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# Where did the timber frame come from? A preliminary multi-variable dendroprovenancing study on living oak trees.

Roberta D'Andrea

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Where did the timber frame come from? A preliminary multi-variable dendroprovenancing study on living oak trees

**Roberta D'Andrea**

PhD student

GEOLAB (University of Limoges)

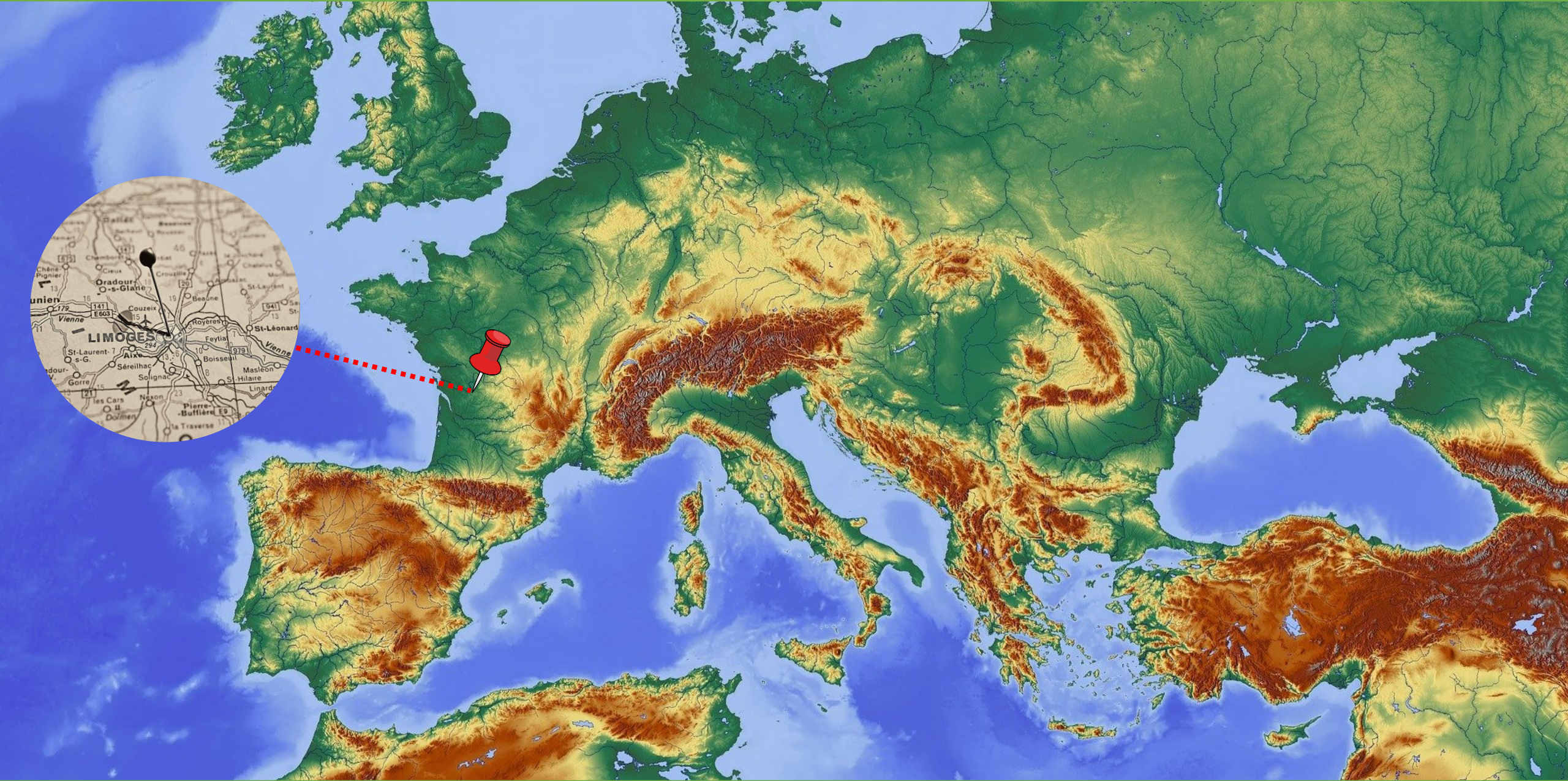
LTRR

Tree-Ring Talk

12/08/2021











Carte de l'état major (1820-1866)



# Haute-Vienne's forests



Where exactly did the wood come from?

How was timber transported?

How were forests managed?

How did construction activities impact

Haute-Vienne's forests?

# Limoges





LANDSCAPE ARCHAEOLOGY

HISTORICAL GEOGRAPHY

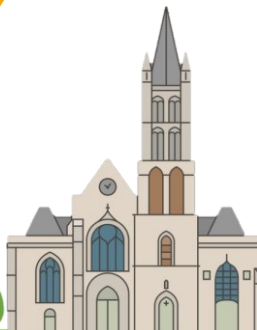
DENDROCHRONOLOGY

GEOARCHAEOLOGY

DENDROPROVENANCING

DENDROGEOGRAPHY

DENDROARCHAEOLOGY







Contents lists available at SciVerse ScienceDirect

Journal of Archaeological Science

journal homepage: <http://www.elsevier.com/locate/jas>

Review

## Locating the origins of wood resources: a review of dendroprovenancing

Martin Bridge\*

Institute of Archaeology, University College London, 31-34 Gordon Square, London WC1H 0PY, UK

## ARTICLE INFO

## Article history:

Received 30 September 2011  
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 Accepted 14 April 2012

## Keywords:

Dendroprovenancing  
 Dendrochronology  
 Tree-rings  
 Archaeology

## ABSTRACT

Dendroprovenancing studies have been shown to have historically been initiated on the use of oak in art-historical contexts, but are now employed on a much wider range of species and artefact types, particularly in relation to ship remains. The commonest methodology is to compare individual site chronologies with a network of other chronologies, and to recognise trends in the geographical distribution of strong matches, suggesting the likely source area of the material. Other studies may look at the matching of individual timbers to draw similar conclusions. It is shown that ecological and genetic factors may strongly influence individual matching results and that ring-widths may therefore be considered a somewhat crude means of provenancing. Additional chemical and genetic markers are discussed, although these are unlikely to become routinely used in the near future.

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Journal of Archaeological Science 36 (2009) 1–11



Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: <http://www.elsevier.com/locate/jas>

Review

## Oaks, tree-rings and wooden cultural heritage: a review of the main characteristics and applications of oak dendrochronology in Europe

Kristof Haneca<sup>a,\*</sup>, Katarina Čufar<sup>b</sup>, Hans Beeckman<sup>c</sup><sup>a</sup> Flanders Heritage Institute, Koning Albert II-laan 19, bus 5, 1210 Brussels, Belgium<sup>b</sup> University of Ljubljana, Biotechnical Faculty, Department of Wood Science and Technology, Razna dolina, Cesta VIII/34, PP 2995, SI-1001 Ljubljana, Slovenia<sup>c</sup> Royal Museum for Central Africa, Laboratory of Wood Biology & Xylarium, Leuvensesteenweg 13, 3080 Tervuren, Belgium

## ARTICLE INFO

## Article history:

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 Accepted 8 July 2008

## Keywords:

Dendrochronology  
 Tree-rings  
 European oak  
*Quercus robur/petraea*  
 Archaeology  
 Art-history  
 Cultural heritage

## ABSTRACT

We overview the recent development of oak dendrochronology in Europe related to archaeology and art-history. Tree-ring series of European oaks (*Quercus robur* and *Q. petraea*) have provided a reliable framework for chronometric dating and reconstruction of past climate and environment. To date, long oak chronologies cover almost the entire Holocene, up to 8480 BC and the network over the entire area in which the two oaks grow is being improved. We present the main characteristics of oak ring series and discuss the latest methodological advances in defining the calendar year in which the tree-rings were formed and in interpreting such dating in terms of the age of a wooden object. Dendrochronology has established itself as a standard dating tool and has been applied in a wide variety of (pre-)historical studies. Archaeological wood, historical buildings, works of art (such as panel paintings and sculptures) have been successfully investigated. Recent advances in dendro-provenancing have helped to obtain more information on the timber trade in the past. Information on past forest structures, silviculture and timber use have become available through scrutinizing historical and contemporary ring-width patterns.

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Contents lists available at ScienceDirect

Dendrochronologia

journal homepage: [www.elsevier.com/locate/dendro](http://www.elsevier.com/locate/dendro)

## Seeing the forest for the trees: New approaches and challenges for dendroarchaeology in the 21st century

Marta Domínguez-Delmás<sup>a,b,c</sup><sup>a</sup> Department of Art History, University of Amsterdam, Postbus 94551, 1090 GN Amsterdam, the Netherlands<sup>b</sup> DendroResearch, 6707JG Wageningen, the Netherlands<sup>c</sup> Rijksmuseum, Hobbemastraat 22, 1071 ZC Amsterdam, the Netherlands

## ARTICLE INFO

## Keywords:

Dendrochronology  
 Timber trade  
 Dendroprovenancing  
 Stable isotope ratios  
 DNA barcoding  
 Computed tomography

## ABSTRACT

The application of tree-ring research to the study of cultural heritage has seen important conceptual and methodological developments in the 21st century. Following the breakthrough discovery in the 1980s of the importation of timber from the south-eastern Baltic to the Low Countries for panel paintings, the historical timber trade acquired paramount relevance in European dendrochronology. The improvement of methods and tools to locate the area of origin of the wood has since become a focal line of research. Reference chronologies of different variables (ring width, earlywood, latewood, earlywood vessel size in oak, latewood density in conifers, stable isotope chronologies of  $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$ ) are now being developed in areas formerly (and currently) exploited for timber production, and isotopic signatures of  $^{87}\text{Sr}/^{86}\text{Sr}$  are being mapped to provide a geochemical reference. In parallel, novel techniques to identify wood species (automated wood identification, chemical biomarkers, DNA barcoding) and their application on historical and ancient wood are being explored, given that this could sometimes help narrow down the timber source area. Modern technology is playing a key role in the study of wooden objects through non-invasive methods, and collaboration with (art) historians, mathematicians, engineers and conservators has proven essential in current achievements. Tree-ring series can now be retrieved from high resolution X-ray computed tomography images, allowing the research of otherwise inaccessible pieces. This paper reviews recent advances in those fields (tree-ring based dendroprovenancing, wood species identification, chemical fingerprinting, use of genetic markers, isotopic signatures, and non-invasive methods), and discusses their implementation and challenges in dendroarchaeological studies.







Figure 1. Location of the early-medieval settlements of Hedeby (Northern Germany), Dorestad (Netherlands) and Wolin (Poland).

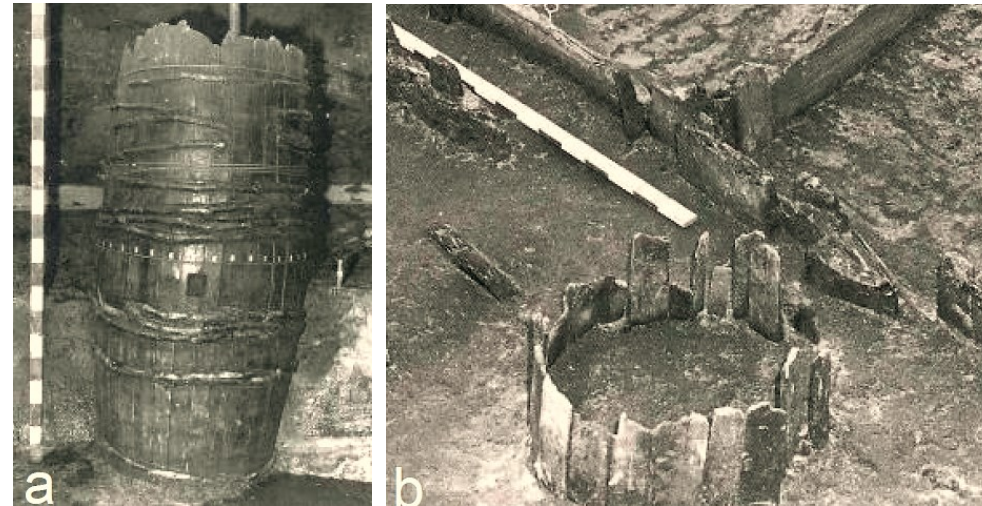


Figure 3. Hedeby: (a) a barrel made of Silver fir; (b) in secondary use as enclosure of a well.

(1) SPECIES IDENTIFICATION  
(2) TREE-RING WIDTH

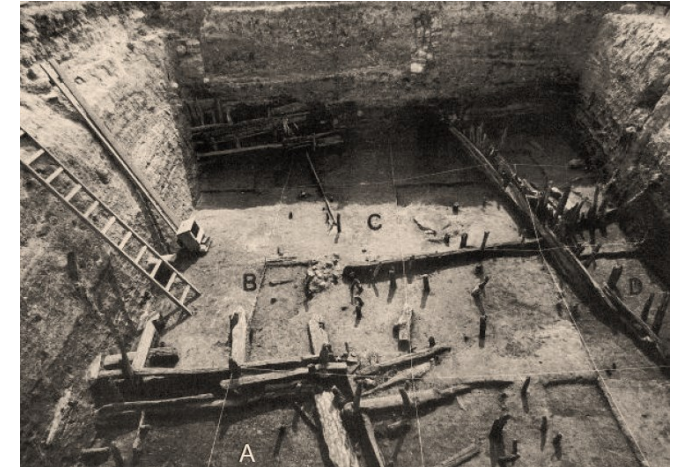


Figure 4. Wolin. Excavated area of the temple (Filipowiak 1992).



