, it was the main regional source for firewood, charcoal, and timber. The supply was, therefore, mainly regional (Charruadas *et al.* 2021), although supra-regional import networks existed in varying proportions at various times, with a major milestone, the building of the Willebroek Canal,

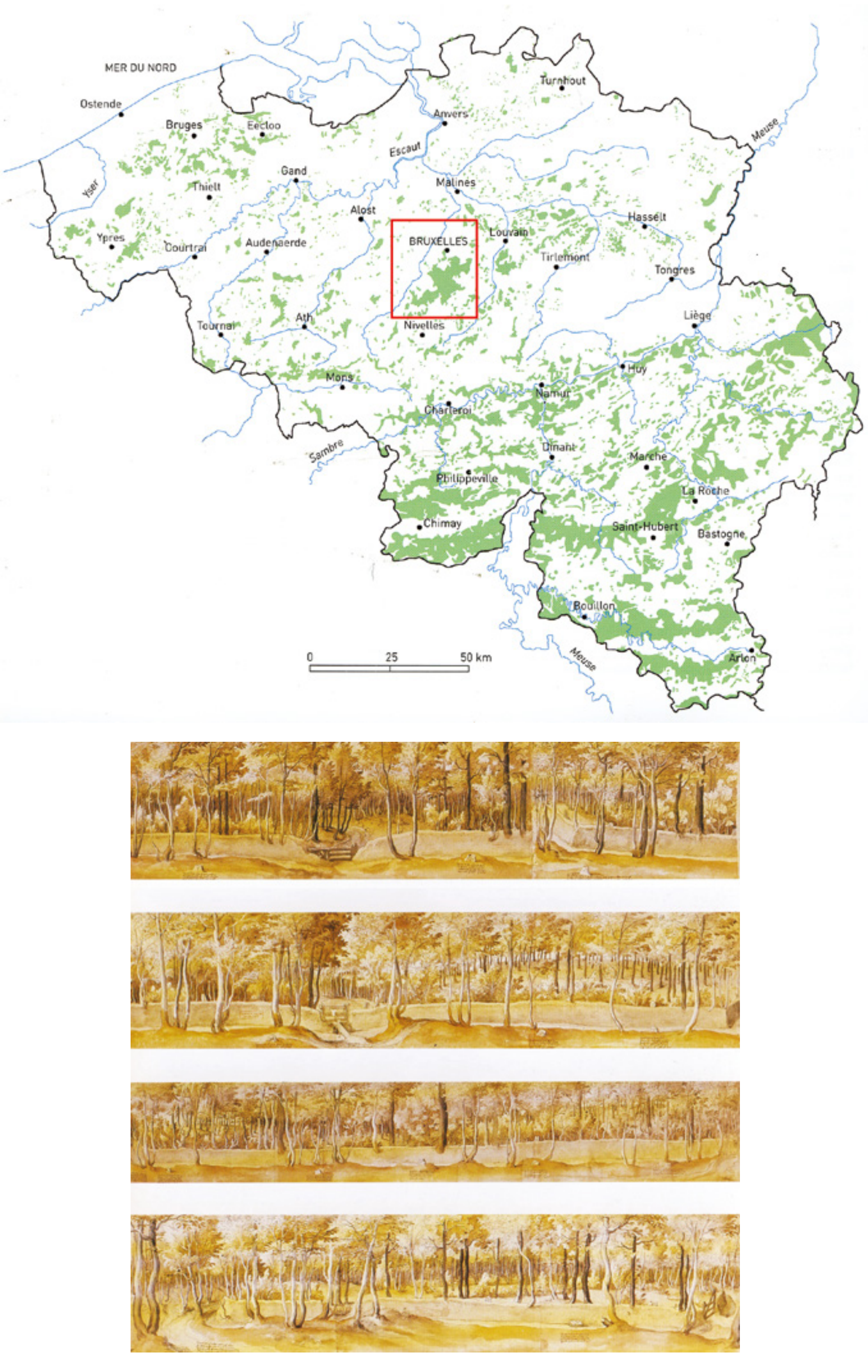

FIGURE 3 (a) Ferraris map redrawn with wooded areas (Tallier 2010) and with the Brussels area highlighted; (b) Drawings of a part of the Sonian Forest, produced when the property of the priory of Jericho in ter Cluysen, under Braine-l'Alleud, was demarcated (coloured drawings on paper, AGR, CPmss, 3003-2/3/4/5).

which opened in 1561 and replaced the irregular navigation on the river Senne (Sosson 1994, 1996). The geohistorical analysis of this territory also reveals an extremely favourable natural hinterland in addition to wood products: silty and sandy-silty soils with excellent soil qualities for agriculture and the production of bricks; sandstone banks (commonly known as 'white stone' or 'Brabant stone'), particularly for supplying the various construction sites (public buildings and facilities, patrician residences, religious buildings, houses, etc.).

The forest cover in the Brussels region is morphologically composed of at least three types of landscapes:

1. The Sonian Forest, which belonged to the prince (the Louvain-Brabant, the Burgundians, then the Habsburgs) and was managed from the 13th–15th centuries by specialised institutions (the Ducal Forestry of Brabant, the Chamber of Accounts, and the Finance Council).
2. A constellation of (more or less) small woods, belonging to private owners (abbeys, convents, individuals).
3. Hedgerows and rows of trees along roads, rivers, and on the borders of farms. This type of exploitation is more than an occasional practice of opportunism; rather, it is a systematic willingness to exploit/commercialise the entire tree cover (Barnes & Williamson 2008). According to Paul Warde, 'in many regions (of western and central Europe) perhaps the majority of trees stood in fields or hedgerows rather than woodland' (Warde 2004).

These resources may appear insufficient for the considerable needs of the urban and rural populations of the Brussels region. Contrary to neighbouring Flanders, Holland, or the north-west of Brabant (the Antwerp region), which have adequate waterways for the relatively easy import of foreign timber (by floating and sea transport), and the Namur region and Principality of Liège, which bordered the well-known forest region of the Ardennes, the Senne was a medium-sized river with irregular flow unfavourable to floating and used by flat-bottomed boats. This specific context probably explains why forestry exploitation has matured in a systematic and extremely sustainable way (Charruadas & Deligne 2019) as well as why Ardennes and Baltic timber is not recorded. The opening of the Willebroek Canal in 1561 seems to have mainly facilitated the import of outside wooden boards (Charruadas *et al.* 2021). All wood was used for making fires and carpentry in a context marked by strong demographic pressure (the Brussels region was one of the most densely populated areas in the southern Netherlands in the pre-industrial period): in sum, there was a high demand but limited resources.

The Sonian Forest presented a pronounced multifunctional character: commercial wood exploitation had to contend with the prince hunting and use rights of the neighbouring populations. Thus, it was managed as a high forest (long rotation about 80 to 100 years), but with an important coppice level. This management method has also favoured the production of gnarled and fast-growing wood. Several documents mention the low number of reserved trees (standards/spindles) per hectare. From the end of the 15th century onwards, the standard was about 16 per hectare. This is an extremely low figure and insufficient to allow the forest to take over from the coppice: such a method leads to the development of a sparse forest, made up of isolated trees, growing freely and without competition (Charruadas 2015).

The private woods appear to have been mainly exploited in the form of coppices under standards, i.e., a low level cutting with a short rotation (7 to 25 years in most documented cases) and high level of large trees (beech, oak, elm) reserved for several rotations. The functions of these two levels were essential and complementary to the extent that a coppice or pure high forest existed very rarely in Brussels: the coppice level provided small-section wood for heating and charcoal and certain construction materials; the upper level provided some protection for the young coppice, which was at risk during storms, ensured the replacement of old stumps tired by several decades of coppice rotations, and, finally, provided wood of larger sections for construction.

