Roof Frames in the Built Heritage of Brussels (Belgium): The contribution of dendrochronology and written sources

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Introduction

A three-year multidisciplinary research project began in October 2013, initiated and headed by the Public Service of the Brussels-Capital Region (SPRB), focusing on roof frames in the building heritage of Brussels. The overall aim is to study wooden structures from archaeological, historical and dendrochronological points of view. To more thoroughly understand these structures, specific aspects including description of the typology of roof structures, the wood used and iron elements associated with wooden structures are included in this research.

Nearly one hundred buildings have been analysed, representing a significant dataset in the present-day Brussels-Capital Region, which covers an area of only 161km². The buildings selected represent a range of religious and civil buildings, high status buildings and vernacular architecture. Most are located in the city centre, some in the formerly rural outskirts, now part of the urban territory of Brussels (Figure 1).

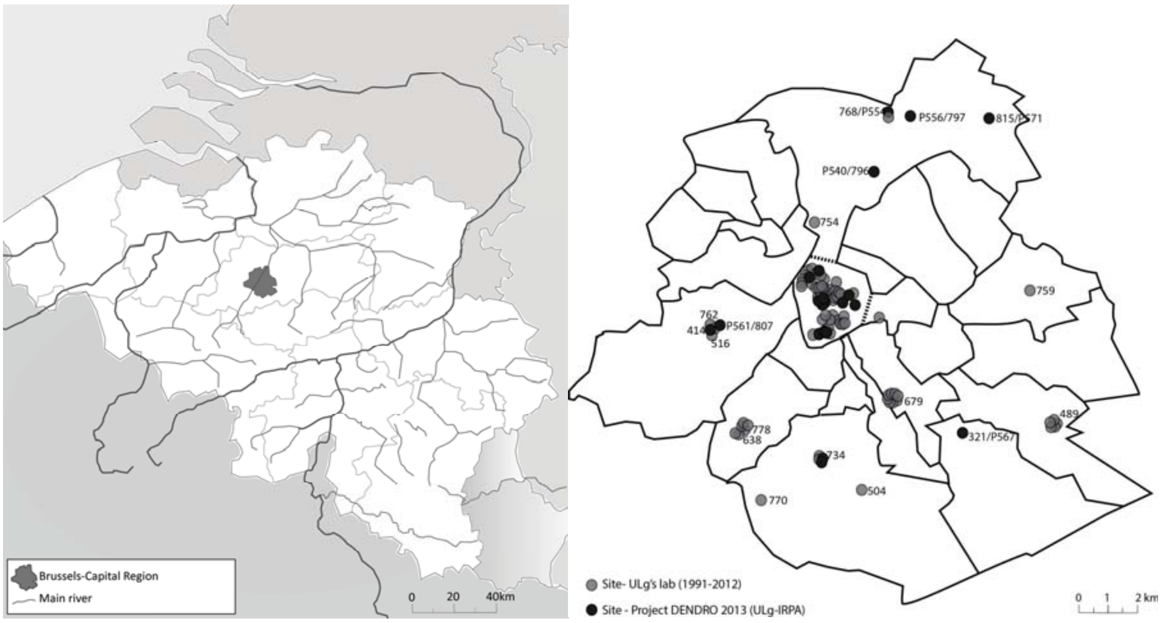

Figure 1: Left: Location of the Brussels region in present-day Belgium (in dark grey). Right: Location of the sites studied within the administrative limits of the Region.©SPRB

To achieve this vast project, two Belgian dendrochronology laboratories are collaborating with the Archaeological Service of the Brussels-Capital Region: the University of Liège (ULg) and the Royal Institute for Cultural Heritage, Brussels (KIK-IRPA), with the occasional participation of other collaborators[1].

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The main objective underlying this acquisition of multidisciplinary data is to shed new light on wood working techniques from the 12th-19thcentury,and on the means of supplying wood for architecture in this specific area.
This paper presents some of the dendrochronological issues of this on-going research with a focus on the complementary work using written sources to better interpret information obtained from the tree rings.