Figure 2. Dieter Eckstein

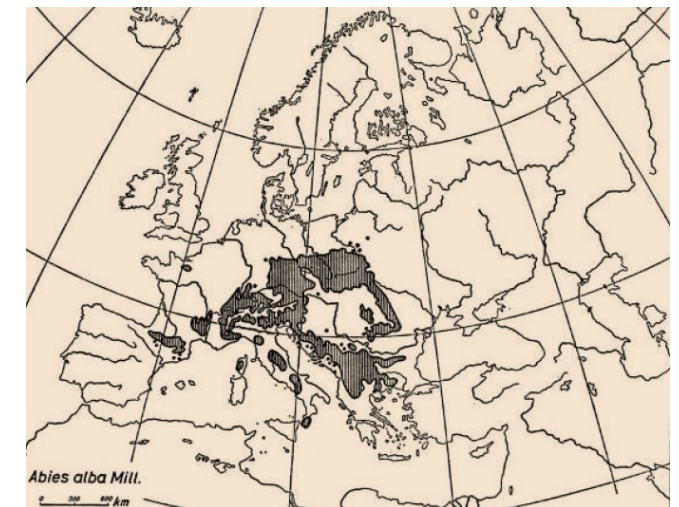


Figure 5. Natural distribution of Silver fir (Dengler 1971).



# BALTIC TIMBER IN WESTERN EUROPE

## Trade of Baltic oak

Ⓐ rafting on a river; Ⓑ Wazny, 2002; Ⓒ dendro-chronologically derived trade routes.



Dendrochronologia 20/3 (2002) 1–8  
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<http://www.urbanfischer.de/journals/dendro> **DENDROCHRONOLOGIA**

**b**

### Baltic timber in Western Europe – an exciting dendrochronological question

**Tomasz Wazny**  
Nicholas Copernicus University of Torun, Institute for Study, Conservation and Restoration of Cultural Heritage, Torun, Poland  
and Academy of Fine Arts, Faculty of Conservation and Restoration, Warsaw, Poland







# ForSEAdiscovery

Forest resources for Iberian Empires: Ecology and Globalization in the Age of Discovery



Northern Europe's timber resources – chronology, origin and exploitation

# TIMBER







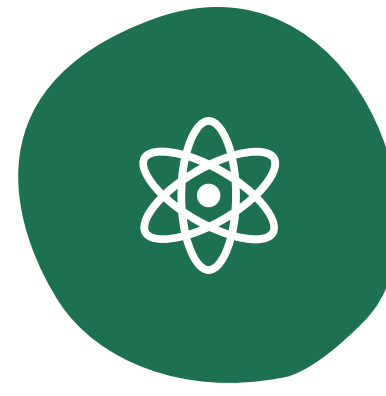
SPECIES  
IDENTIFICATION



RING-WIDTH  
SERIES



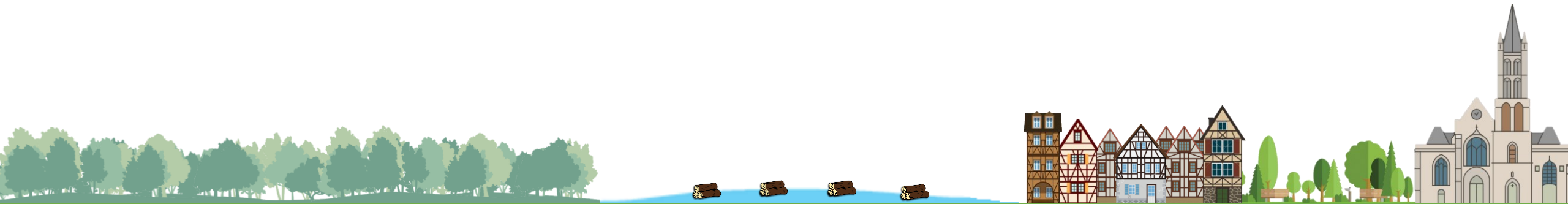
WOOD  
ANATOMY



STABLE  
ISOTOPES



DNA



Received: 17 July 2018 | Revised: 3 February 2019 | Accepted: 17 March 2019

DOI: 10.1111/jbi.13576



## RESEARCH PAPER

Journal of  
Biogeography

WILEY



ELSEVIER

Journal of Archaeological Science 86 (2017) 24–49

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: <http://www.elsevier.com/locate/jas>**Multi-variable approach pinpoints origin of oak wood with higher precision**Linar Akhmetzyanov<sup>1</sup> | Allan Buras<sup>1</sup> | Ute Sass-Klaassen<sup>1</sup> | Jan den Ouden<sup>1</sup> | Frits Mohren<sup>1</sup> | Peter Groenendijk<sup>2,3</sup> | Ignacio García-González<sup>2</sup> <sup>1</sup>Forest Ecology and Forest Management Group, Wageningen University & Research, Wageningen, The Netherlands<sup>2</sup>Departamento de Botánica, Escola Politécnica Superior de Enxeñaría, Universidade de Santiago de Compostela, Lugo, Spain<sup>3</sup>Department of Plant Biology, Institute of Biology, University of Campinas – UNICAMP, Campinas, SP, Brazil**Abstract**

**Aim:** Spatial variations of environmental conditions translate into biogeographical patterns of tree growth. This fact is used to identify the origin of timber by means of dendroprovenancing. Yet, dendroprovenancing attempts are commonly only based on ring-width measurements, and largely neglect additional tree-ring variables. We explore the potential of using wood anatomy as a dendroprovenancing tool, and investigate whether it increases the precision of identifying the origin of oak wood.

**scientific reports****OPEN DNA of centuries-old timber can reveal its origin**Linar Akhmetzyanov<sup>1</sup> , Paul Copini<sup>2</sup>, Ute Sass-Klaassen<sup>1</sup>, Hilke Schroeder<sup>3</sup>, G. Arjen de Groot<sup>2</sup>, Ivo Laros<sup>2</sup> & Aoife Daly<sup>4</sup>**Radiogenic and “stable” strontium isotopes in provenance studies: A review and first results on archaeological wood from shipwrecks**Fadi Hajj<sup>a,\*</sup>, Anne Poszwa<sup>a</sup>, Julien Bouchez<sup>b</sup>, François Guérol<sup>a</sup><sup>a</sup> Laboratoire Interdisciplinaire des Environnements Continentaux, UMR 7360 CNRS, Université de Lorraine, 54506 Vandoeuvre-lès-Nancy, France<sup>b</sup> Institut de Physique du Globe de Paris, UMR 7154 CNRS, Université Sorbonne-Paris Cité, 75238 Paris, France

## ARTICLE INFO

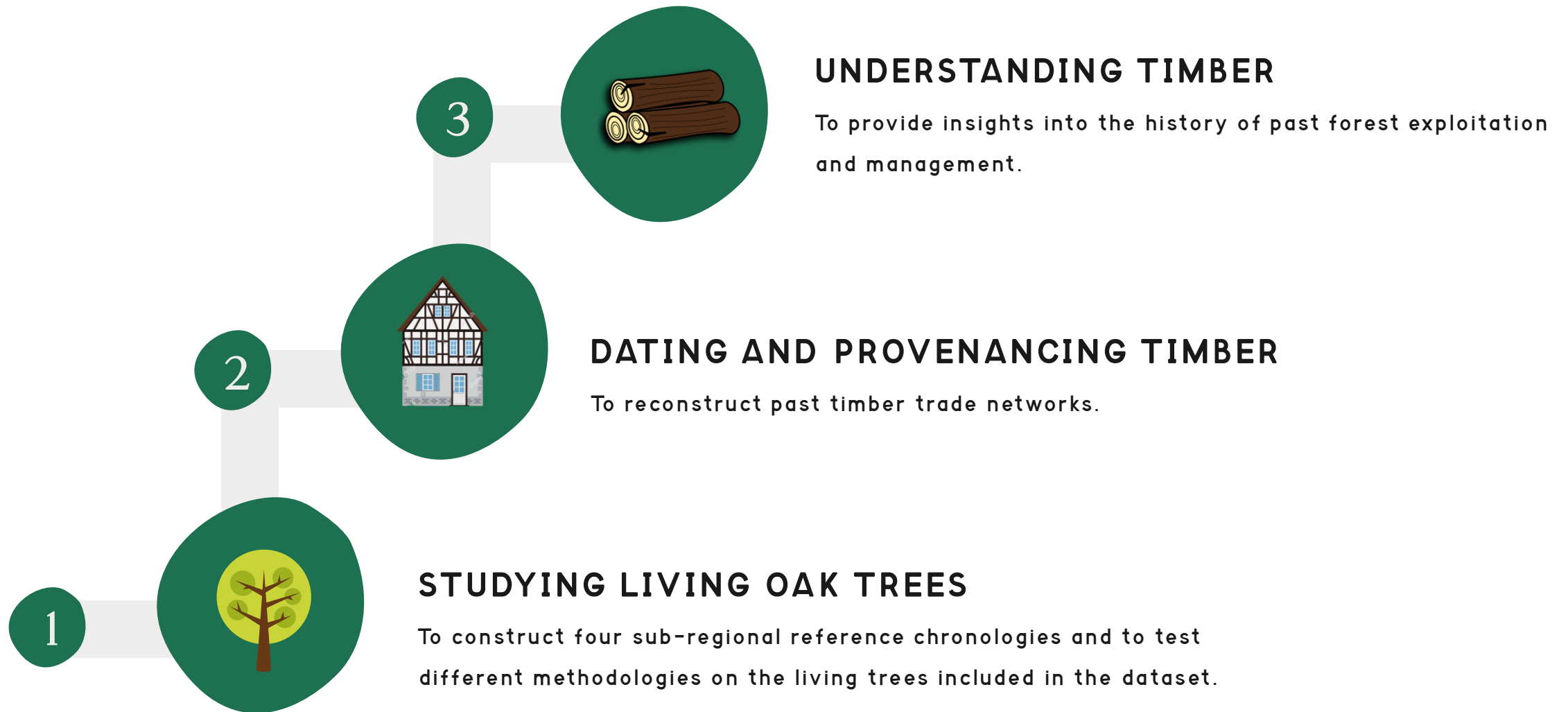
**Article history:**Received 4 January 2017  
Received in revised form  
18 June 2017  
Accepted 2 September 2017  
Available online 11 September 2017**Keywords:**Wood provenance  
Shipwrecks  
Radiogenic and stable Sr isotopes  
Site signature  
Mass-dependent fractionation  
Wood signature modification

## ABSTRACT

Different approaches are used to study wood provenance, but most of them are based on tracers in wood that are generally controlled by climatic factors. The strontium isotopic ratio  $^{87}\text{Sr}/^{86}\text{Sr}$  in trees and soils is related to the signature of the local bedrock. Despite being used in diverse archaeological studies, Sr isotopes have rarely been used to trace the provenance of archaeological wood and especially wood from shipwrecks. In addition, recent analytical advances have allowed the detection of mass-dependent fractionation of Sr isotopes during biogeochemical processes, as reflected in the variation of  $\delta^{88/86}\text{Sr}$  values between different environmental materials. The  $\delta^{88/86}\text{Sr}$  values could be used in conjunction with the  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope ratio to improve constraints on the sources of Sr in the archaeological materials being studied. This paper discusses the potential and limitations of using both of these Sr isotope ratios to trace the provenance of wood from shipwrecks. We review the  $^{87}\text{Sr}/^{86}\text{Sr}$  and  $\delta^{88/86}\text{Sr}$  variations in rocks, waters, soils, plants and other living organisms and discuss how to determine the local Sr isotopic signature of potential sites. We also compile a list of known wood *post mortem* modifications in seawater. Possible implications in terms of the modification of the original Sr isotope ratios of wood during storage in seawater are illustrated through preliminary observations. This paper points out some limitations and perspectives for using Sr isotopes in provenancing wood from shipwrecks, and suggests future research to test and apply this approach for tracing the origin of archaeological wood.

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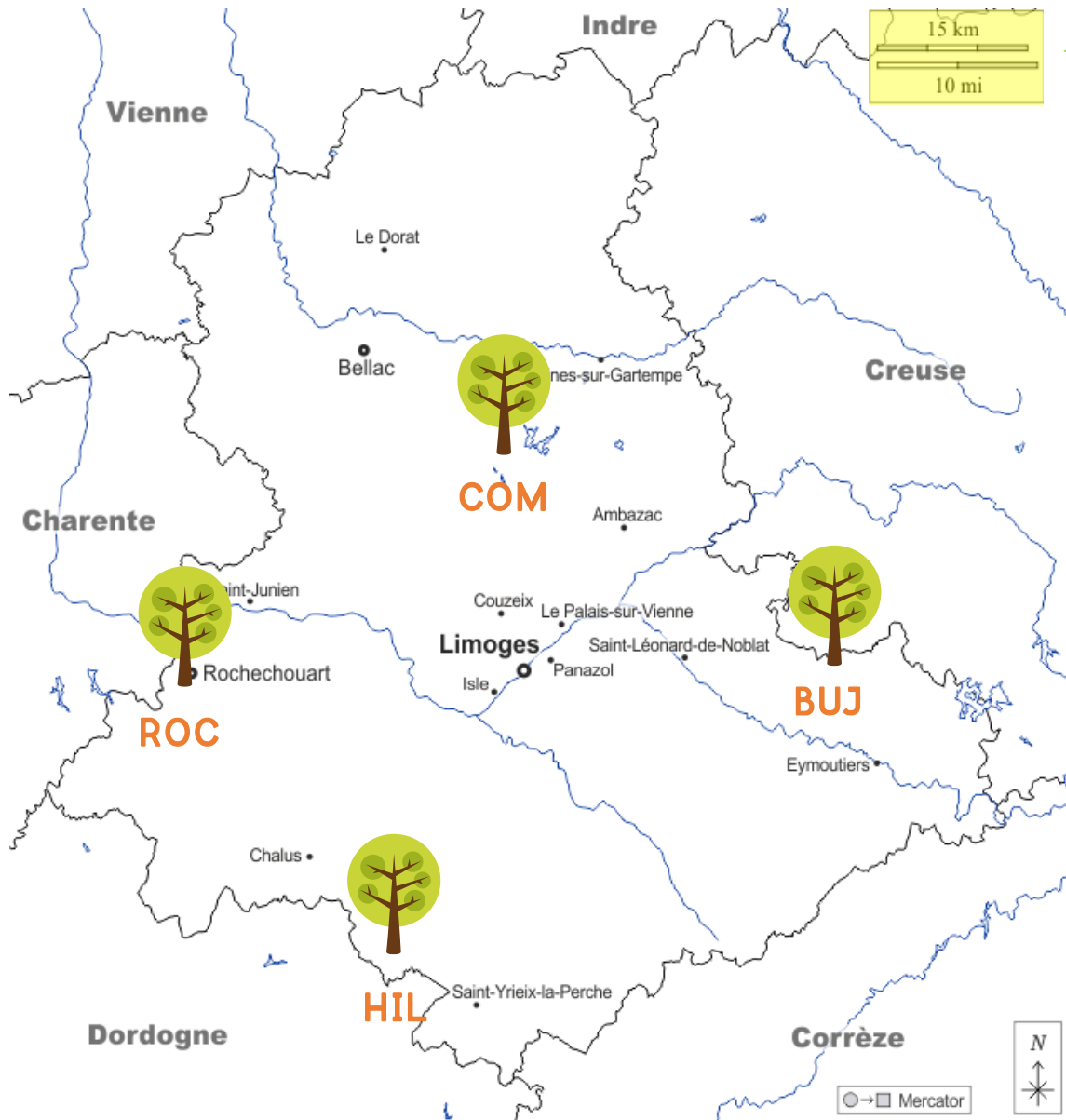