In this context, the large trees potentially destined for carpentry grew in an open environment with little competition, and thus had a de facto fast-growing profile, expanding in diameter more than height and developing branches and suckers without much hindrance (Tack *et al.* 1993). The same applies to avenue trees, which grew in an even less constrained environment.

In brief, it is worth underlining the multi-functionality and complex character of the facies of Brussels forests and woodlands. These features are not the result of chance or indiscriminate over-exploitation but the attempt of a society subject to strong demographic pressure, disadvantaged in terms of forest cover and transport techniques, to ensure the supply of woodland products to many types of users.

3 The Wood Species Used by the Construction Sector in Brussels Identified through Archaeological and Dendrochronological Studies

One of the main findings of the research conducted over the last 30 years in the Brussels region is the predominance of oak (*Quercus robur* L. or *Q. petraea* Liebl.) as a species used in timber roofs from the 12th–19th centuries (Fig. 4). Nevertheless, the use of other species for timber roofs has also been observed, especially from the 17th century onwards (at present, our corpus

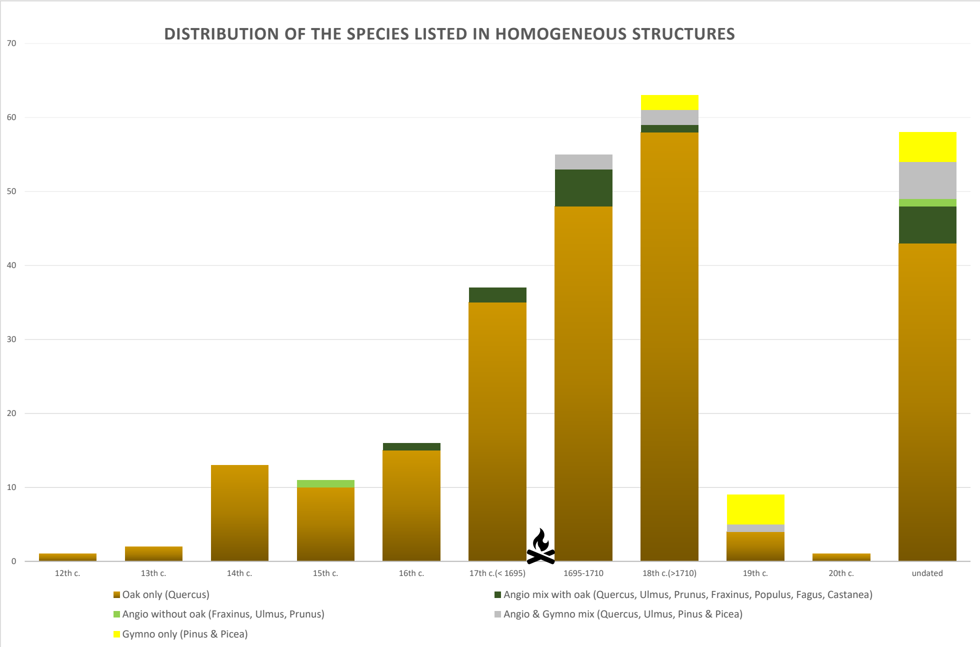

FIGURE 4 Diagram of the distribution of species in the structures studied
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includes only one older example, but this does not appear to be an isolated case if we consult the few archival sources available). As such, mixed structures combining oak and other species (9% of the corpus) have been identified in a wide variety of building types. Structures entirely made of coniferous, elm, ash, or fruit trees were rarer (5% of the corpus) and only included ordinary urban or rural dwellings.

The situation is generally different for finishing work, for which a wide variety of species was used. For example, in addition to oak, elm, various types of softwoods, and poplar (or willow) were widely used for the manufacture of planking structures (roofboards, floorboards, etc.), stairs, doors and window frames.

3.1 *Structural Roof Timber from the 12th–16th Centuries: Predominance of Oak*

Oak, a native species, is particularly well-suited for construction purposes in the above-mentioned region. It can be dated dendrochronologically, with an accuracy of within one season; thus, with well-designed and efficient sampling, it is possible to precisely identify the phasing of a given construction site.

Currently, 43 timber roofs have been dated to the period from the end of the 12th century to the 16th (16% of the corpus), including the structures covering the primary and most famous churches in the Brabant Gothic style. There is just one case of a Romanesque church roof, in Woluwe-Saint-Lambert. Seven oak roof frames from urban houses built prior to the 17th century have survived to the present. In rural areas, the roof frame of the main building of the Château de Trois-Fontaines in Auderghem probably involved the reuse of 14th-century timbers (1324–1335d (d=date obtained by dendro datation)) in the 16th or 17th century, and the roof frame of the L'abreuvoir farm in Uccle dates from the 15th century (after 1476d). In this type of architecture, other, more modest species were used rather than oak, such as, for example, in the former Beguinage of Anderlecht in the 15th century.

The typologies observed in these buildings are similar: during the medieval period, most involve common rafter roofs alternating trusses with tiebeams and trusses with raised tiebeams divided into bays; in the modern era, these are mostly principal rafter roofs (with principal trusses and purlins that carry the common rafters). The specific feature of the roof frames in Brussels, as was the case elsewhere in Brabant in the past, is that the principal trusses are portal frames: in the lower part of the truss, a base cruck supports a collar beam, above which there is a separate superstructure with variations in the upper part of the roof and bracing. For the purposes of this article, the important feature of this typology is that it involves a system of portal frames which makes it possible to use short timbers that may not be straight and may occasionally have knots. This type of timber can be sourced in open environments, such as sparse woods and hedgerows, which corresponds to the forest exploitation context documented by the texts (see above). The profile of the principal rafters or knee braces, particularly in roofs over knee walls (which are very frequent in the urban environment of Brussels), also accommodates slightly curved or widened timbers at their base, which makes it possible to install purlins at the end of the tiebeam or collar while keeping a sufficient width of tenon. It is possible for this kind of profile to be obtained with oaks from stump sprouts in a coppice crop. Sparse stands could also produce trees with large branches that could be used in this type of structure. This avenue is being explored and could explain the lack of sensitivity of certain dendrochronological series (Schweingruber 1996, p. 119–121).

3.1.1 The Roof Frame of Saint-Lambert Church in Woluwe-Saint-Lambert (12th Century)

So far, the oldest documented evidence in the Brussels region is an oak frame covering the western part of the south aisle of the church of Saint Lambert in

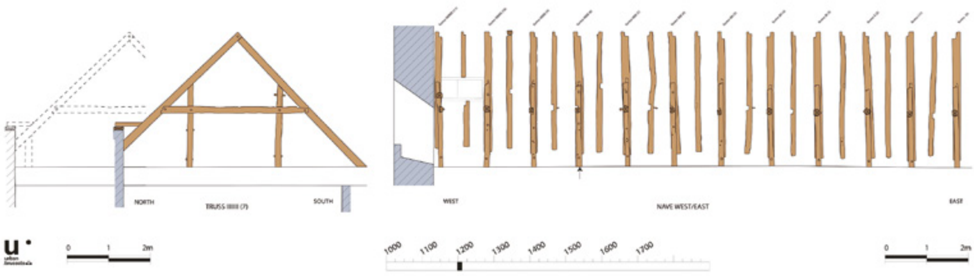

FIGURE 5 Lateral and longitudinal section of the roof structure covering the nave of Saint-Lambert church, Woluwe-Saint-Lambert

Woluwe-Saint-Lambert, a remnant of the Romanesque church (Fig. 5). Here, the felling of the timbers used in the roof frame was dated to between 1195 and 1217d (Hoffsummer *et al.* 2011a).