Materials

The project was undertaken in the Brussels region and involved buildings of different status, selected in conjunction with rescue and planned archaeology. The dataset is composed mostly of urban houses and also includes private mansions, farms, mills, city halls, churches, religious and industrial buildings.
For a maximal time coverage of the inventory, buildings covering the longest period, i.e., from the 12th-19th century, weresurveyed and analysed.
Depending on the intervention context, which could be prior to renovation, after demolition, or from a perspective of promoting cultural heritage, the conservation state of historical wood was highly variable.
The Brussels beams are generally produced from young, fast-growing trees (almost 80% of the 877 current samples have less than 80 rings and 47% of the oaks have an average ring width of more than 2 mm). These data are however not entirely representative of the wood material used in Brussels roof frames, as the youngest and knottiest trees, less suitable for dendrochronology, were not sampled and are therefore under-represented in this dataset.
Oak (*Quercus robur* or *Q. petraea*) was the most common species (90%), but other species were also exploited. In the remaining 10%, species including elm (*Ulmus* spp.), alder (*Alnus* sp.), poplar (*Populus* spp.), ash (*Fraxinus* spp.), fruit trees (*Prunus* spp.) and conifers (*Pinus sylvetris* L.) have been identified. Such diversity is quite different from other regions in present-day Belgium where oakwas almost exclusively used in roof construction (Hoffsummer 1999), at least until the 19th century which saw an increasing use of Scots pine beams throughout the area.
With respect to such species diversity in Brussels, elm, ash and fruit trees seem to be more frequently found in vernacular architecture and in less urbanized contexts from the 15th to 17th century. This observation should however be refined with further examples. Of note is the fact that different species have sometimes been found in a single wooden structure: oak and elm were used for example in the roof frame of the Church Saint-Nicolas, Neder-Over-Heembeek, and in a townhouse, rue Marché-aux-Herbes8-10 (Figure 2).
The Brussels context reveals another distinctive characteristic: a common practice of re-using well-preserved beams from older buildings. These re-used beams can often be identified, for example by the presence of empty mortises or incoherent carpenter assembly marks. Such elements are not really useful from a chronological point of view, as they no longer document the structure in place, but are still instructive with respect to wood economy and wood supply issues.

elm (*Ulmus*sp.)

oak (*Quercus*sp.)

Figure 2 – Truss with oak and elm beams in the roof of the house, Rue Marché-aux-Herbes 8, Brussels.© SPRB

Methods

For the dendrochronological sampling, beams with the best dendrochronological potential for dating were selected, i.e., with a substantial number of rings, the fewest growth deformations and the presence of bark or cambium on beams accessible for coring.

Samples were principally obtained using corers[2], but could also be sawn sections when beams had been removed. Samples were sanded[3] and measured[4] in the laboratory. The dating procedure was carried out with the *Dendron-IV* program (Lambert et al. 2005; Lambert 2011).To overcome potential problems in dating, it was crucial to increase the number of samples analysed and, for the most difficult cases, to work in conjunction with other dating methods such as ^{14}C.

To provide a dendroecological description of the exploited tree populations, cambial age was estimated on cored or sawn samples, in order to evaluate the minimum age of the trees felled. The growth scheme was then compared with models proposed by different authors (e.g., Haneca et al. 2005; Haneca et al. 2006; Girardclos & Petit 2011; Billamboz 2006) to determine the original growing environment of the trees (high forest, coppiced wood, hedges, open environment, etc.).

To identify supply networks, the geographic origin of the wood was determined applying dendro provenancing (e.g.,Schweingruber 1988; Jansma 1995; Bonde et al. 1997;Fraiture 2009) by using European oak chronologies available in both laboratories as well as colleagues' databases in some

[2] RINNTECH Dry wood borers, 8 mm inside/16 mm outside diameter x 250 mm length, or Schär Core, 10 mm inside / 25 mm outside diameter x 440 mm length.

[3] Papers with grains from 60 to 1200 (CAMI).