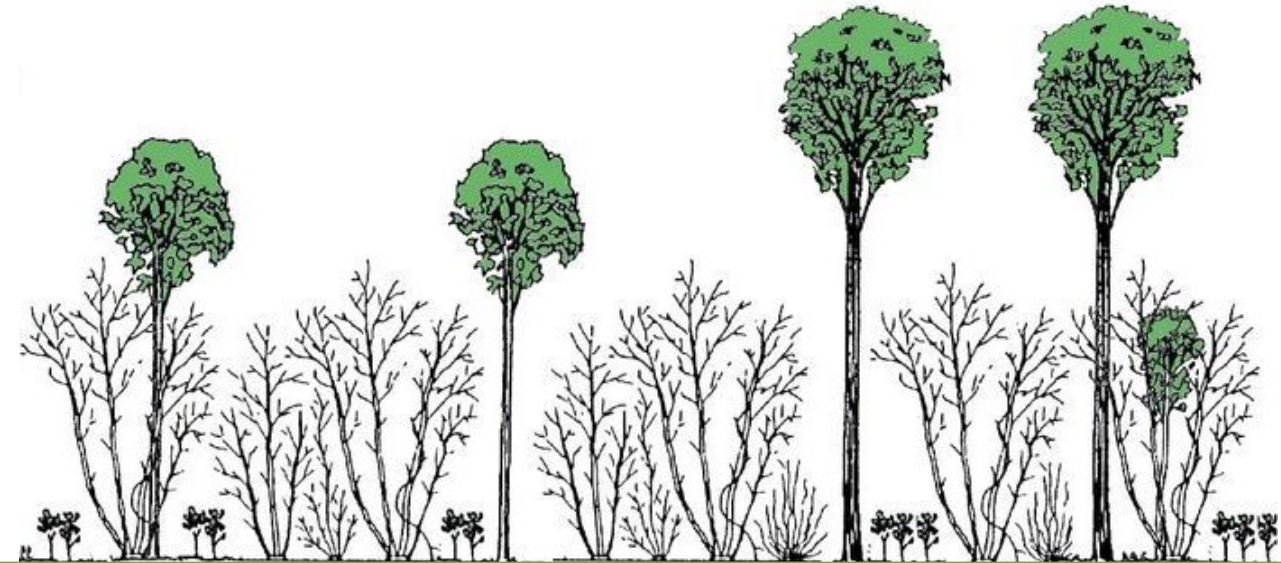






← **SHORT-DISTANCE DENDROPROVENANCING**

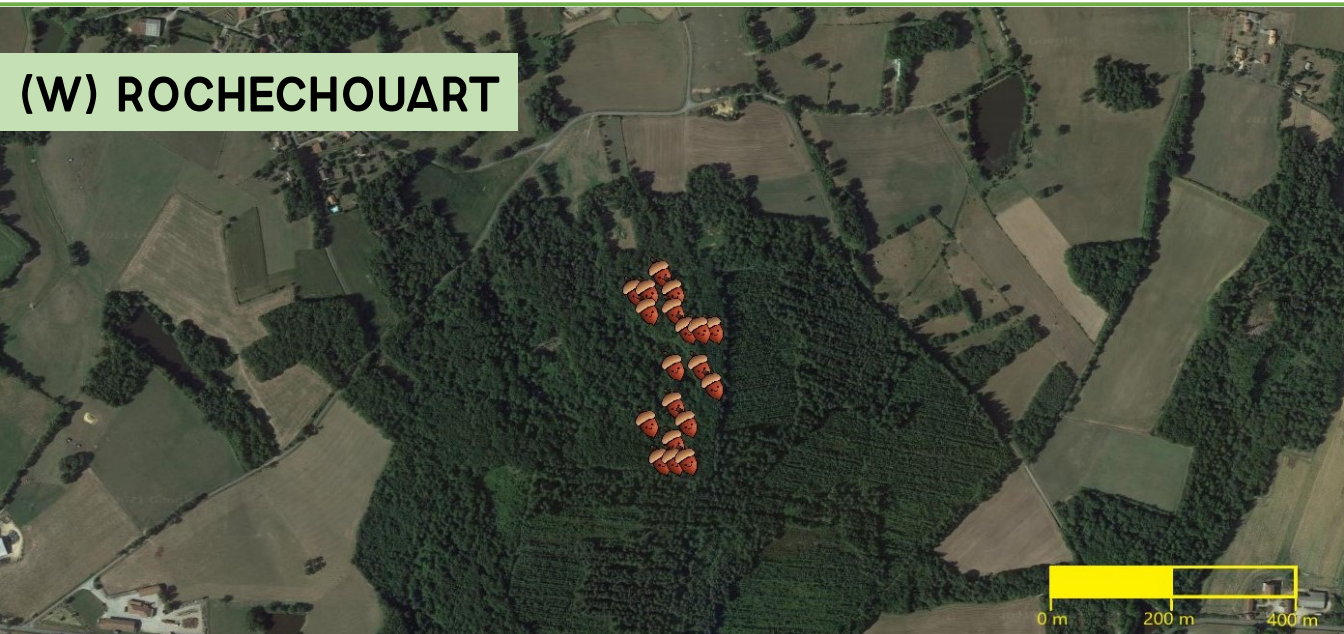
- 4 coppice-with-standards forest stands;
- Between 20 and 30 standard trees per stand (two cores per tree);
- A few core samples from coppice stools, to compare their growth patterns to those observed on archaeological samples.