The double pitch roof has small dimensions: 5.50 m wide and 3.30 m high with a 45° inclination. Tiebeams connect twelve pairs of rafters which form the principal trusses, and these are supported by two rows of posts that are crossed by a collar, without bracing. The secondary trusses, of which there are 11, are joined at the top with halved joints. They have empty mortices at mid-height, proof of the disappearance of collars assembled at mid-height at the same height as those of the principal trusses. The wood used appears to be essentially boxed heart based on the wane areas observed and the orientation of the cracks in the heart. Most of the squaring was done with an axe on all four sides. A few rare traces of a manual pit saw were observed (Hoffsummer *et al.* 2011a; Cremer 2016b) (Fig. 6).

Examples of roof frames from this period with a similar typology are rare. The insertion of a secondary truss with a collar between two principal trusses can be found at Ename (Oudenaard, East Flanders) in the church of Saint-Laurent, dated with difficulty and reservations, to 1170–1180d, and at Huy, in the church of Saint-Mort, dated with more certainty to 1226–1230d (Hoffsummer 1992, 2002, p. 170).

In the case of the church of Saint-Lambert, the pieces are small sections because the roof is modest-sized: about 11×13 cm for the posts, 12×15 cm for the collar, 18×17 cm at the base and 16×15 cm at the top for the rafters of the principal trusses. The dendrochronological samples, of which there are 12, show between 12 and 51 rings, with an average of 33. Estimating the missing pith rings and adding a maximum number of sapwood rings for the four core samples with sapwood allows us to estimate that the logged trees were between

FIGURE 6 Frame covering the nave of the church of Saint-Lambert in Woluwe-Saint-lambert
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13 and 73 years old. The dating of the dendrochronological average series of the site, only 49 rings long, was confirmed by radiocarbon dating (between 1060 and 1200 AD at 95.4%: wiggle matching, KIA-45468 and KIA-45469; Van Strydonck 2011; Boudin 2019).

3.1.2 The Roof Frame of the Church of Notre-Dame Du Sablon in Brussels (14th–15th Centuries)

At the Church of Notre-Dame du Sablon in Brussels (Fig. 7), the study of the timbers (Houbrechts & Eeckhout 2002; Weitz *et al.* 2016a; Cremer 2016a; Cremer *et al.* 2016), and the metal elements (Maggi 2015) visible in the attic has made it possible to trace the evolution of the building, which spanned the late 14th–mid-16th centuries.

The wooden structures are made entirely of oak. The double pitch roof has a 63–64° inclination and is approximately 10 m wide and 10 m high (Fig. 8). The type of structure, with three superimposed porticos, considerably reduces the number of long pieces of wood required. Only the tiebeams and rafters require long, straight bole oak from high forests. The first tiebeam, which is the most imposing piece, is a 10-m-long boxed heart oak piece measuring 41×45 cm in cross-section. The principal rafters are limited to a maximum length of 3 m (Fig. 9).

FIGURE 7 Exterior view of the church of Notre-Dame du Sablon
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FIGURE 8 General view of the framework of the nave of the church of Notre-Dame du Sablon
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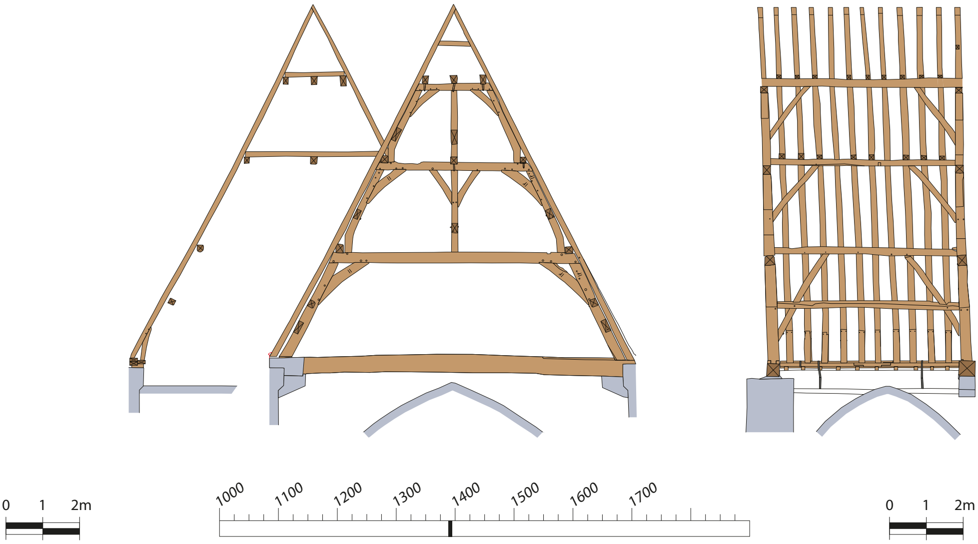

FIGURE 9 Cross-section and longitudinal section of the choir of the church of Notre-Dame du Sablon © RELEVÉS TENSEN & HUON, URBAN.BRUSSELS

Precise felling dates were obtained for each structure despite the poor dendrochronological quality of the wood, which had a small number of rings, knots, and growth deformations. Interestingly, one or two felling campaigns, mainly in the autumn/winter, and a few in the spring, one year apart, were identified for each wooden structure. However, these dates, separated by one year, are not located in the same area of the roof frame, which could indicate that the first felling enabled production of the first assembly of trusses and so on. Bearing in mind that the wood is processed green, it is possible that the logs were processed directly after felling and that the raising of the trusses only took place once they had the required number. A question then arises as to the correlation between the regulation limiting the number of trees felled per season (see above) and the presence of these successive felling campaigns per structure. In effect, being limited in terms of the available trees, the foreman would have had to plan his construction project over several years, with felling occurring in autumn-winter and spring to supply the construction site.

As such, for the choir, the wood used was felled in the autumn-winter of 1391–1392d and 1392–1393d, for the south transept in the autumn-winter of 1451–1452d and 1452–1453d, for the transept crossing in the autumn-winter of 1457–58d, and for the north transept in the autumn-winter of 1476–1477d and spring of 1477d. Two phases have been identified in the nave. The three spans on the eastern side are dated to autumn-winter 1486–1487d and 1487–1488d. The four spans on the western side are dated according to felling that took place in the autumn-winter of 1532–1533d and 1533–1534d.

At this site, as is often the case, the use of a single log to produce several similar structural pieces could be identified from dendrochronological samples, such as, for example, two principal rafters used in two successive trusses. In the choir, the implementation of two types of forest profiles was observed for two types of wood pieces. For the small section rafters (16×12 cm), the wood has an average ring size between 1 and 2 mm, while, for larger sections such as the principal rafters and soulaces (26×30 cm) and tiebeams (41×45 cm), the trees used show faster growth, with an average ring size between 3.39 and 4.31 mm.