[4]*LINTAB*^{TM} *6* RINNTECH e.K and *TSAP-Win Professional* (KIK-IRPA) or *MITUTOYO Measurement table* and *dendro Acquisition, Clar M. & Rakka S.* (ULg).

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cases. The probable provenance was identified using *t*-values (on maps and in correlation matrices; Fraiture 2013) and Pearson's correlation coefficient (r). However, a constraint was the fact that dendro provenancing provides information only for dated chronologies; therefore, young fast-growing trees were excluded from this research. In parallel to the information obtained directly from tree-rings, archives and written sources were also studied to document local logging to medium-long distance trade.

Results and Discussion

Dating

Around 400 oak samples have been dated so far, as well as a few beams of Scots pine (around 10).From the first dendro-studies in Brussels in the 1990s[5] until May 2015, around 70 oak site chronologies have been dated for the region (Figure 3) and cover the period AD 1146-1845. However, although the oldest roof dated at present goes back to the end of the 12th century, very few roofs older than the 14th century have been dated. In Brussels, the 'old' conserved wooden roof structures date mainly from the 15th-18th century. Later, roof types changed radically, with the addition of metal structures and prevalent use of conifer wood.

It should be noted that most tree-ring series from Brussels buildings were short (30-50 rings). For instance, in the Saint-Lambert parish church roof (Woluwe Saint-Lambert) a chronology of only 48 rings was built from the five 'best' samples of the site. For this chronology, only a tentative dendrochronological date could be proposed because of the low number of rings, 1194d[6] for the last ring. Radiocarbon dating was done to verify this proposition, providing a date of ca. AD 1040-1220 (890 ± 20BP) for the last ring, with a 95.4% probability (Van Strydonck 2011). This ^{14}C result supports the tentative tree-ring date and it was thus possible to conclude that the trees used to build the roof were felled between 1195d and 1199d, making it the currently oldest known and preserved roof frame for the region. Another extreme example is given by the house with a street-corbelled façade (Rue Saint-Ghislain 86, Brussels), in which only one truss with very fast-growing tree beams was conserved. To date this specific truss typology, one tree-ring sample (40 rings) was cored to be dated by wiggle-matching analysis. The last ring was radiocarbon dated to ca. AD 1445-1485 (357 ± 28BP) with a 95.4%probability (Van Strydonck & Boudin 2015).

[5] The dendrochronological studies from 1990-2013 were made in the Laboratory of Dendrochronology of the University of Liège (Eeckhout J., Houbrechts D., Hoffsummer P., Maggi C., Weitz A.).

[6] 'd' after a date means that it is a dendrochronological date (Hoffsummer 1989).