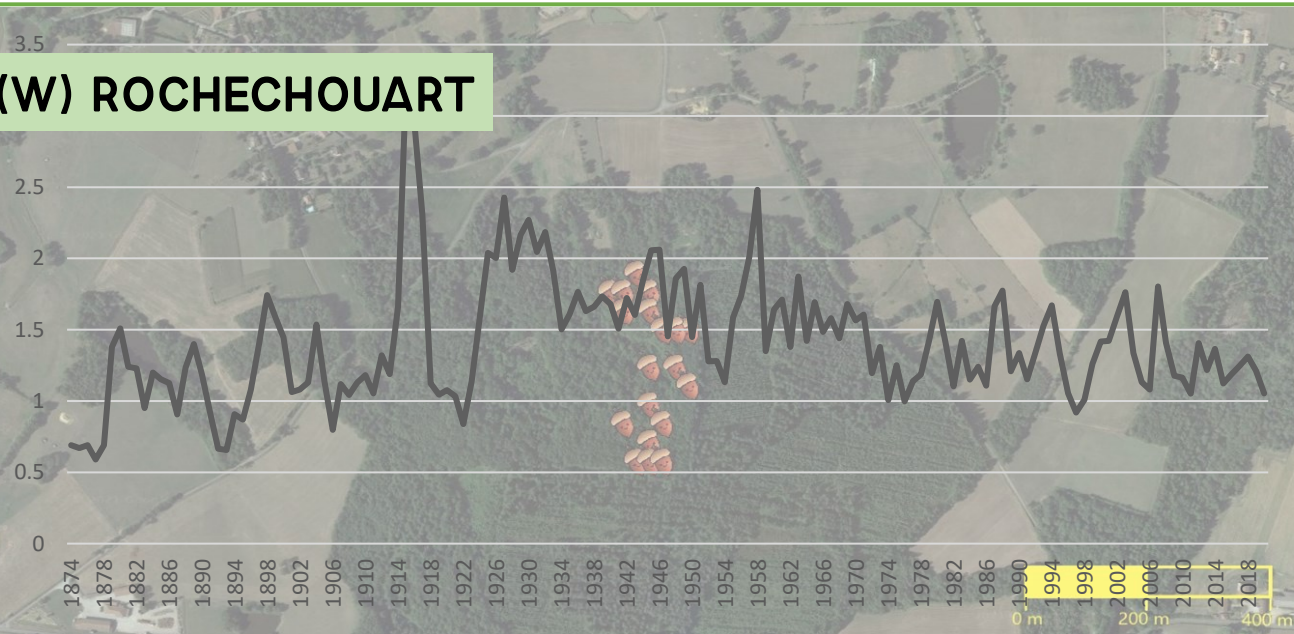




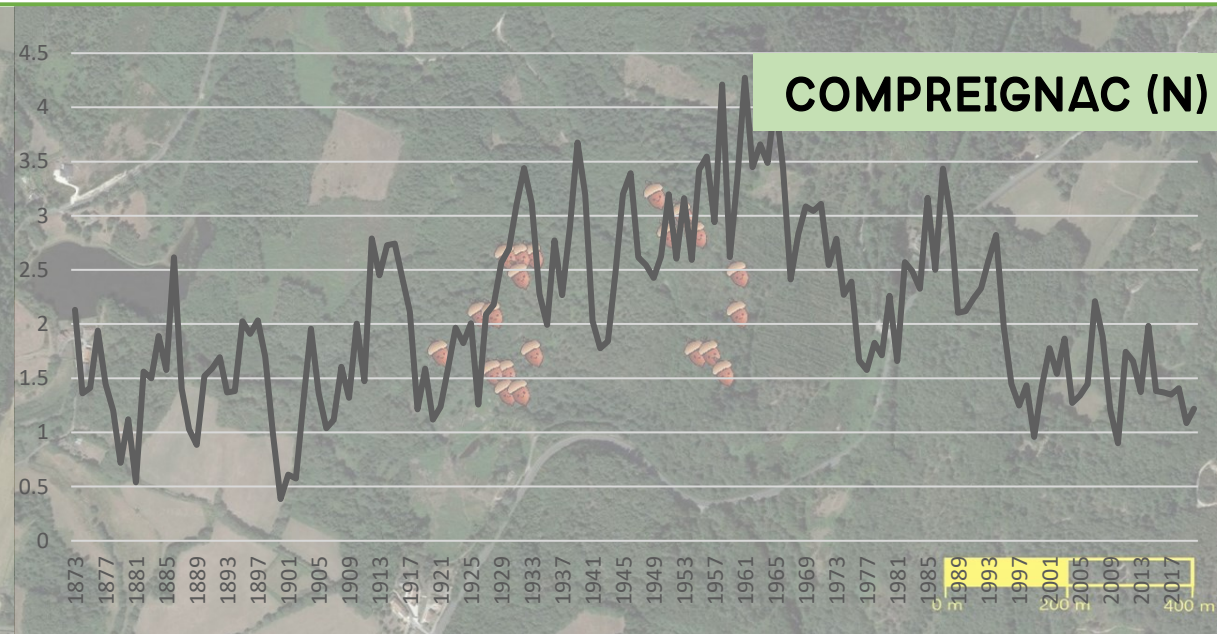




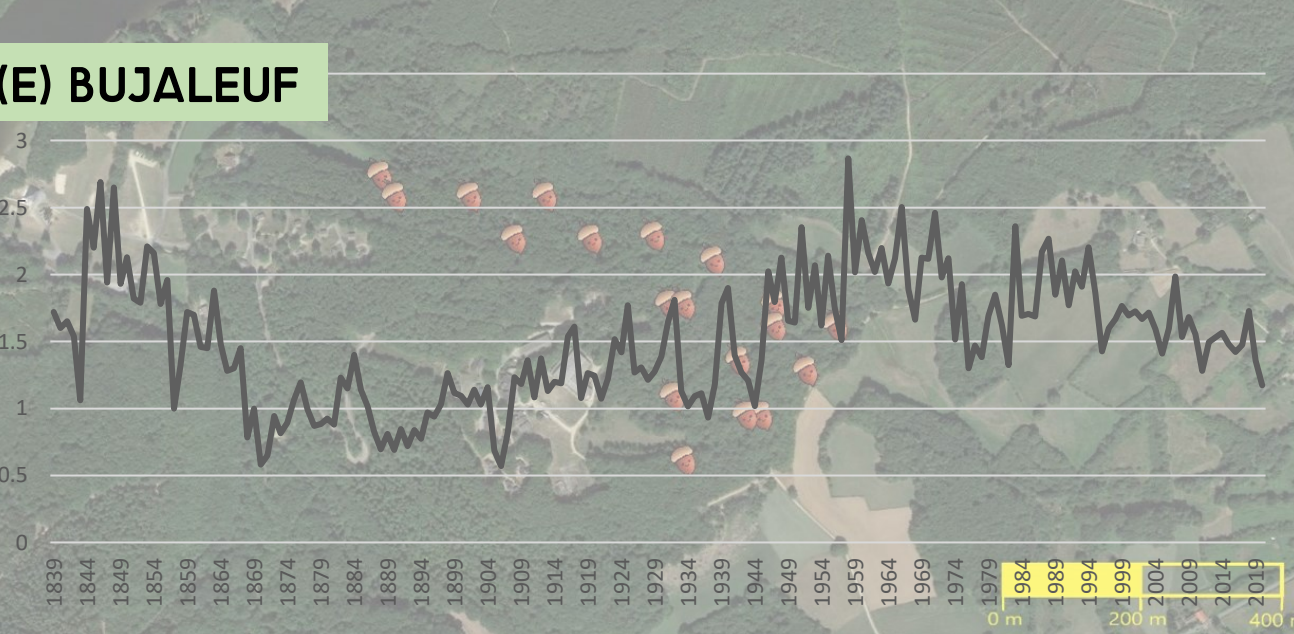
**(W) ROCHECHOUART**



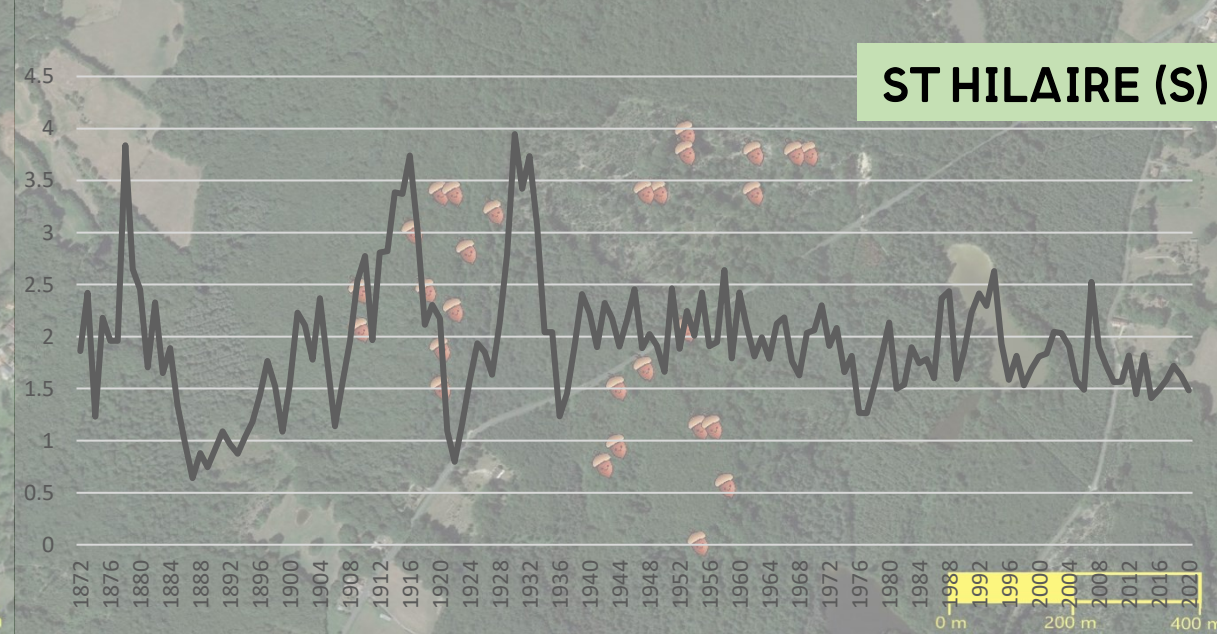
**COMPREIGNAC (N)**



**(E) BUJALEUF**

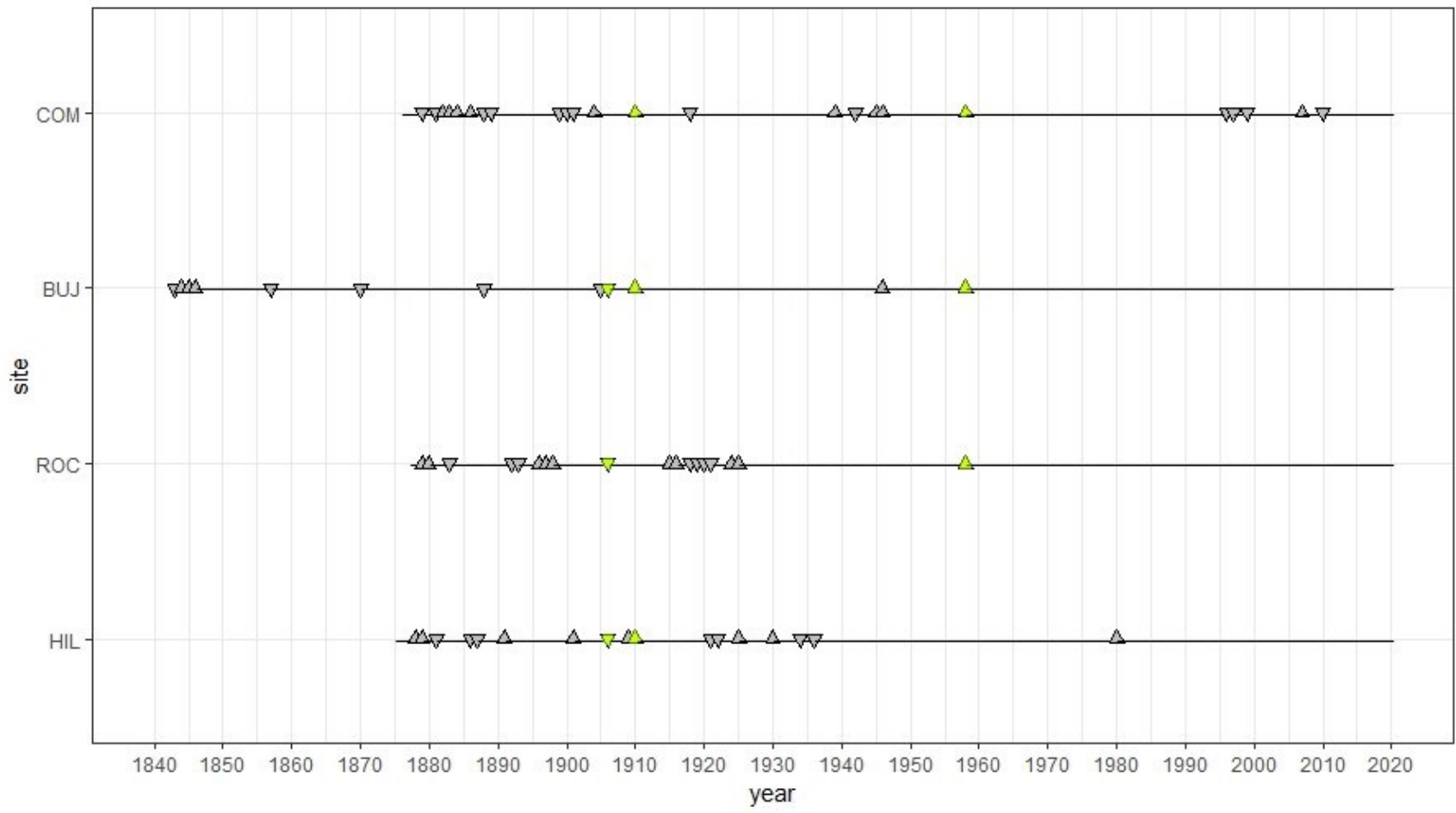


**ST HILAIRE (S)**





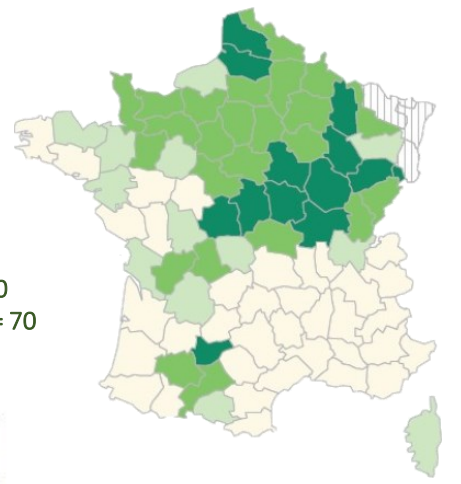
### «Abrupt growth change method» (Schweingruber et al. 1986)



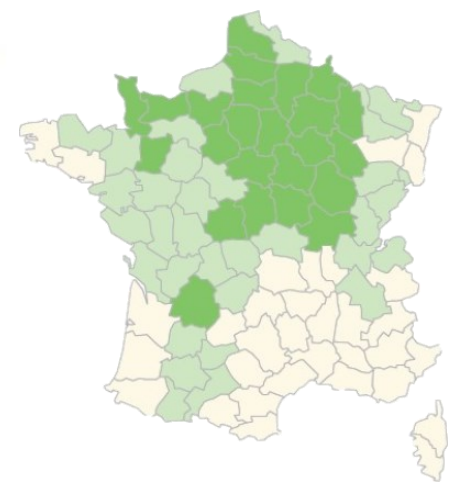
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 rgc.thresh = 30  
 series.thresh = 70