3.1.3 The Roof Frame of Bruegel House, 132 Rue Haute, Brussels

A remarkable example of bourgeois housing could be the Bruegel house located at number 132 rue Haute in Brussels (Fig. 10). In this imposing house, the structural woodwork is also entirely made of oak. The roof frame, for which the felling dates lie between 1539 and 1558d (Hoffsummer *et al.* 2011b), sits in a roof over knee walls with a gable roof facing the street with a 59° pitch. The structure is about 6.80 m wide and 6.80 m high. The typology is that of superimposed portico trusses with the feet of the principal rafters having a stronger section at their base and a slight fretwork profile. These pieces, as well as the soulaces and the second tiebeam, are 18 × 25 cm. It employs quarter, half log, or boxed heart wood. Interestingly, the squaring was done with a manual pit saw (Cremer 2018). This confirms the hypothesis that squaring appeared earlier in the Brussels region than in the Walloon region or in France (from the end of the 16th century) (Hoffsummer & Weitz 2017, p. 43). At present, only two other examples have been recorded in the corpus from before the 17th century. These are the wooden structures of the church of Notre-Dame du Sablon in Brussels (see above) and one of the chapels of the collegiate church of Saint-Pierre-et-Saint-Guidon in Anderlecht (1558d) (Cremer 2018).

On the ground floor, the ceiling beams of the back room have profiles with moulded decorations. These oaks were sampled to verify the contemporary nature of the structures. One, from a quarter log, had 67 rings with an average ring width of 4.01 mm; the other, from a half log, had 17 rings with an average ring width of 7.21 mm. The beam with 67 rings could be dated and confirms the homogeneity of the floor beams and the roof frame as well as the presence of a common supply of oak. Such rapid growth is not uncommon in the building stock in Brussels, which has long been an obstacle to achieving dating results for the region.

FIGURE 10 Bruegel House, general view of the attic
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3.2 *Oak and Other Species from the 15th–18th Centuries*

3.2.1 The Former Beguinage in Anderlecht (15th Century)

In our corpus of dated structures, the only example of mixed use of species prior to the 17th century is the western wing of the former Beguinage in Anderlecht (Charruadas & Sosnowska 2013), which has, fortunately, been documented by numerous archives covering its construction and material history. This building, with wood panelling, underwent two enlargements, one towards the west at the beginning of the 16th century, and the other towards the south at the beginning of the 18th. The early core of the building was radiocarbon dated to between 1435 and 1470 AD with 95.4% probability (wiggle matching: RICH-31002 and RICH-31003, Boudin 2022). The absence of expenditures for the structural work in the Beguinage's accounts kept from 1460 onwards makes it possible to narrow the upper range to 1460.

The preservation of various elements of the façade (Fig. 11) and of four of the five structural trusses makes it possible to reconstruct the complete plan of the 15th-century core. With a surface area of 50 m² each, the two levels were divided into two spaces. The archaeology of the building also makes it possible to put forward a theory regarding the original state of the roof (4.56 m wide×4.90 m high, 60° pitch), where the roof frame would have been a principal rafter roof (Fig. 12). In this roof over knee walls, the trusses are composed

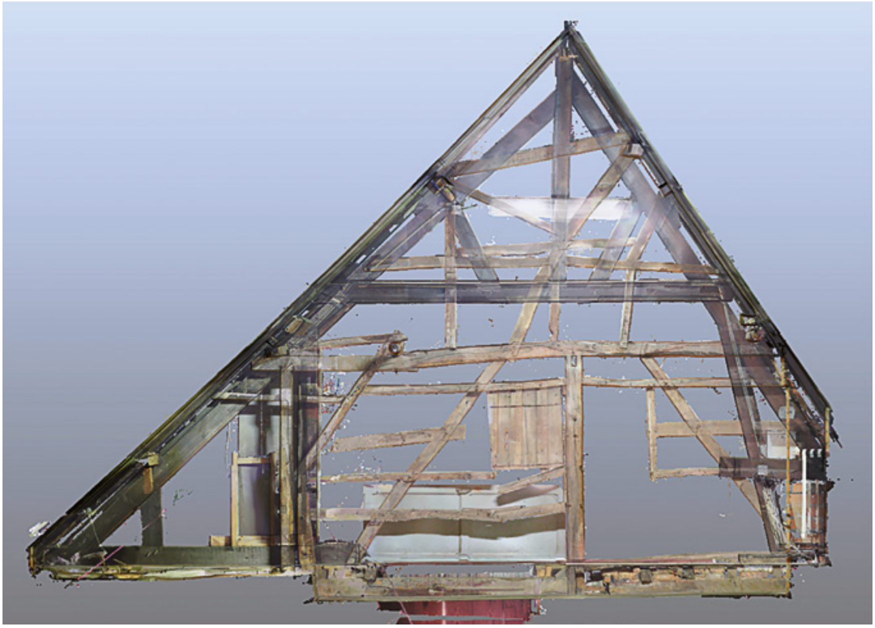

FIGURE 11 3D scan with Faro, former Beguinage of Anderlecht
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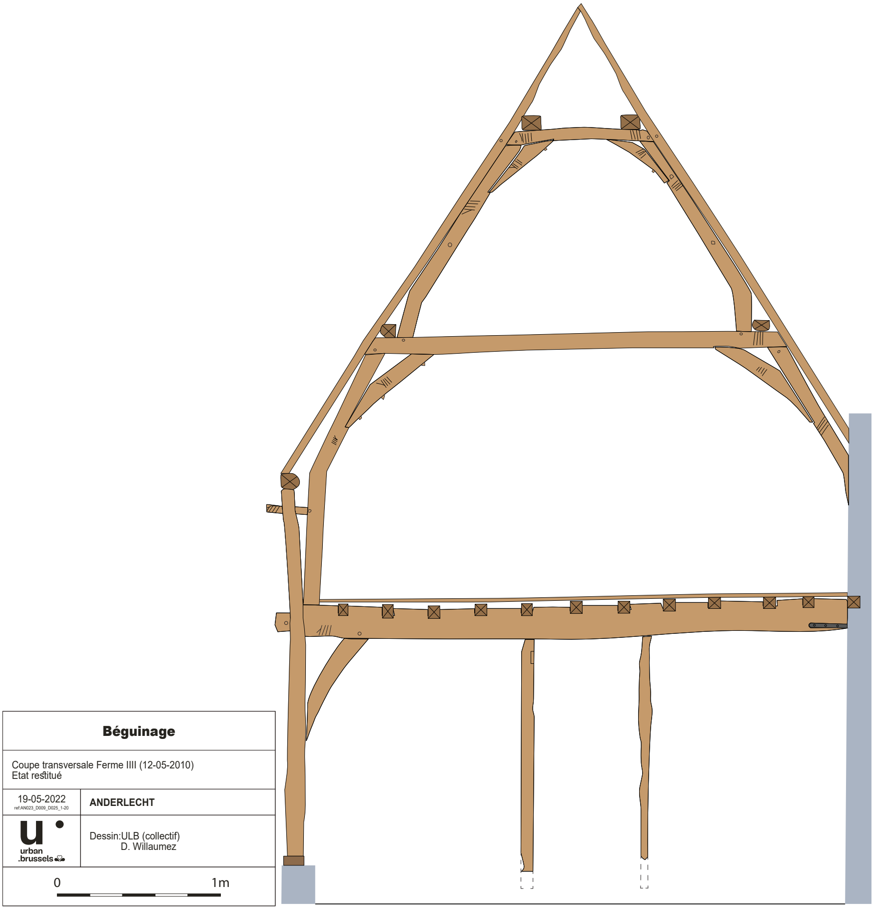

FIGURE 12 Cross-section of the truss IIII of the former Beguinage of Anderlecht, reconstructed state
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of two superimposed porticos made up of knee braces, soulaces, and tie-beams. This tiered set-up makes it possible to use relatively short timbers, as found in Brabant from the 15th–18th centuries (Hoffsummer 2002, p. 247–250; Hoffsummer & Weitz 2011). The wood processing evidence combines saw marks from the sawing and axe marks from the squaring/hewing.