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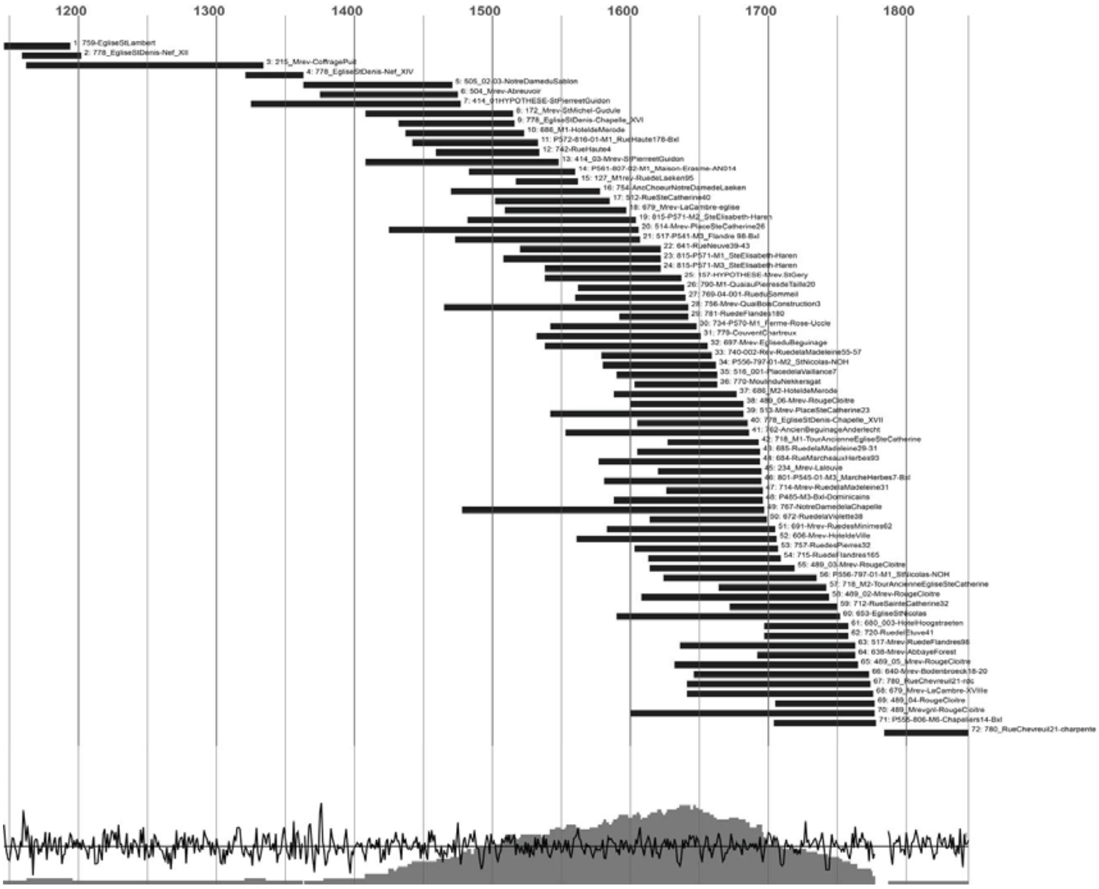

Figure 3. Dendrochronological bar-graph of the site chronologies available for the Brussels region as of May 2015. © ULg, KIK-IRPA

Forest management

Many of the trees examined were young, often with knots or even forks (Figure 4). These features could reflect intense and specific exploitation of local woodlands using coppice-with-standards management. In practice, coppices were exploited with a short cutting cycle, generally less than 30 years, to provide firewood. Second-level vegetation, tall but disseminated trees usually older than 50 years, was used as timber material for building purposes. These tall trees grew during periods without any competition, which caused their rapid and knotty growth.

It should be noted that this part of the research is still in progress: dendrochronological data as well as archives require further in-depth analysis to refine these observations and better perceive the practices exploited in the Brussels region.

Figure 4 - Example of a fork in a tie beam near the assembly with the rafter.© SPRB

Provenance

The dendrochronological comparisons between the currently dated Brussels site chronologies show clearly distinct groups of data. The chronologies grouped within one of these clusters would be explained as belonging to the same 'dendrochronological *terroir*' (Girardclos, Petit, 2011), for which the interpretation is complex because a 'terroir' involves a combination of several parameters: the geographic provenance itself as well as the type of forest exploitation, the type of soil, etc. On the other hand, for the wood used in buildings, groups that are clearly distinct from each other would in all likelihood reflect different provenance zones.

For softwood joinery work, which requires specific qualities (straight grain, length, etc.), the long-distance importation of wood is attested by dendrochronology at the earliest from the end of the 16th-early 17th century: floorings of the Hotel de Merode were made of Scots pine from Sweden (Fraiture & Crémer 2013, Sosnowska 2013). Nevertheless, it would appear that long-distance trade for construction beams only became common from the 19th century onwards. For this period, tree-ring dating has proved the use of conifer beams that also came from Scandinavia and the Baltic regions. Interestingly, these provenances can be associated with specific merchants' timber marks present on some archaeological woods (Fig. 5). In a warehouse of the Godin factory in Brussels, three beams with merchant's marks were dated (felling between AD 1835-1851d) with the highest correlations with chronologies from central Sweden. This can be associated with the supply area of the Sundswall port (Vandenabeele 2014: 42, *cf*. Demanet 1847). We are currently working on deciphering these marks, which seem to correspond to a complex system of identification of the owners of the timber, its quality, its provenance, etc[7].