pointer year  
 ▽ negative  
 - none  
 ▲ positive

All sites

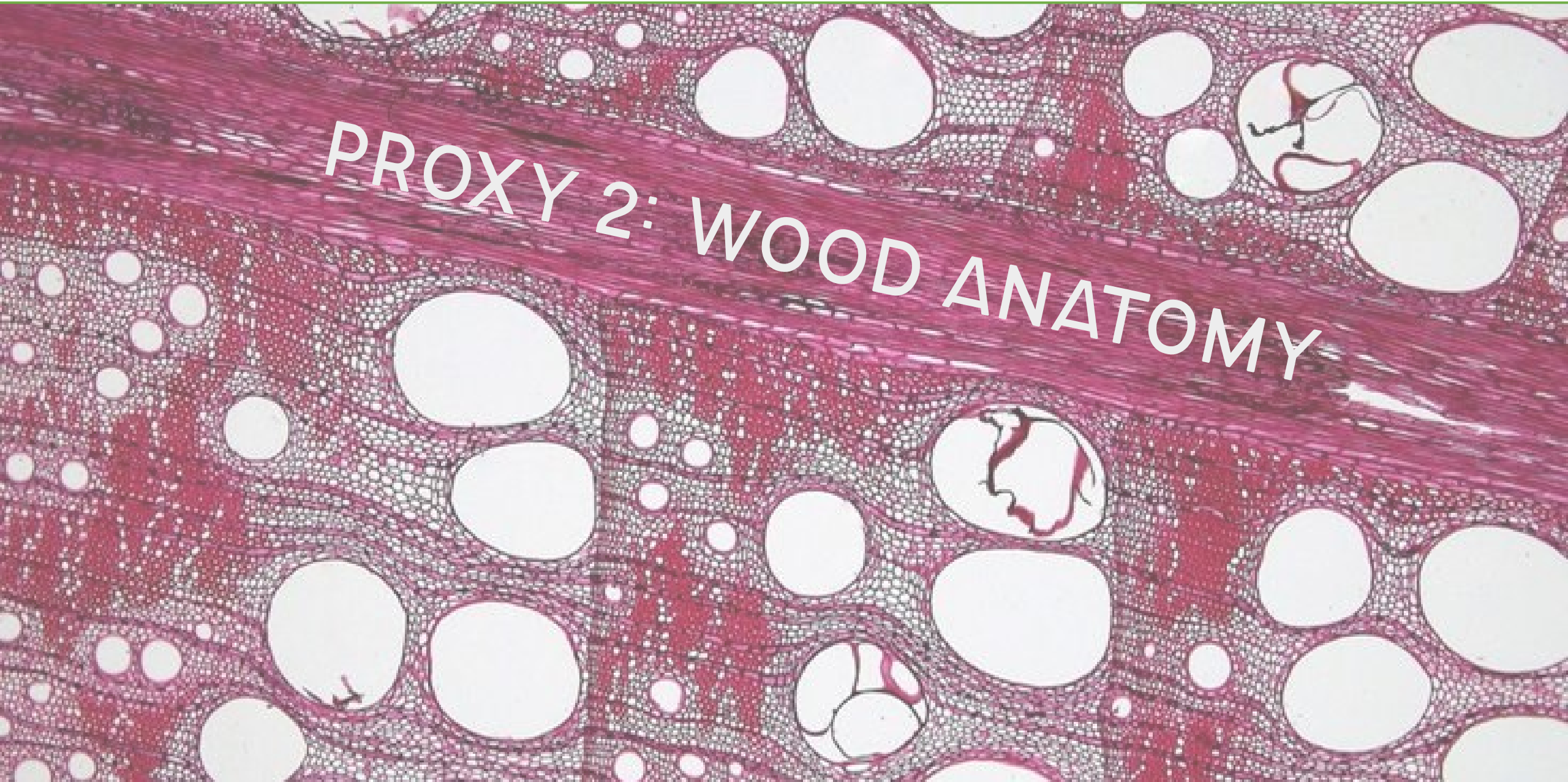


Coppice-with-standards 1908



Coppice-with-standards 1980





# PROXY 2: WOOD ANATOMY

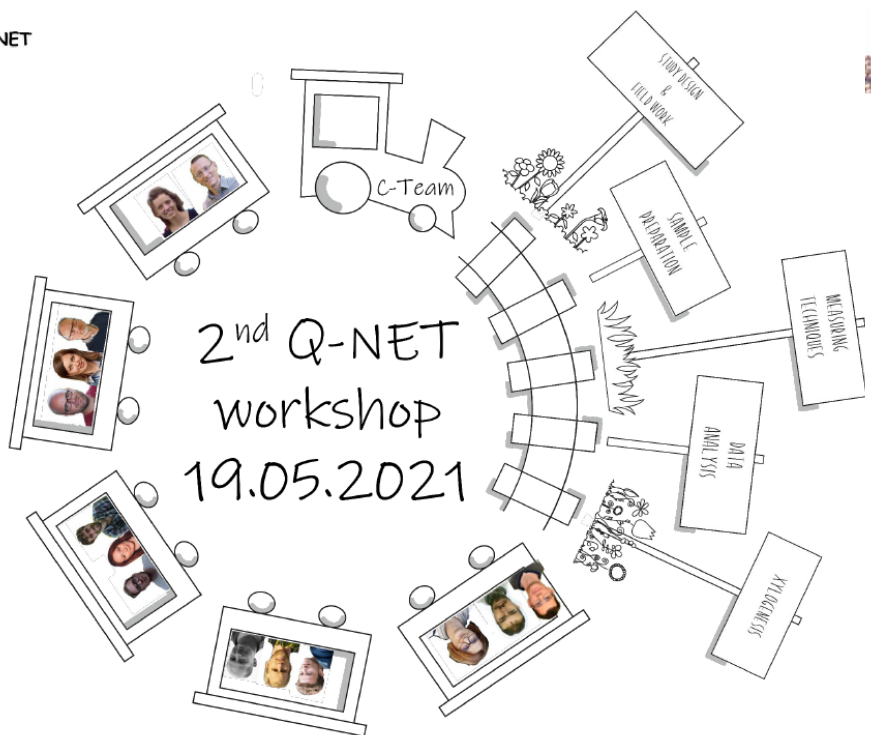
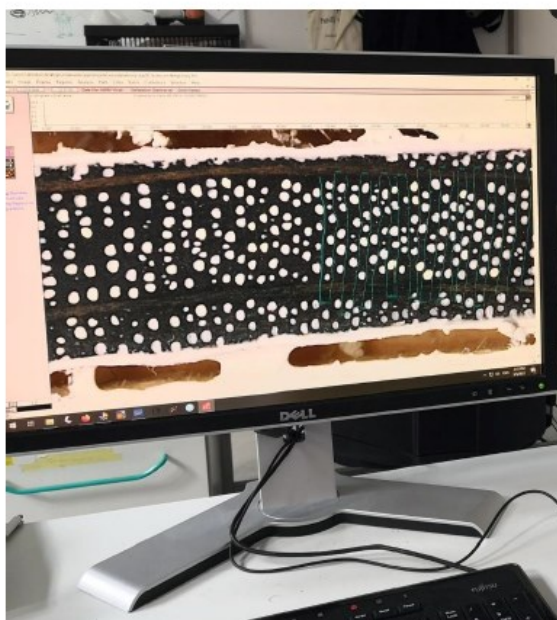
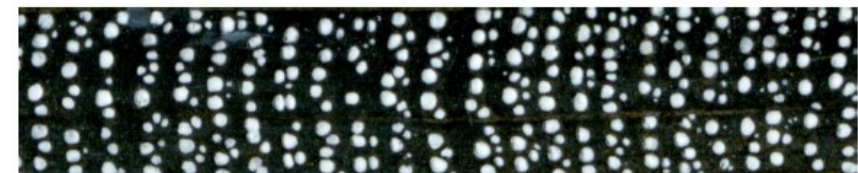
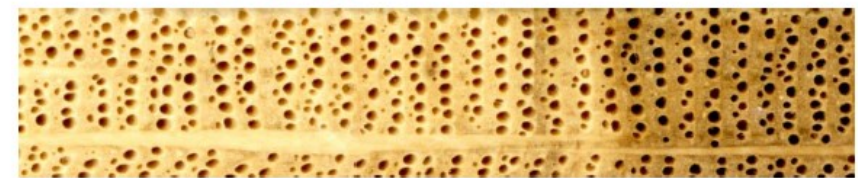


## IV. Alternative to thin sectioning technique



### Direct scan of sample

Spraying, blackening and waxing



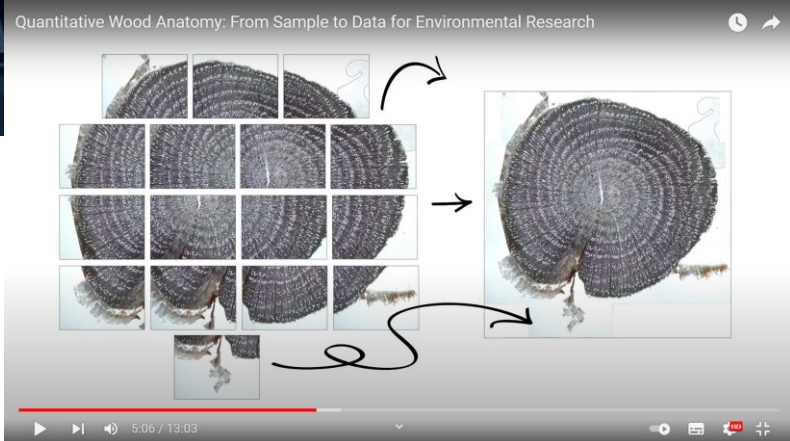
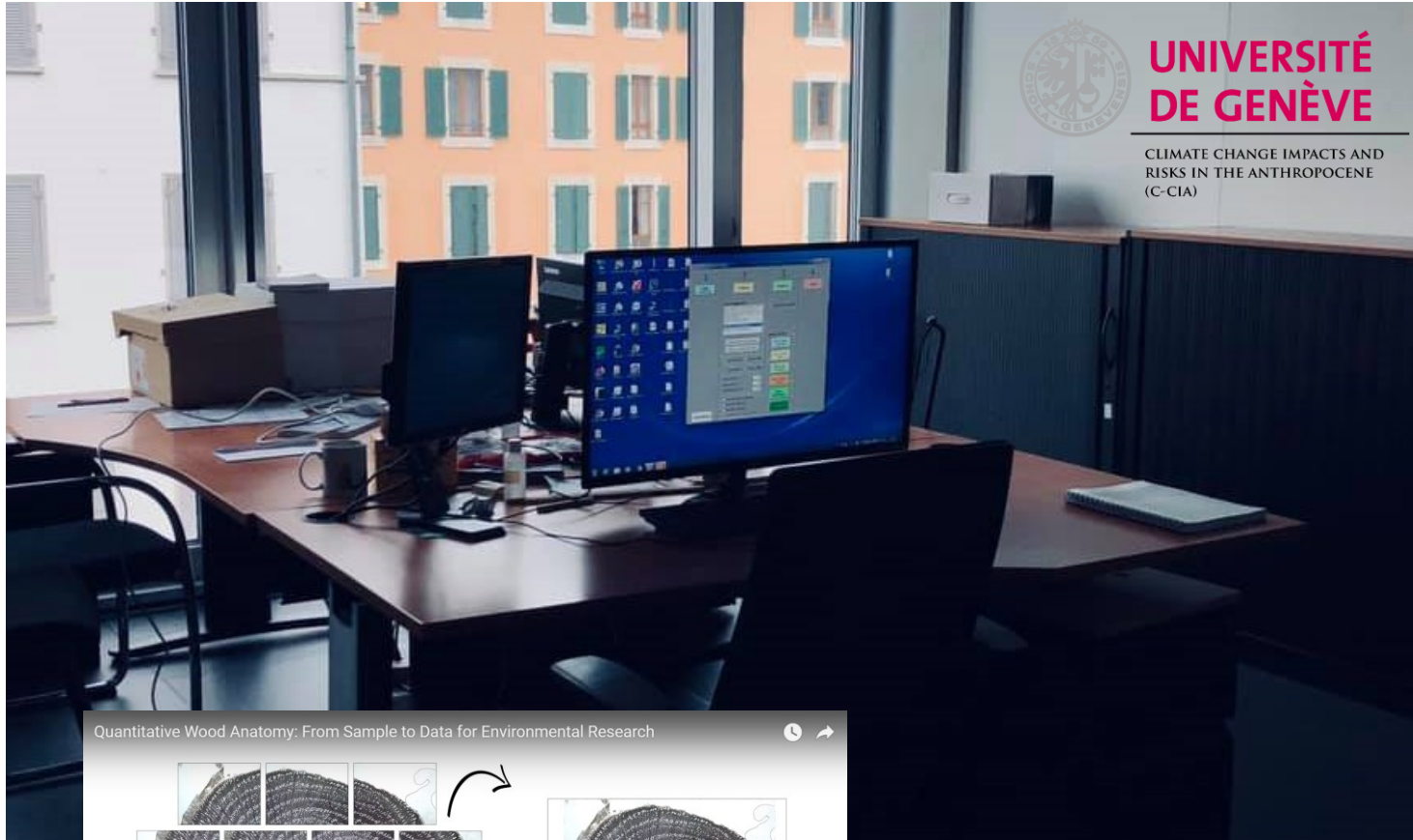
# STOPOVER 2 Sample preparation

<https://qwa-net.com>

Sass, U. and D. Eckstein. 1995. The variability of vessel size in beech (*Fagus sylvatica* L.) and its ecophysiological interpretation. *Trees* 9:247 – 252.

Fonti, P., García-González, I. (2004). Suitability of chestnut earlywood vessel chronologies for ecological studies. *New Phytologist* 163(1): 67-86.



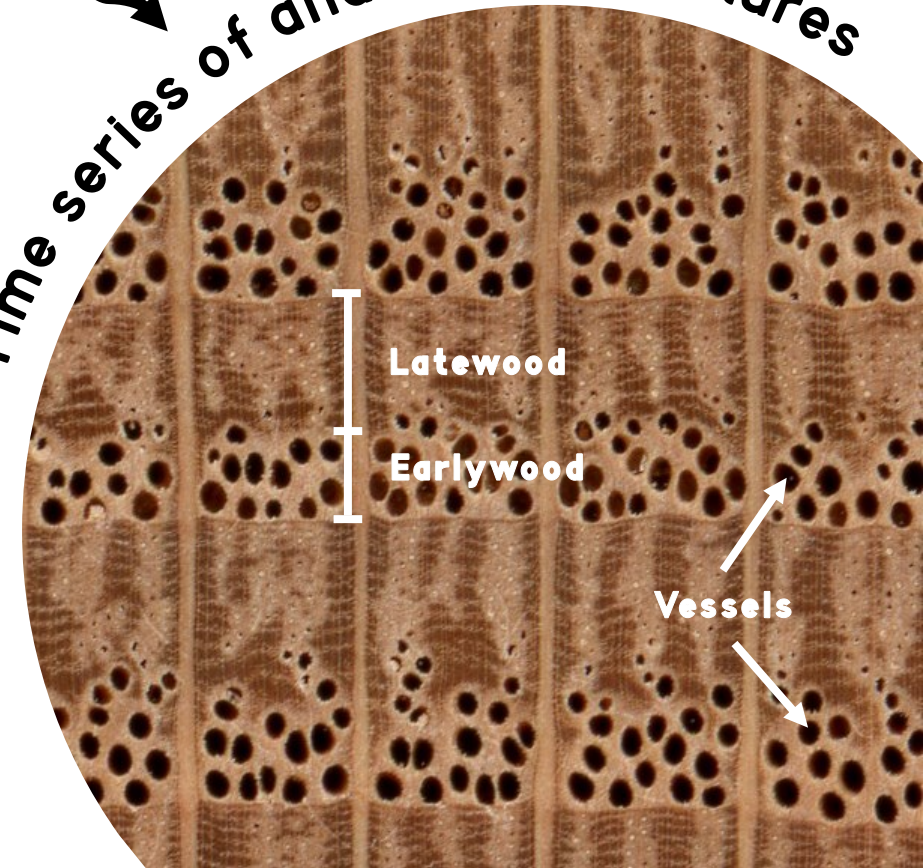


YouTube video →  
**Quantitative Wood Anatomy:  
From Sample to Data for  
Environmental Research**