As for the species used, ash (*Fraxinus* sp.) and fruit trees (cherry or false cherry (*Prunus avium* L. or *P. mahaleb* L.) (Gerrienne & Weitz 2011) were used exclusively as timber for all the wooden structures (panelling, floors and roof structure). It can be seen from the many documents that were preserved that the buildings of the Beguinage were situated within a vast enclosure with a large orchard planted with cherry trees in particular, but also with ash trees in the hedges that marked the boundary: it is, therefore, highly likely that this timber came directly from here.

The extension on the western side was realised with oaks felled in the spring of 1510d (Weitz *et al.* data not shown). The accounts confirm expenses for the realisation of this work during the period from 1510–1514. The oak appears for the first time in beams, posts, and purlins, while the ash only appears to have been used in floor beams that also incorporated chestnut joists. In the flooring, three groups can be identified. The joists are mostly made of ash, with a few elements in oak (section between 6.5–9 cm×6.5–9 cm). One of the floors stands out from the others on account of the use of chestnut joists (section 12–14 cm×9 cm) (Weitz 2019). However, the flooring may have been modified later. The construction of the extension on the southern side was completed exclusively with oak, the felling of which has been precisely dated to the spring of 1721d (Weitz *et al.* data not shown; the receipts preserved with the accounts specifically indicate that construction took place between 1720–1722).

The present Beguinage has another eastern wing built in two stages in the 18th century. The first, main building (in brick and stone) was probably built during the same campaign as the southern extension of the original core; the dendrochronological study gives an estimated date between 1713–1732d. A second building, located to the north of the first and built later (the texts confirm construction between February and May 1756 (Charruadas *et al.* forthcoming)) involved the use of oak and, again, a fruit tree, either cherry or false cherry (*Prunus avium* L. or *P. mahaleb* L.). The two roof frames from the 18th century have a different typology from the first wing, which is characteristic of the Brussels region and of Brabant generally, consisting of a series of superimposed porticoes which made it possible to use short timbers and, in the upper portico, the presence of a post to support a ridge purlin.

This evolution in the use of species in the Beguinage in Anderlecht — ash and fruit trees growing at the site at first, then oak, then, again, fruit trees associated with oak — has not yet been clearly explained. In any case, we know from a few entries found in written sources from the 17th–18th centuries that vernacular construction may have made use of woods such as poplar or other inexpensive species (Pierron 1905, pp. 142 and 182; Charruadas & Sosnowska 2013). In an urban setting, the representativeness of these species within the corpus remains relatively anecdotal. However, the use of poplar in structural wood has so far only been encountered in the example of small buildings located in rue Notre-Dame du Sommeil in Brussels, dating from the 17th century. Various floor beams and a purlin in poplar have been observed at houses no. 11–13, 15, and 17. The purlin turned out to be a case of reuse based on the assemblies found. Their arrangement suggests that a piece was part of wood panelling, but the original location remains unknown (Hoffsummer & Weitz 2011).

3.3 *The 17th Century and the Reconstruction of the Centre of Brussels in 1695: Predominance of Oak, But Not Only …*

In the 17th century (before the bombardment of 1695), our corpus includes 37 dated structures. They are all made of oak, except for two: the Nekkersgat Mill in Uccle (1663d) and the church of St. Nicolas in Neder-Over-Heembeek (1662–1663d), where elm was used in the roof frames in combination with oak.

After part of the city was destroyed in August 1695, the reconstruction naturally required more timber than usual over a short period. High-quality oak (without worming or bark) was then specifically mentioned in relation to the structural work and some finishing elements, such as the doors facing the street or the pillars and stair treads in some contracts. This is the case in the contract for the joinery work for two houses belonging to the Kempeneer family in rue de la Colline, from 13 April 1701 (SAB, Archives notariales de Bruxelles 1862, quoted with mistranslation in Culot *et al.* 1992, p. 175). Nevertheless, other species were exploited. Between the bombardment and 1710, i.e., over a period of only 15 years, 55 structures were add to the corpus, seven of which involved the use of species other than oak (not just broadleaf species, such as elm and beech, but also conifers, such as Scots pine, in the wooden structures or floors). All the structures were urban housing located within a 200-m radius of the Grand Place, the main target of the cannon. This rise in the use of species other than oak is most likely evidence of a more extensive practice than the current body of work suggests. From 1710–1800, the period during which the corpus has the greatest number of dated structures (63 in total), we observed not only two cases of mixed species use, but also two structures built entirely of Scots pine. Scots pine could not be dated for these structures, but archaeological studies have attested to its contemporaneity with dated neighbouring structures: rue des Pierres 46 (contemporaneous with 48) and the rear building of Grand Place House 13 (contemporaneous with the front building and the neighbouring building at 14).

3.3.1 Context of the Bombardment and the Reconstruction

A major event in the history of Brussels, the bombardment of the city was part of the Nine Years' War (1688–1697) between Louis XIV's France and the League of Augsburg (England, Spain, the United Provinces, the Holy Roman Empire, and others). While the French armies were bogged down in the region, the king sought to convey a message to Europe, which had coalesced against him and his military power. To this end, he ordered the attack on Brussels, a gesture that was more symbolic than strategic, since the city was not taken, but the urban centre around the Grand-Place was indeed subjected to intense bombardment — 5000 bombs and 4000 cannonballs were fired — under the command of Marshal de Villeroy (Wauters 1848, p. 28; Billen & Duvosquel 2000, p. 92).

The French cannons were unleashed on 14 August at 7 p.m. and did not stop until the afternoon of 16 August (Culot *et al.* 1992, p. 124). It is estimated that 4575 dwellings were severely damaged (Culot *et al.* 1992, p. 144). A quarter of the city was reduced to 'ashes' and an estimated one-third of homes were demolished (Wauters 1848, p. 28).

In the aftermath of the disaster, the authorities put in place a reconstruction policy that involved various levels of the construction sector. The measures pertained to the whole sector for the production, supply, transport, and sale of materials (in particular, setting a maximum price for timber) and the building profession (temporary abolition of corporate monopolies). These measures were all intended to ensure rapid reconstruction of the devastated centre.

To this end, the construction sector benefited from a massive supply of imported materials alongside local products, which were insufficient during the first years of the reconstruction (Sosnowska & Goemare 2016). The provision of external materials appears to have been prolific in the case of bricks, which were imported from the Netherlands. The desire to rebuild quickly also encouraged builders to use materials of lower quality, particularly stone. The widespread use of recycled materials contributes to this effort (Sosnowska 2018, p. 9–10). Finally, from a construction perspective, the various professions readily adapted their construction to the materials available at the site, sometimes mixing up to three or four types of bricks to build the same wall or combining several types of stone to build certain structural elements (Sosnowska & Goemaere 2016, p. 74–75). In general, the builders respected certain traditional forms of architecture while demonstrating a talent for adaptation and innovative character in their building work. Research into construction timber appears to yield similar findings: the use of local or imported timber, a drop in the quality of the material, the use of recycled materials, and the mixing of forest species.

3.3.2 The Supply of Wood after the Bombardment: The Sonian Forest

In the months and years following the bombardment, the demand for construction wood put significant pressure on supply. It is possible that the timber in stock was immediately mobilised. In the building located at rue Marché-aux-Herbes 8, for example, we found a piece of wood that was felled before the event: an oak post from an interior wall that was cut down in the autumn-winter of 1694–1695d. The remaining oaks used in the building were cut in the spring-summer of 1695d and the autumn-winter of 1695–1696d (Weitz *et al.* 2016b). At present, no other felling prior to the bombardment and used during the reconstruction has been identified. The explanation may lie in the date of the bombardment, almost on the eve of a new felling season, with stocks certainly already largely depleted.