Figure 5. Merchant's timber marks, Godin Factory, Brussels.© SPRB

Dendrochronology in Brussels also reveals the existence of medium-distance trade: for instance, the Meuse Basin would have been a provenance area for Brussels buildings (100-130 km), as seen in a house on the Rue de Flandre98. Interestingly, other examples of this medium-scale network are depicted in archives, such as the Hainaut forests (Mormal – 120 km from Brussels)which provided beams of exceptional dimensions for the construction of the Aula Magna in the Palace of Coudenberg (Brussels), and La Houssière (50 km from the city) which furnished more common timber for ducal buildings throughout the 15th century (Rochette 1960: 263; Dickstein-Bernard 2007: 56). Unfortunately the wooden structures of the Aula Magna and the ducal buildings did not survive and cannot be sampled.

Next to these long- or medium-scale supply sources, it is known from historical sources that the forest of Soignes and other private woodlands around the city of Brussels were important resources for the urban market (Weitz et al. 2014): their location close to the city ensured low

[7] For example, L. Vandenabeele, Engineered timber. Appraisal of historic timber roof structures in 19th and early 20thcentury Belgium, PhD in progress, Vrij Univresiteit Brussel.

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transport costs (Weitzet al. 2014). Indeed, forest exploitation and commercialisation of the timber products from Soignes are well-documented in written sources from the 15th century onwards. However, identifying local wood in a specific building by dendro provenancing is not an easy task given the lack of chronologies from local living forests extending back to the studied period. In these cases, the combination of historical and dendrochronological data is relevant to increase our knowledge of this local commercial context. For example, in a neoclassical townhouse located Rue Ducaleno. 43 (Brussels), accounts relating to its construction specify the provenance area, revealing that the trees were cut in various woodlands around Brussels, in the domain of Dieleghem Abbey in Jette. The documents also mention the type of forest management (‘*raspe sous futaie*’, i.e., coppice-with-standards, with a 7-year rotation).Ten samples were collected and dated: the trees were felled between spring 1780d and winter 1780-1781d. Interestingly, in the building itself, the carpenter stamped his name and the date of his work on a beam: ‘G. Van. Schepdael. Me fecit. 1781’ (Fig. 6). Therefore, this study provides not only a precisely located site chronology for Brussels, but also an example of the rapid use of the trees after felling in the Brussels region.

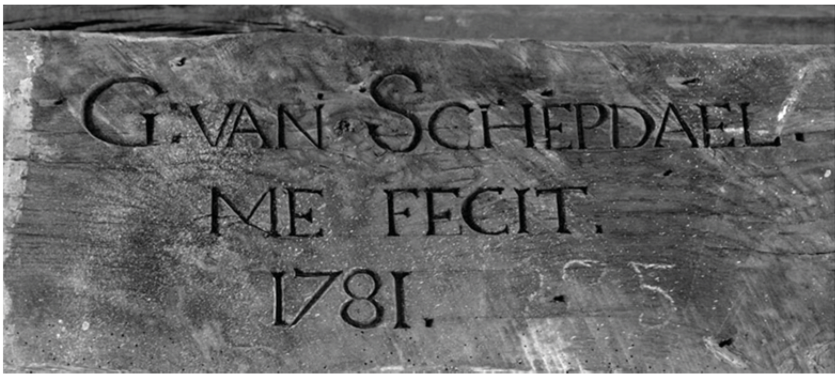

Figure 6 – Stamp with name of the carpenter and date of construction on a beam, Rue Ducale 43, Brussels. © SPRB

Conclusions

Dated chronologies provide key information to address archaeological questions. At minimum, they allow the buildings themselves to be dated, but also add new dated structures to enlarge the roof ‘chrono-typology’ database (Hoffsummer 1999, 2002, 2011). They also offer chronological markers for wood working techniques (tools, use of iron reinforcement, etc.). On the whole, the increase in results builds a more complete picture of chronological change in wood utilisation in building archaeology.