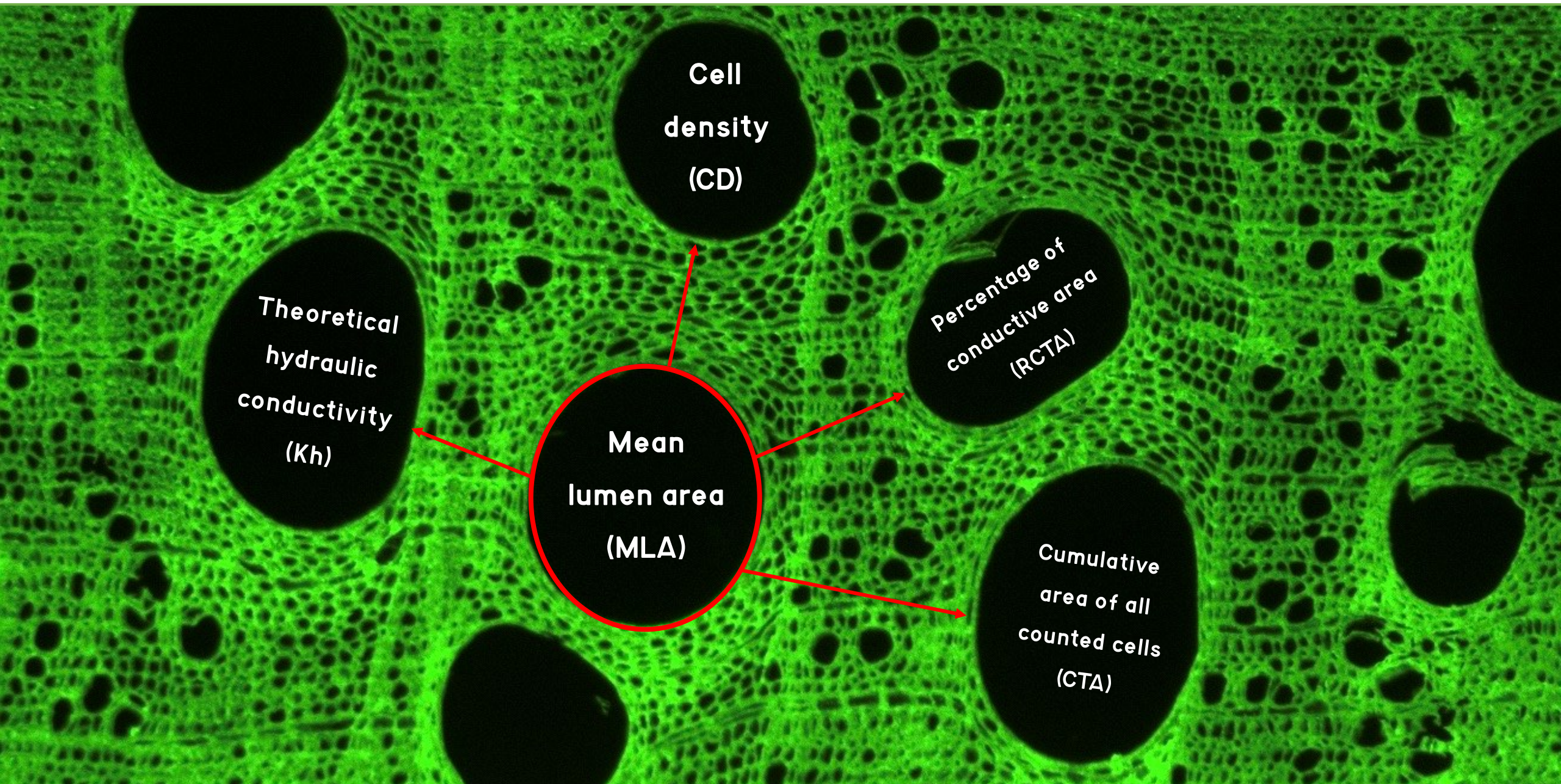


# ROXAS software

*Time series of anatomical features*

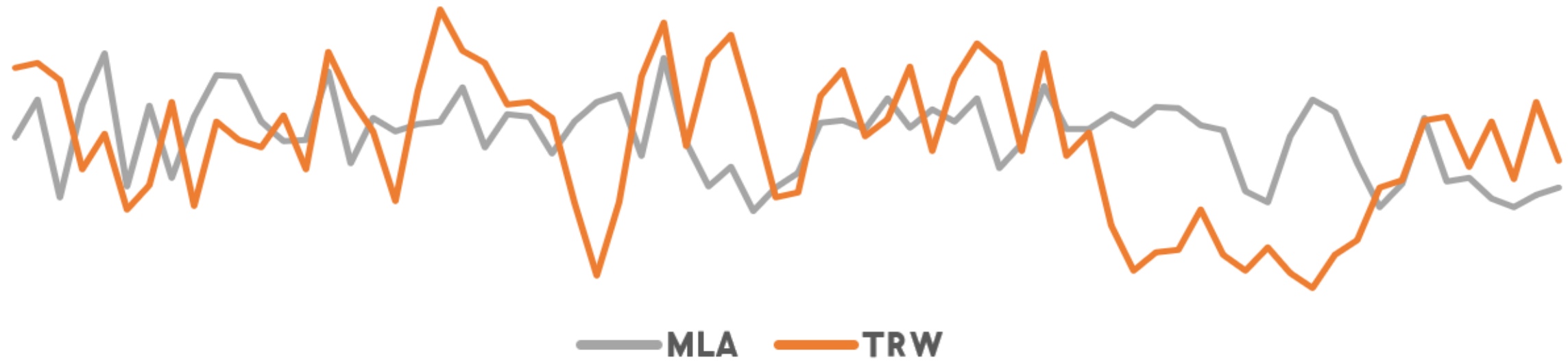






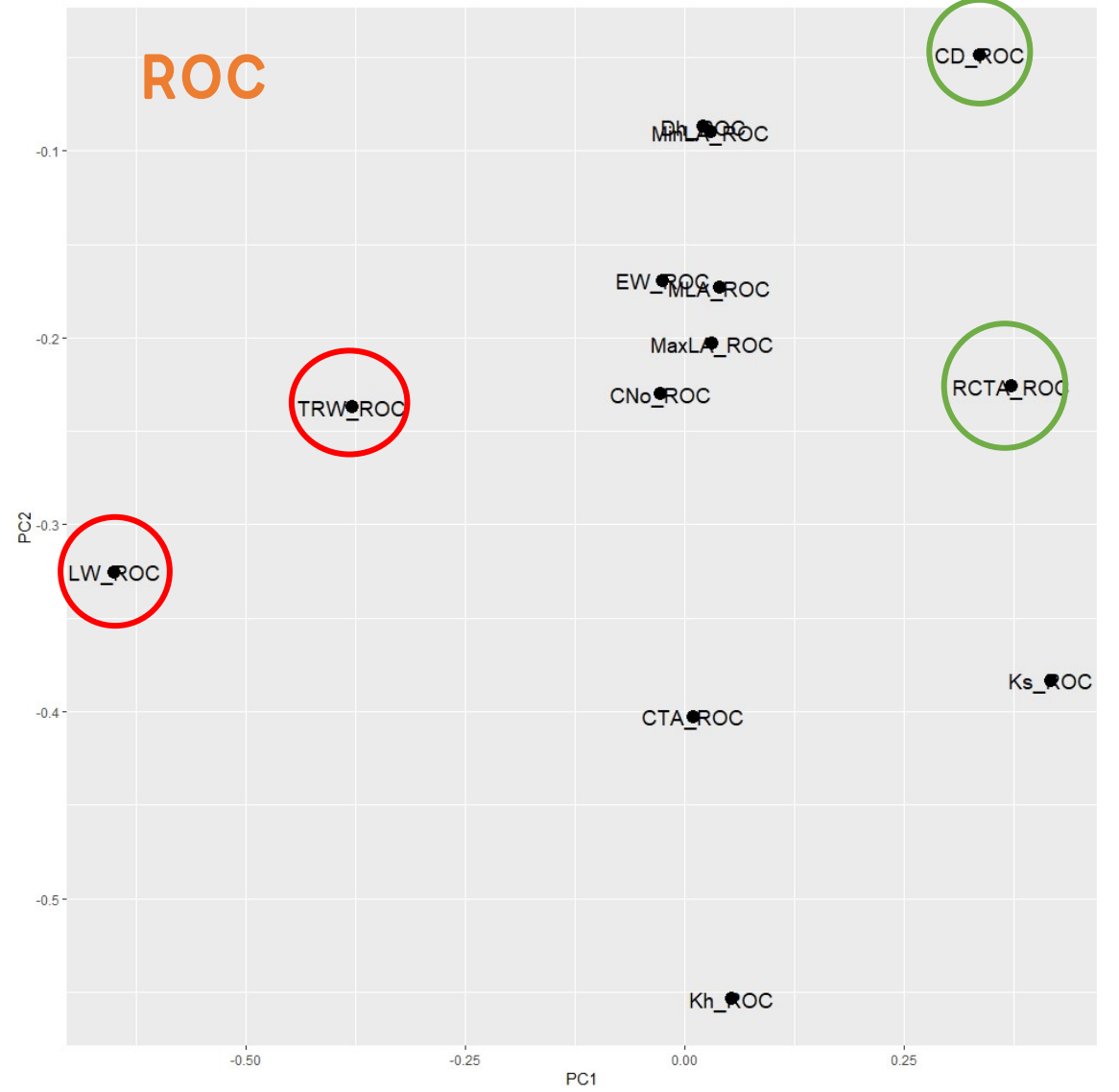
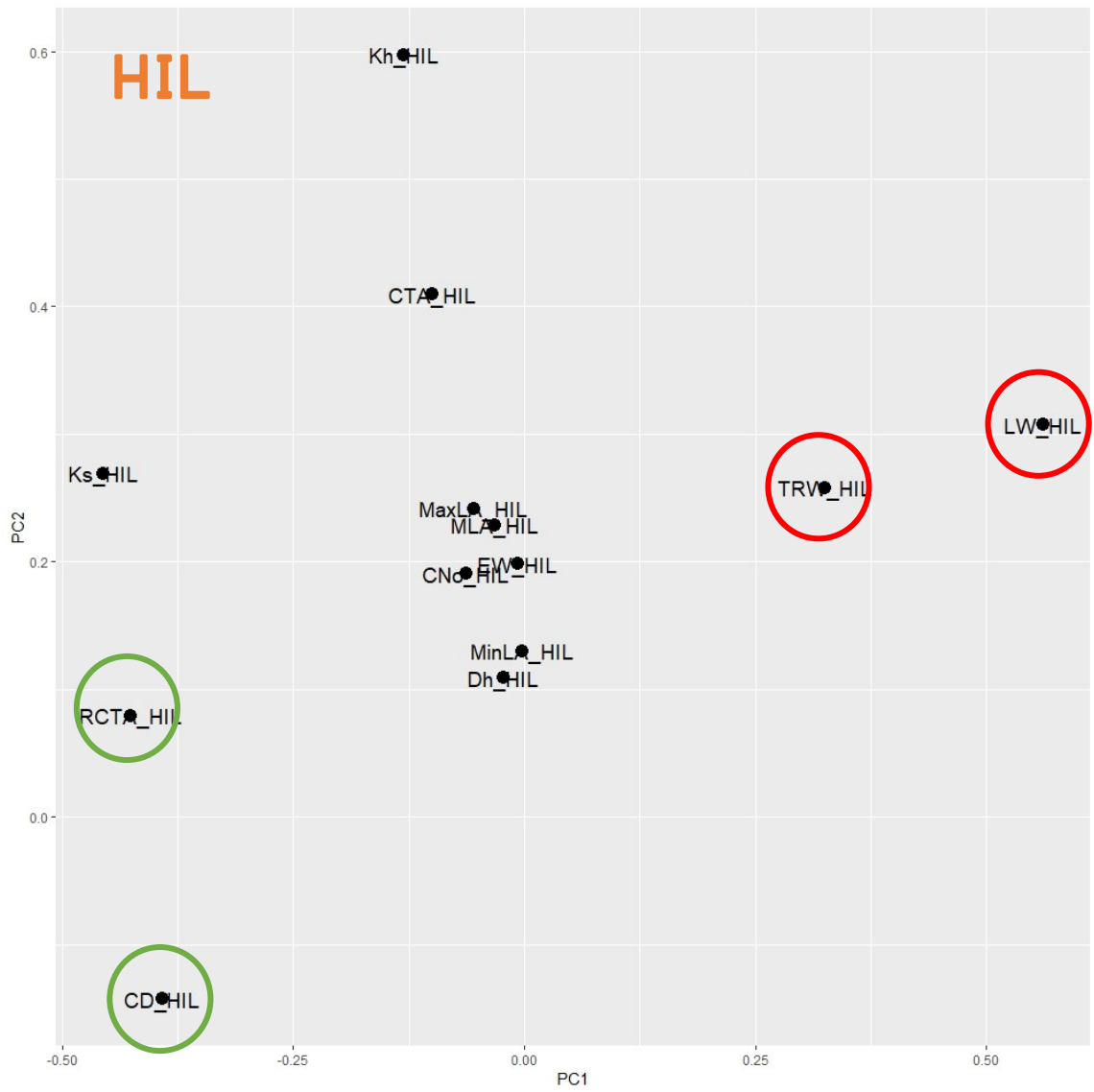