The state-owned Sonian Forest, the main source of timber for the city in normal times, was naturally called upon throughout the reconstruction effort. To facilitate the reconstruction, the official sale of timber from this forest was brought forward and took place on 15 September 1695. A second felling campaign was decided upon despite the opposition of the Chamber of Accounts, which advised importing timber from Westphalia (Pierron 1905, p. 98), Munster, and the vicinity of Namur, Dave and Villers (Pierron 1905, p. 201; Hennaut 2011, p. 82). In November 1695, oaks were, therefore, marked for felling. The quantity almost doubled compared to the previous felling (Pierron 1905, p. 98). Dendrochronological dating has made it possible to identify some of the wooden structures (a dozen in the corpus) using oaks felled from 1695 onwards. The Town Hall, whose eastern and western wings face the Grand Place (Weitz *et al.* 2021) was rebuilt with trees felled in the autumn-winter of 1695–1696d, the spring of 1696d, and the autumn-winter of 1696–1697d, a dating that corroborates the historical analyses of the building (Heymans & Sosnowska 2011, p. 261–265). Bourgeois houses on rue du Marché-aux-Herbes, petite rue des Bouchers, petite rue au Beurre, rue de l'Etuve, rue de la Madeleine, and rue des Chapeliers also benefited from the first felling of trees following the bombardment. The reconstruction was, therefore, carried out very rapidly from 1695 onwards but according to the capacities and financial strategies of the private owners, thereby extending the period into the 1710s and beyond (Fig. 13).

For the construction of the classical wing of the Town Hall, a felling permit was granted to the master carpenter François van Benthem for a period of three months from March 1706, allowing him to collect trees from the Sonian Forest. A second document details the sums paid to the same person for sawing, storing, and felling trees in the forest between 25 March 1706 and 12 January 1707 (ACB, Archives anciennes, bundle 505; Weitz 2012). The species is not specified in these documents ('trees' and 'wood' are mentioned). From the archaeological study, we know that only oak was used in the structural work. A precise phasing of the construction site was carried out by dendrochronology, which made it possible to precisely pinpoint, among the 11 wooden structures rebuilt between 1695 and 1707, the oaks felled in the Sonian Forest between March 1706 and January 1707 (Weitz *et al.* 2021). They were used in the roof frames of the

FIGURE 13 Location of the buildings, currently dated by dendrochronology, rebuilt after the bombardment, using timber felled between 1695 and 1698 (in black) and between 1699 and 1710 (in red). Google maps background
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classical wing on the side of rue d'Amigo and rue de la Tête d'Or (Fig. 14). These samples will be used to inform the ongoing research on dendro-provenance in Belgium.

The wood used in the Town Hall shows a significant correlation with other sites in the city centre, one of which is located only 200 m away: the building on rue de l'Etuve 49–51, where two buildings (B and C) have retained their old wooden structures. These roof frames are much more modest than those of the Town Hall. For one of them (Building B), the felling of the trees has been dated precisely to the autumn-winter of 1695–1696d and, oddly, it is made of oak and elm (Weitz *et al.* 2020). The mixed-species roof has a 60° pitch. It covers a roof over knee walls about 6.60 m wide and 6 m high (Fig. 15). The other (Building C) was constructed slightly later and involved the use of wood from trees felled between 1705 and 1714d. The roof has a 60° pitch. The roof over knee walls is only 3.40 m wide and 2.76 m high. The roof frame is entirely made of oak (Fig. 16).

Finally, this variety of wood species has also been observed in the use of floor joists as a supporting structure. The case of a house located on petite rue des Bouchers 10 demonstrates this construction practice. It features the use of

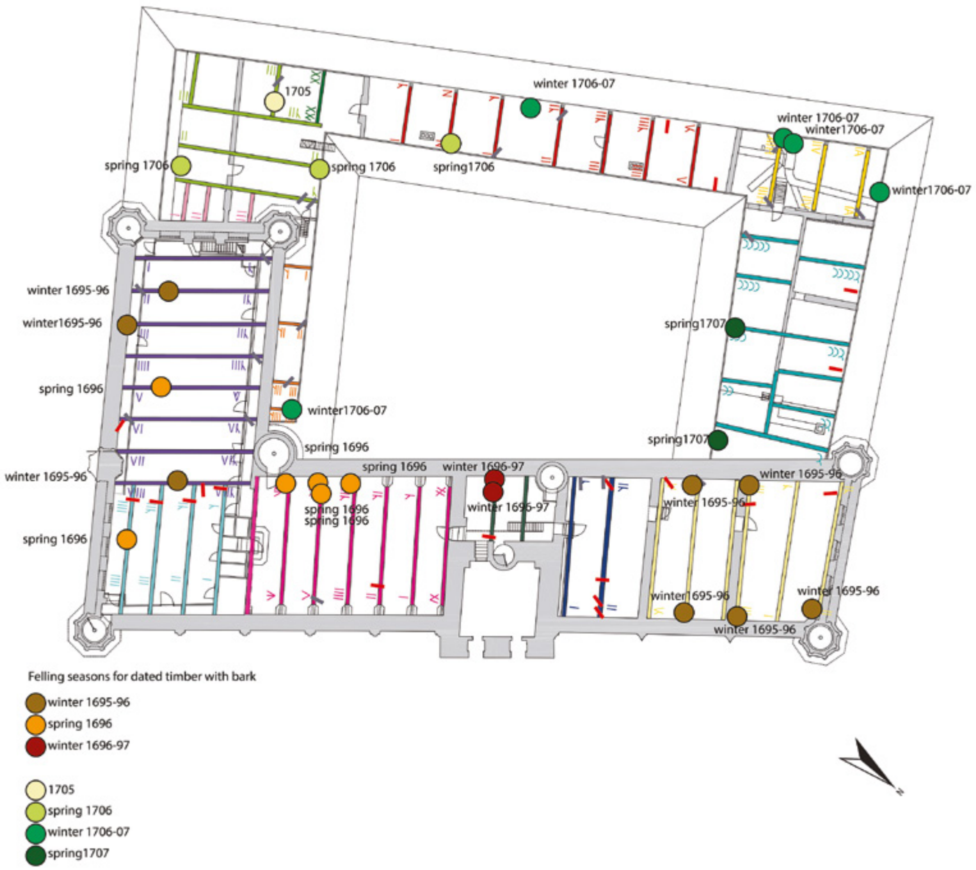

FIGURE 14 Dated samples with bark located on the plan of the Brussels Town Hall
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four distinct species to establish a floor level. Oak, elm, Scots pine, and fir logs were simply cut into two pieces to directly support the flooring. This relatively unrefined work clearly attests to labour savings on the part of the carpenter, but the reasons for it are difficult to ascertain: they could include the financial frugality of the owner, limited supply of building materials, or need to rebuild quickly, all of which could characterise the context of this intense period of reconstruction of the city centre of Brussels.