The Brussels project involves buildings from a broad range of contexts, providing a valuable dataset with oak as the main material exploited, but with other species also represented. The use of different species in a single structure has only rarely been documented in present-day Belgian buildings, where oak widely dominates. The systematic study of the distribution of the different species would thus provide further information on the wood supply conditions for Brussels.

The poor dendrochronological potential of the trees used often makes dating difficult and requires an increase in the number of samples collected per structure, and sometimes recourse to radiocarbon dating. Nevertheless, at present, around 70 oak chronologies have been dated for the Brussels region, covering the period AD 1146-1845 with the highest representation during the 16th and 17th centuries.

The building structures and the samples collected for dating are also studied to document the carpentry work, the wood resources exploited and the supply networks. Archival investigations complement this approach and allow precision or explanation of some of the dendro- or archaeological observations. For example, dendrochronological analyses demonstrate the

exploitation of supplies from local logging to long-distance trade, while written sources often provide details that allow them to be identified more precisely.
This increasing dendrochronological corpus, alongside further historical research, will lead to better interpretation of both the ecological growing environments and the geographic provenances of the raw material, and then will permit to reconstruct the economic contexts and networks used for supplying construction wood to Brussels.

Acknowledgements

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References

Billamboz A. (2006): Dendroarchäologische Untersuchungen in den neolithischen Ufersiedlungen von Hornstaad-Hörnle, Siedlungsarchäologie im Alpenvorland IX. *Forsch. u. Ber. Vor u. Frühgesch. BadenWürttemberg 98*: 297–359.

BondeN., Tyers I., Ważny T. (1997): Where does the timber come from? Dendrochronological evidence of the timber trade in Northem Europe. In: Sinclair A., Slater E., Gowlett J. (eds), Proceedings of a conference on the application of scientific techniques to the study of archaeology (Liverpool) (1995), Oxford (Archaelogical Sciences, Oxbow Monograph, 64). 201-204.

Demanet A. (1847): Cours de construction professé à l'Ecole militaire de Bruxelles (1843-1847): Connaissance des matériaux- Emploi des matériaux- Théorie de construction. Brussels.

Dickstein-Bernard C. (2007): La construction de l'*Aula Magna* au Palais du Coudenberg. Histoire du chantier (1452-1461 ?). *Annales de la Société royale d'Archéologie de Bruxelles,* Société royale d'archéologie de Bruxelles, Vol. 68:35-64.

Fraiture, P. (2009): Contribution of dendrochronology to understanding of wood procurement sources for panel paintings in the former Southern Netherlands from 1450 to 1650, *Dendrochronologia*, 27: 95-111.

Fraiture, P. (2013):Dendrochronological research on sculptures from the Elsloo Group. In: Peters F. (dir.), A Masterly Hand. Interdisciplinary Research on the Late Medieval Sculptor Master of Elsloo in an International Perspective. Proceedings of the Conference, Brussels, Royal Institute for Cultural Heritage, 20-21 October 2011(*Scientia Artis* 9), Brussels. 162-183.

Girardclos O. Petit C. (2011): Dendro-archaeological contribution to the history of forest exploitation. The case of the Gallo-Roman settlement of Oedenburg (Alsace, France) between 10 and 180AD. In:Fraiture P. (dir.), Tree Rings, Art, Archaeology.Proceedings of the conference, Brussels, Royal Institute for Cultural Heritage, 10-12 February 2010 (*Scientia Artis* 7), Brussels. 77-95.

Haneca K., Van Acker J., Beeckman H. (2005): Growth trends reveal the forest structure during Roman and Medieval times in Western Europe: a comparison between archaeological and actual oak ring series (*Quercus robur* and *Quercus petraea*). *Annals of Forest Science,* 62: 767-805.