## HIL221

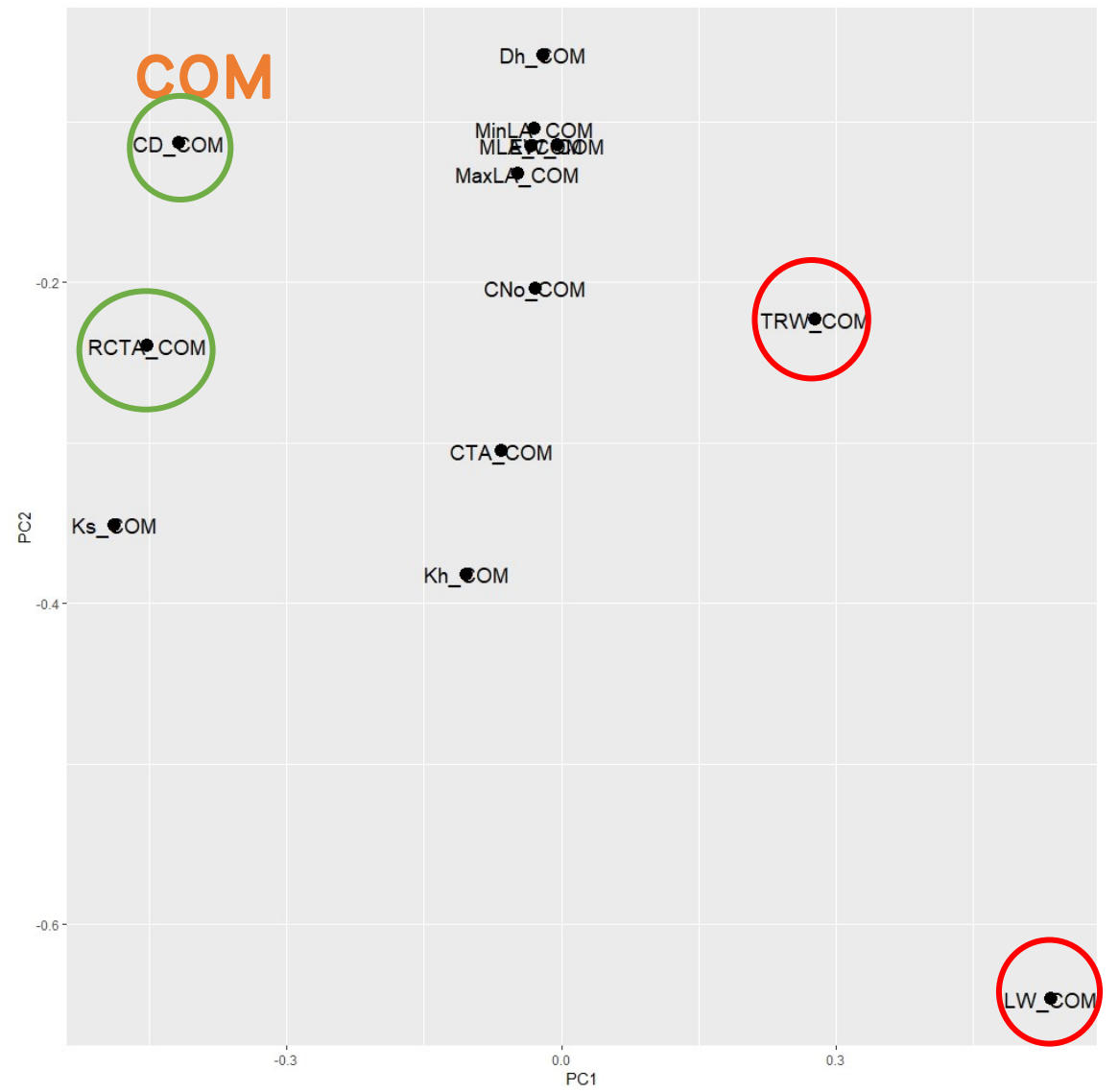
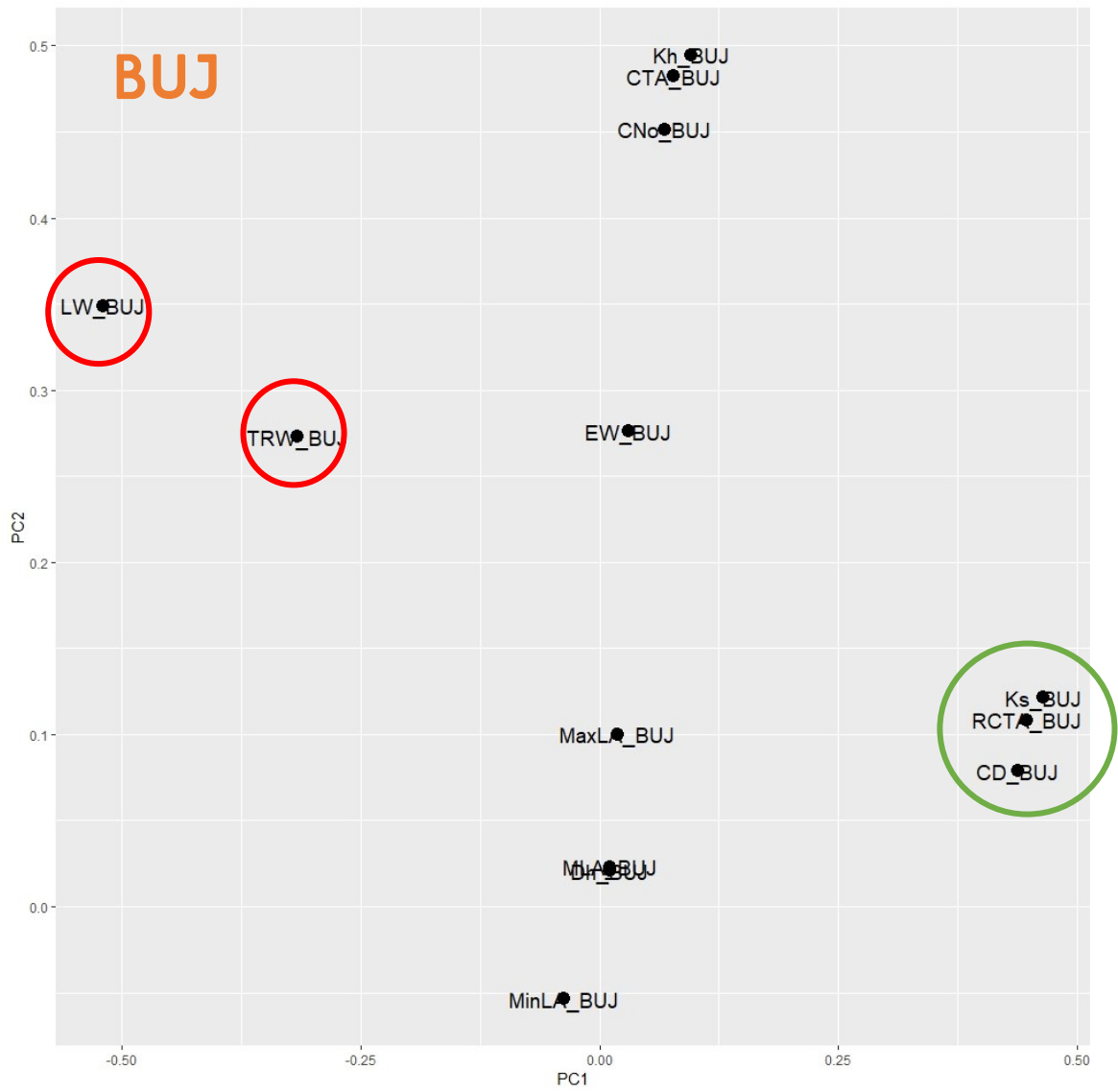


Wood anatomical variables → no strong trends, lower decadal variability, age-related trends → **smoothing splines** (Fonti et al. 2007; Fonti & García-González 2008; García-González et al. 2014, García-González 2016).





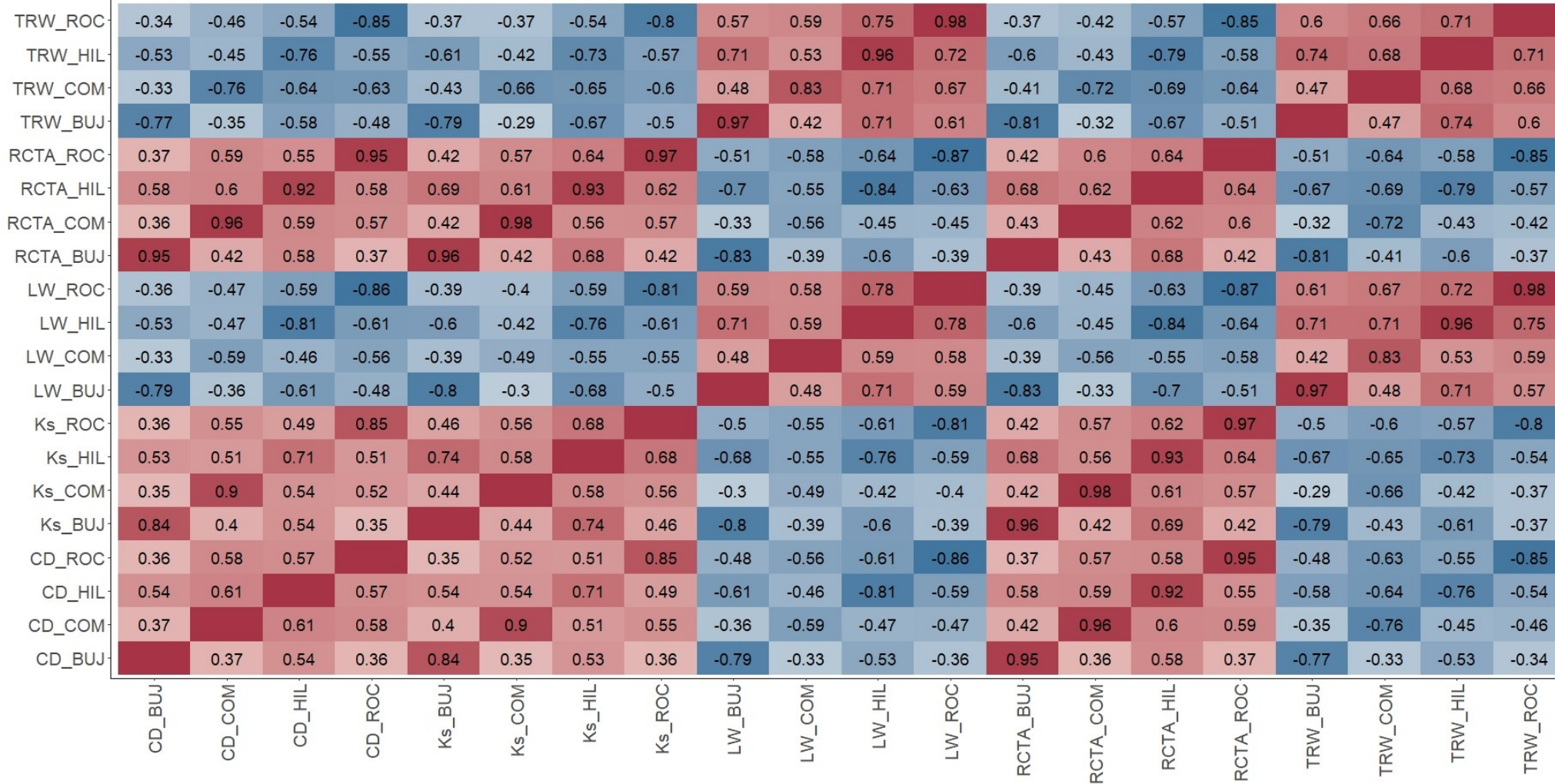




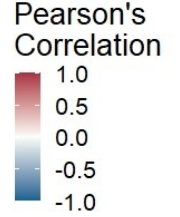


Correlation matrix

Only significant Pearson's correlation coefficients shown

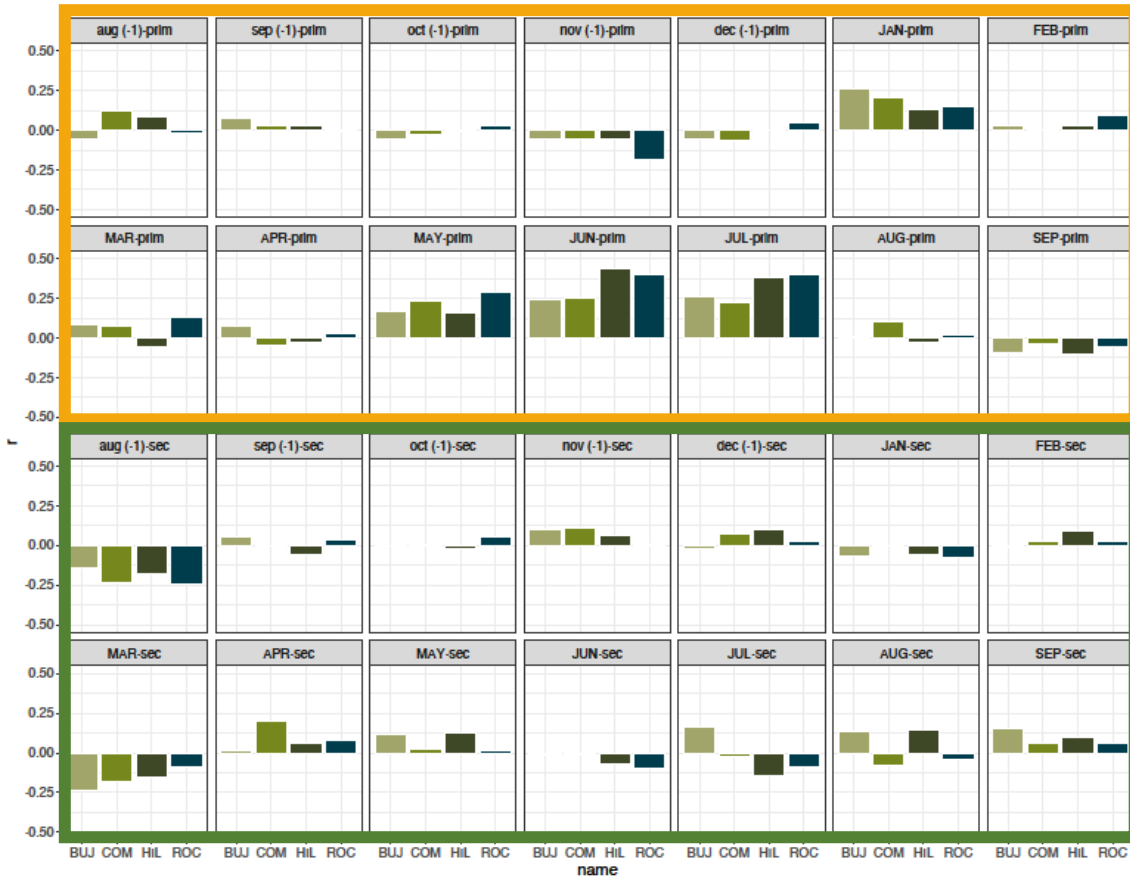


Width variables  
vs. vesels size  
variables (CD,  
RCTA and Ks)