3.3.3 The Supply of Wood after the Bombardment: Imports

The Sonian Forest clearly did not have the capacity to supply all the reconstruction sites in the city quickly and adequately: oak and softwoods were, therefore, imported both for the construction of wooden structures and for finishing elements such as floors (see below). The reconstruction of the church

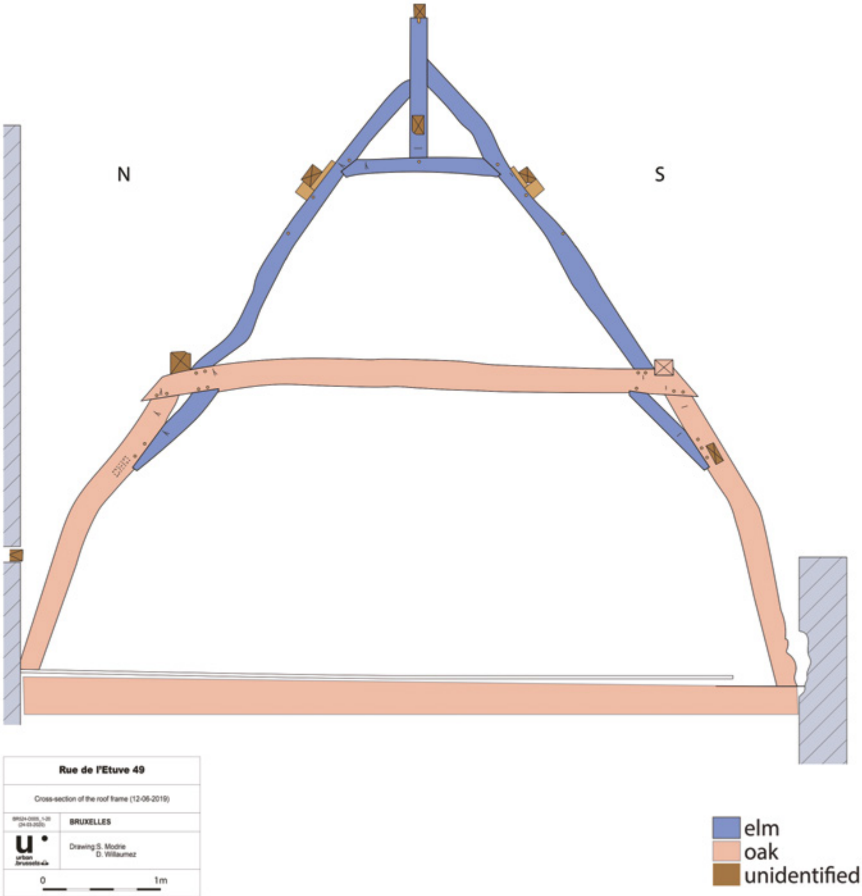

FIGURE 15 Cross-section of the roof frame in Building B. Distribution of species located on the archaeological survey of the roof trusse 1, rue de l'Etuve 49–51, Brussels
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and the Dominican convent was, therefore, carried out with wood imported via six ships from Holland, which arrived in Brussels at the end of December 1696 (Janssens 1997, p. 47). Their origin is not known with certainty. Another case that is currently unique in the corpus involves a building at rue des Pierres 46, where the wooden structure was built entirely of Scots pine (*Pinus sylvestris* L.) but followed the typology of those in oak precisely. The frame is approximately 7.40 m wide and 6.90 m high and is in a roof over knee walls. The roof has a pitch of 55°. The roof frame is a principal rafter roof, with plumb-faced purlins assembled in a portal frame, braced by purlins, and an upper part with two

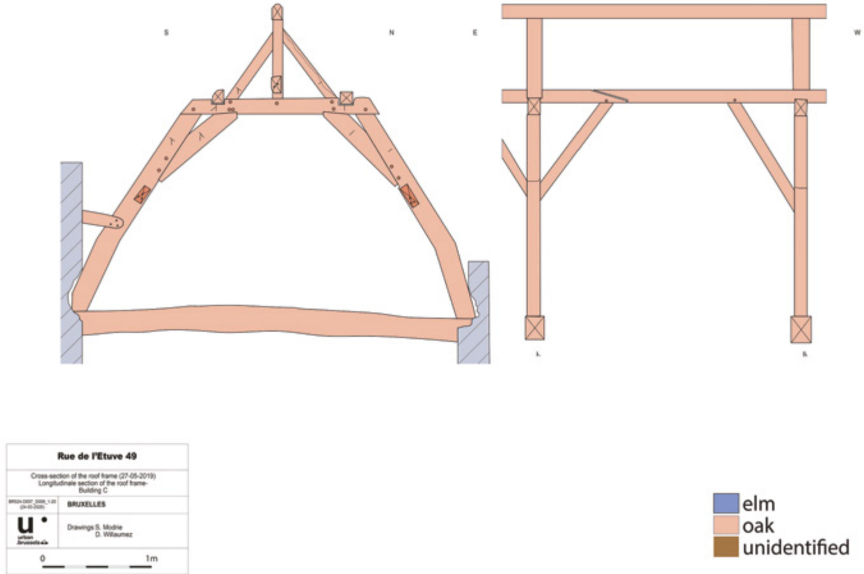

FIGURE 16 Cross and longitudinal sections of the roof frame in Building C. Distribution of species located on the archaeological surveys of the roof trusse I and between I and II, rue de l'Etuve 49–51, Brussels

principal rafters and a collar, in a roof over knee walls (Fig. 17). A header in the floor, in the middle of the overhang, is present on the various levels, even in the attic: this opening, probably intended to allow goods to be carried through a trapdoor, could indicate a warehouse function for the building.

The timbers of this building have not been dated by dendrochronology, but via an archaeological study, which attributes its construction to the post-bombardment period. The geographical origin of the Scots pine used in this house could not be ascertained through dendro-provenancing. This was not the case for those used in the contemporary neighbouring building (rue des Pierres 48). Scots pine sampled from the floor beams could be dated against Scandinavian chronologies (imported wood used in the Netherlands, Gävle region in Sweden and Finland) with the last ring in 1706d, proving the import of softwoods from these regions for construction in the early 18th century (Weitz *et al.* 2018).

At about the same time, we know that some wealthy clients were able to buy materials directly from Holland via a local merchant and then commission boatmen to transport the goods to Brussels. This was the case in 1706 when

FIGURE 17 Frame in Scots pine, rue des Pierres 46, Brussels
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François Ansillon, owner of a small château in the quayside district and former mayor of Brussels at the time of the bombardment, imported more than 2000 florins' worth of timber purchased in Dordrecht from Scandinavia and the Baltics (Charruadas *et al.* 2021).

3.4 *Floorboards for the Finishing Work: The Use of Several Species*

An analysis of the boards used in floor structures has revealed the use of various wood species. The study is based on a corpus of 32 structures in the Brussels region for which a dendrological analysis was carried out. The earliest structure was not constructed earlier than the late 16th or early 17th century, and most of the floorboards dated either by dendrochronological analysis or archaeological evidence range from the final quarter of the 16th century to the first third of the 19th (Sosnowska 2013; Sosnowska *et al.* 2016).

As such, for Brussels, the absence of oak for the construction of this type of structure should be regarded as unique. Poplar and Scots pine, with 11 occurrences each, were the main species that were turned into floorboards. To a lesser extent, fir (*Abies alba* mill.) (3 cases), common spruce or Norway spruce (*Picea abies* Karsten) (2 cases), and elm (*Ulmus* sp.) (2 cases) were also used. Finally, four additional conifer examples which could not be precisely identified demonstrate the importance of the use of softwood by the construction sector, a timber type that has dominated the corpus until now. It also appears that the distribution of these species within the corpus does not correspond, at first glance, to a choice determined by the financial capacity of the clients commissioning the work. Indeed, the former residence of the Dukes of Bournonville, now the Merode Hotel, saw the use of Scots pine and poplar for the construction of floors in privileged areas, indicating two distinct phases of work in the 17th century. A more detailed analysis of the socio-economic profiles of the owners would perhaps allow a more in-depth reflection in the future.