Haneca K., Boeren I., Van Acker J., Beeckman H. (2006): Dendrochronology in suboptimal conditions: tree rings from medieval oak from Flanders (Belgium) as dating tools and archives of past forest management.*Veget Hist Archaeobot* 15*:* 137-144.

Hoffsummer P. (1999): *Les Charpentes de toitures en Wallonie, Etudes et Documents, Monuments et Sites,* 1 (2nd ed.), Namur. 173p.

Hoffsummer P. (dir.) (2002):*Les charpentes du XIe au XIXe siècle: typologie et évolution en France du Nord et en Belgique,* Centre des monuments nationaux, Paris. 375p.

Hoffsummer P. (dir.) (2011): Les charpentes du XIe au XIXe siècle, typologie et évolution dans le grand ouest de la France, Architectura MediiAevi, Vol. 5, Brépols, Turnhout. 385p.

Jansma E. (1995): Remember Rings. The Development and Application of Local and Regional Tree-ring Chronologies of Oak for the Purposes of Archaeological and Historical Research in the Netherlands, Nederlandsearcheologischerapporten, 19. 114p.

Lambert G.-N., Durost S. &Cuaz J. (2005): 2500 years from dendrochronology back to historic French human biotopes. Concerned trees: low altitude oaks. In: Heinrich I. &Monbaron M. (ed.),Annual conference on Tree Ring, Climate, Archaeology and Environment (TRACE), Fribourg, 21–23 April 2005, Association for Tree Ring Research (ATR), Actes, vol. 4. 244–264.

Lambert G.-N. (2011): Dendrochronology, archaeology and science. In: Fraiture P. (dir.), Tree Rings, Art, Archaeology, Proceedings of the conference, Brussels, Royal Institute for Cultural Heritage, 10-12 February 2010 (*Scientia Artis* 7), Brussels. 19-30.

Rochette D. (1960): Introduction à l'étude de l'usage du bois à Bruxelles au XV^{e} siècle, et notamment l'organisation de l'exploitation de la forêt de Soignes.Master's thesis, Universitélibre de Bruxelles.

SchweingruberF.H. (1988): Tree-ring. Basics and Applications of Dendrochronology, D. Reidel Publishing Compagny, Dordrecht. 276p.

Sosnowska P. (2013):De boiset de brique. Contribution à l'histoire de l'architecture à Bruxelles. Etude archéologique, technique et historique des matériaux de construction (XIII-XVIII^{e} s.), Unpublished doctoral thesis, Université libre de Bruxelles.

Vandenabeele L. (2014): Historical Timber Warehouses in Brussels, Master's thesis, Université libre de Bruxelles- Bruface.

Weitz A., Charruadas P., Crémer S., Fraiture P., Gerrienne P., Hoffsummer P., Modrie S., Sosnowska P. (2014): Construction d'une capitale: les ressources ligneuses exploitées pour le bâti bruxellois. *Cities in Europe Cities in the World*, 12th international conference on Urban History, European Association for Urban History, Lisbon, 3-6/09/2014, (forthcoming)

Unpublished reports

Eeckhout J., Galand A.(2005): Rapport d'analyse dendrochronologique. L'église Saint-Jean et Saint-Etienne aux Minimes à Bruxelles, rapport d'étude inédit, Université de Liège-Centre Européen d'Archéométrie(unpublished).

Fraiture P., Crémer S. (2013) :Rapport d'analyse dendrochronologique. Planchers. Bruxelles […], Institut royal du Patrimoine artistique, réf. labo. P480-P481-P482-P497-P498 (Unpublished report for P. SOSNOWSKA, Centre de Recherche en Archéologie et Patrimoine / Université Libre de Bruxelles).

Van Strydonck M. (2011): *Radiocarbon dating report*, KIK-IRPA, 01/08/2011.

Van Strydonck M., Boudin M. (2015): *Radiocarbon dating report*, KIK-IRPA, 03/03/2015.

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http://doi.org/10.2312/GFZ.b103-16042