The use of this type of wood might seem surprising at first glance in the context of the southern Netherlands. Nevertheless, from the old documents, it appears that the use of species other than oak, such as elm, poplar, and fir was not excluded (Sosnowska *et al.* 2016, p. 92–93; Charruadas *et al.* 2021, p. 461).

The use of Scots pine, imported from Scandinavia and the Baltics (Fraiture *et al.* 2013), is explained by the intrinsic qualities of the material: it is strong, can be easily nailed, is less subject to hygrometric variability, and deforms less once attached to joists and beams (Barry-Lenger *et al.* 1999, p. 94–95; Sosnowska *et al.* 2016, p. 94). It was the best choice for making floorboards and shutters according to some documents from the turn of the 17th and 18th centuries (Charruadas *et al.* 2021, p. 461). In this light, the 'specifications' of some dwellings rebuilt at the end of the 17th century stipulated the use of 'red fir', a name cautiously associated with Scots pine (Sosnowska *et al.* 2016, p. 94), as a guarantee of quality for making floorboards, staircase partitions, and interior doors (Culot *et al.* 1992, pp. 264–266).

Poplar, a fast-growing local species, is inexpensive compared to others (Charruadas & Sosnowska 2013, p. 35). Although it is much less resistant than Scots pine, it nevertheless appears light and less deformable than oak. The floorboards extracted from the logs are also wide and reach up to 45 cm, making them useful for realising this type of structure (Barry-Lenger *et al.* 1999, pp. 94–95; Sosnowska 2013; Sosnowska *et al.* 2016, pp. 94, 96).

Fir and spruce have similar mechanical qualities to poplar (Barry-Lenger *et al.* 1999, pp. 94–95). As for elm, identified in two cases, while it is sometimes used in carpentry and joinery, it is characterised as being not very suitable for undertaking structural work, as it is difficult to plane and is prone to woodworm (Nosban 1827, p. 46).

Mixing of species by carpenters or joiners is a documented practice. It was identified twice in the production of the same floor, in which floorboards of Scots pine and spruce or fir (*Abies alba* mill.) were combined. In the eyes of craftsmen, this combination perhaps did not appear to represent a mixture, since they are all conifers. In the case of tongue and groove joinery (Sosnowska *et al.* 2016, pp. 97–99), the carpenters used Scots pine to produce the floorboards, while the splines were cut from oak. In this case, mechanical strength can be invoked to explain this specific use, as oak is considered among the strongest common species (Barry-Lenger *et al.* 1999, pp. 94–95).

Finally, in addition to the qualities noted for most of the species presented, one last argument can be cautiously advanced to explain this choice. It reflects the management of the Sonian Forest domain (see above). Oak is available but limited compared to other forest areas. It was, therefore, primarily reserved for structural timber for producing wooden structures. This supply constraint may have prompted carpenters and joiners to access other wood resources for flooring, especially since these species had undeniable qualities for the work required. Floorboards do not appear to be the only type of structure built with species other than oak. Indeed, partitions and wooden sarking boards studied during archaeological surveys, dated from the late 17th and 18th centuries, show the use of softwoods (mainly Scots pine) and poplar (or willow, as it is not always possible to distinguish the species) (see the reports of Weitz and Weitz and Gerrienne). The first finding suggests a specific choice for using these two species for the manufacture of boards intended to supply the Brussels construction sites with floorboards, partition boards, and roofboards during the period envisaged by this research. It demonstrates, in this case, that these species can no longer be considered 'secondary', as they are widely used.

4 Conclusion

With a multidisciplinary team of researchers in place, preventive archaeology in Brussels has made it possible to gather important data on the history of wooden construction, especially in urban areas in the early Middle Ages and modern era, and, to a lesser extent, on vernacular architecture. Most of the analyses pertain to wooden roof structures, which nicely illustrate the typo-chronological characteristics of carpentry in Brabant, both in relation to large monuments and urban habitats which are representative of different social strata. Although, in an ideal world, it would be ideal to have programmed research to obtain a better corpus for the medieval period, the data from the 128 sites studied are already statistically significant.

As such, regarding structural wood resources, oak predominates in urban areas, especially before the 17th century. Unlike the cities of the Meuse region (Dinant, Namur, Liège, Huy, Maastricht) and some Flemish cities near the coast (Ghent and Bruges) which, thanks to rafting logs and maritime transport, benefited from the import of quality oak from the great forests of the Ardennes and the Baltics, the resources in Brussels and its surroundings were more local, at least before the digging of the Willebroek canal in 1561.

However, around the major Brabant city of Brussels, the surrounding forest landscape has been subjected to considerable human pressure to extract maximum resources, both for firewood and construction. Therefore, oak can come from three types of forest settings, cleared or degraded to varying degrees. The princely Sonian Forest is the best resource and is under strict princely management, but it reduces the competition between the large trees. Small state-owned or private woods are another source of structural wood. Finally, hedgerows and trees on the edges of open landscapes provide wood of lower quality.

As a result, oak growth is rapid, sometimes very rapid, and the wood can be dotted with large branch starts. The oak tree rings are wide, and the dendrochronological sequences are so short that dating is often difficult. These problems are increasingly being overcome thanks to more comparative data within the dendrochronological database. Multiplying the samples on site is, therefore, an effective strategy. If this does not work, carbon-14 dating or the support of a historian can be useful. The increase in the number of samples with traces of bark has also led to an unexpected discovery. While the use of green wood has been confirmed in most cases, we often see, within a given construction phase, at least two felling campaigns spread over two years. This raises questions about the supply chain, from felling to the construction site and the implementation process, which is an avenue to be explored for future research.

The situation appears to be more complex in rural areas where more variety is the rule. The Beguinage in Anderlecht is a good example. In the case of this piece of architecture, which is both vernacular and monastic, we can observe a context of local supply where all trees could be used as a resource. Sometimes fruit trees and ash were used in 15th-century wood panelling, then oak in another phase of the development of the building in the 16th century, then again fruit trees associated with oak in the 18th century; to date, no satisfactory explanation has been found for this variability.

Generally, from the 17th century onwards, broadleaves other than oak and conifers began to appear not only in attics, but also elsewhere in buildings, testifying to a practice that was probably more widespread than the present corpus suggests. In this respect, the bombardment of the centre of Brussels in 1695 was a significant turning point. The reconstruction effort mobilised huge quantities of materials of every description, including timber. While the typology of the reconstructed roof frames is not fundamentally different from that prior to 1695, the wood species used were often much more heterogeneous. The Sonian Forest was still in great demand, but more for prestigious building sites, such as the town hall. Less-wealthy clients had to make do with lesser quality oak, sometimes combined with other species, such as elm, poplar, or softwood. The presence of re-uses of timber is also unsurprising.

Finally, the case of the floorboards is unique in Brussels, at least for the period for which this type of finishing work has been preserved, i.e., from the 16th–19th centuries. In comparison to other regions in Belgium, where oak can also be found in the floors (various studies by the dendrochronology laboratories of the University of Liège and Royal Institute for Cultural Heritage), the Brussels floors studied so far are only covered with poplar, elm, Scots pine, fir, and spruce. In the local context, the best explanation, without ruling out other possibilities, is probably economic and can be ascribed to the cost of oak. Indeed, oak from the Sonian Forest could not be wasted, as it was very much in demand for roof structures. The use of other species for finishing work was, therefore, fully justified.

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