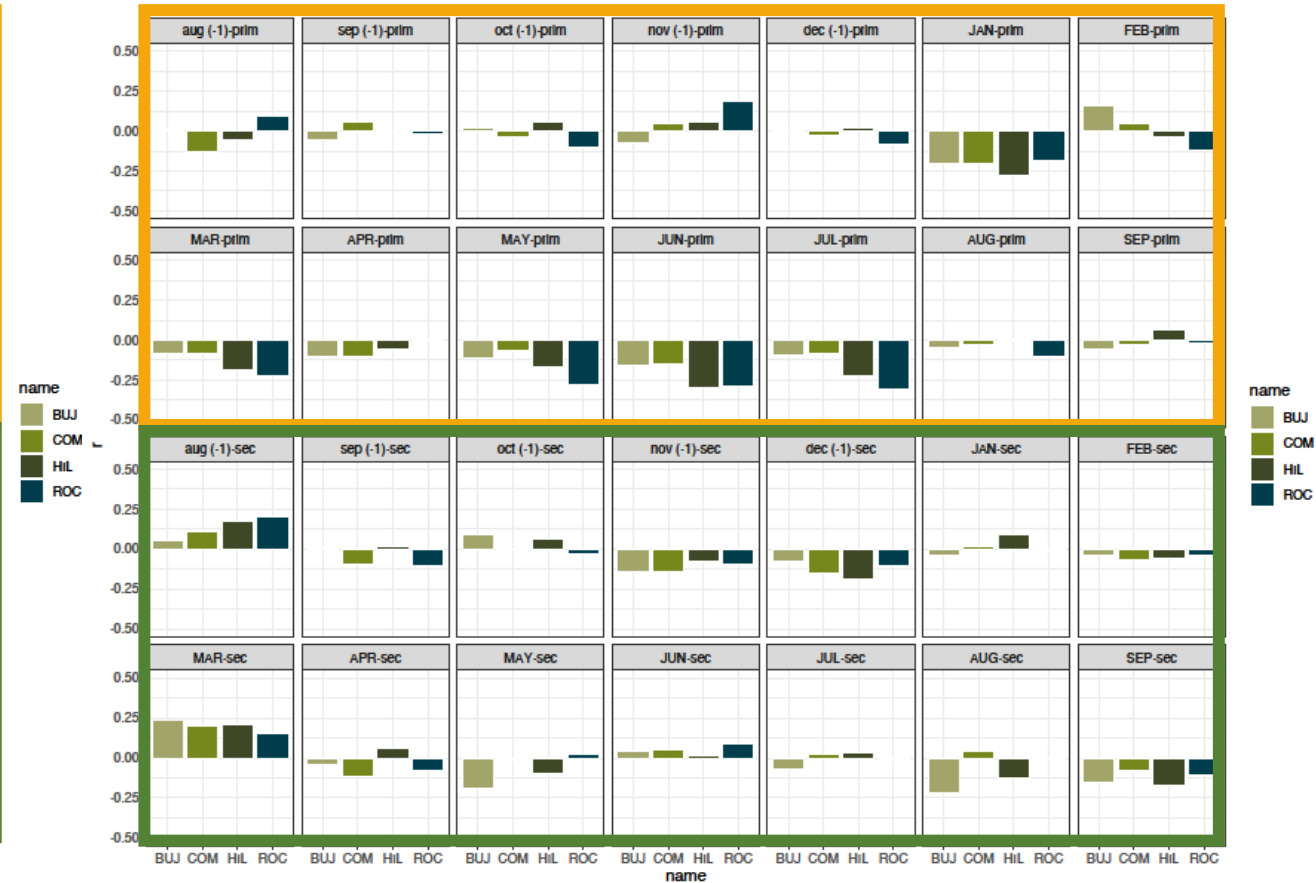




## Latewood – Precipitations



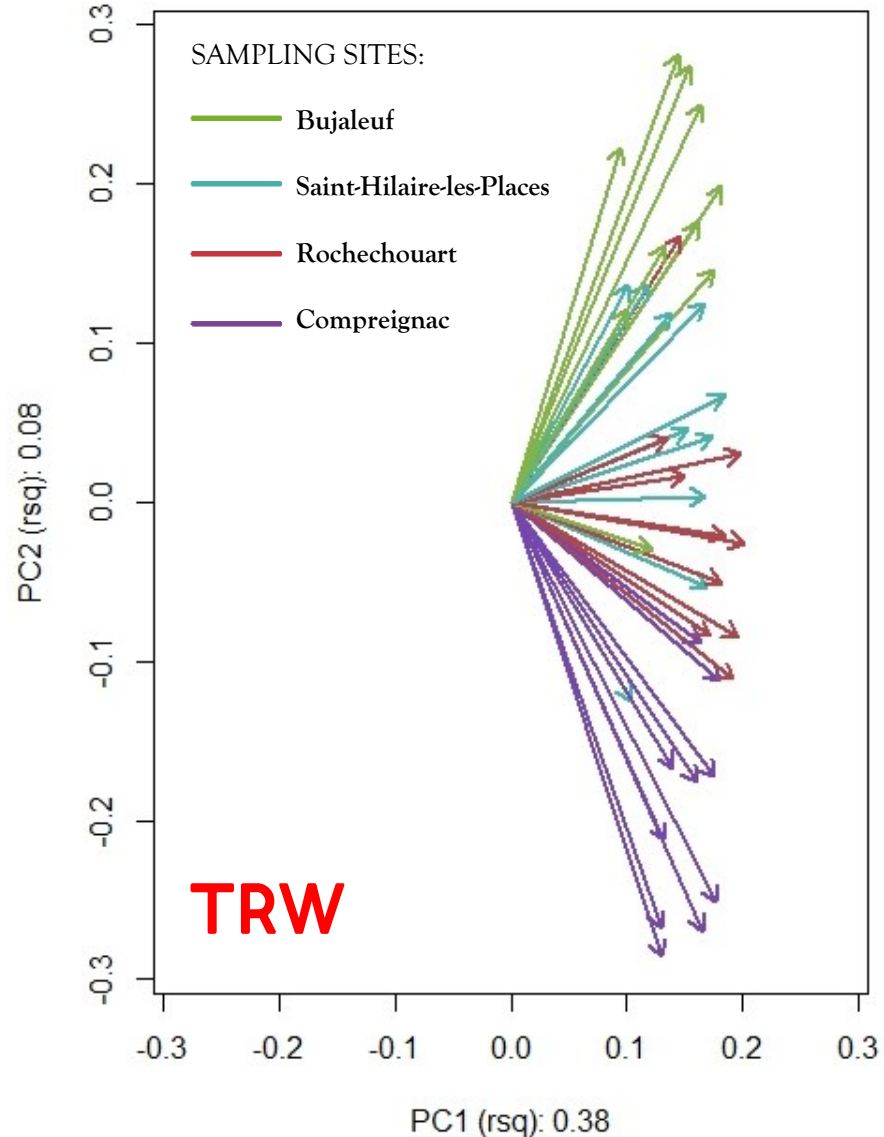
## Precipitations – Cell density



## Latewood – Temperature

## Temperature – Cell density





## PCGA (principal component gradient analysis)

- 10 trees per site;
- Common period: **1951-2020**;
- Detrending method: **Friedman's super smoother**  
(Friedman, 1984).

PLOS ONE

RESEARCH ARTICLE

### Tuning the Voices of a Choir: Detecting Ecological Gradients in Time-Series Populations

Allan Buras<sup>1\*</sup>, Marieke van der Maaten-Theunissen<sup>1</sup>, Ernst van der Maaten<sup>1</sup>, Svenja Ahlgrimm<sup>1</sup>, Philipp Hermann<sup>1</sup>, Sonia Simard<sup>2</sup>, Ingo Heinrich<sup>2</sup>, Gerd Helle<sup>2</sup>, Martin Unterseher<sup>1</sup>, Martin Schnittler<sup>1</sup>, Pascal Eusemann<sup>1</sup>, Martin Wilking<sup>1</sup>

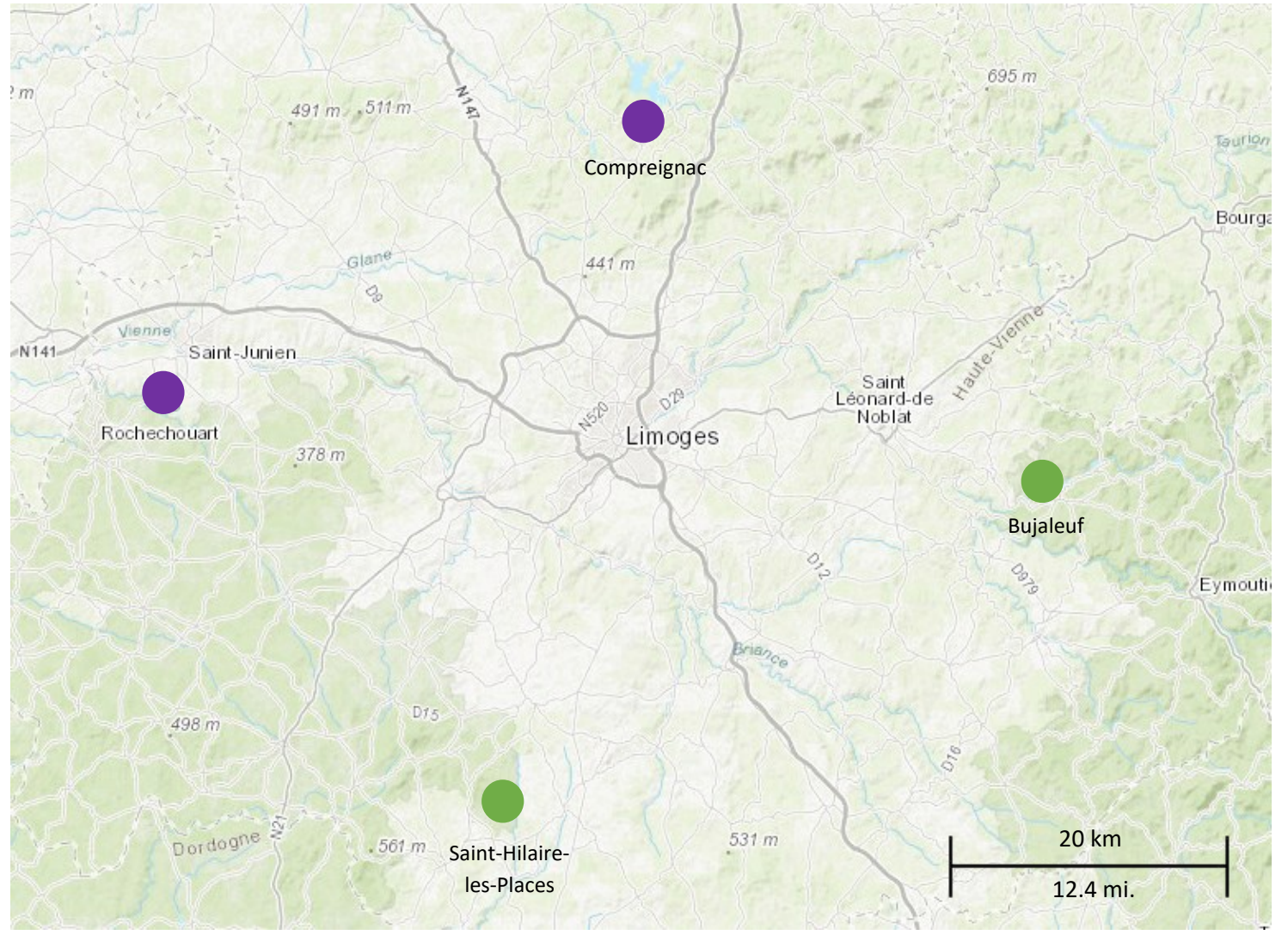
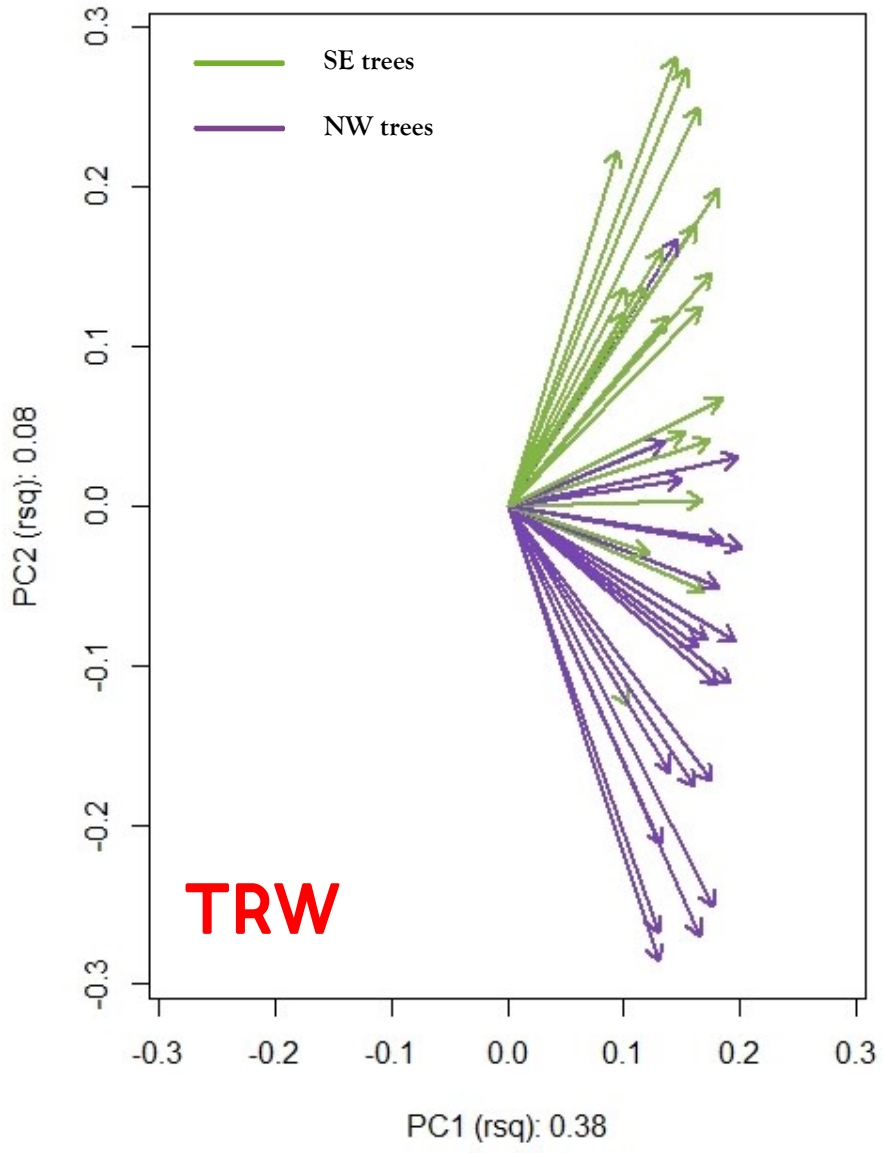
<sup>1</sup> Institute of Botany and Landscape Ecology, Ernst-Moritz-Arndt-Universität, Soldmannstraße 15, 17487 Greifswald, Germany, <sup>2</sup> GFZ German Research Centre for Geosciences, Section 5.2, Telegrafenberg, 14473 Potsdam, Germany

\* Current address: Department of Ecology and Ecosystem Management, Technische Universität München, Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, Germany

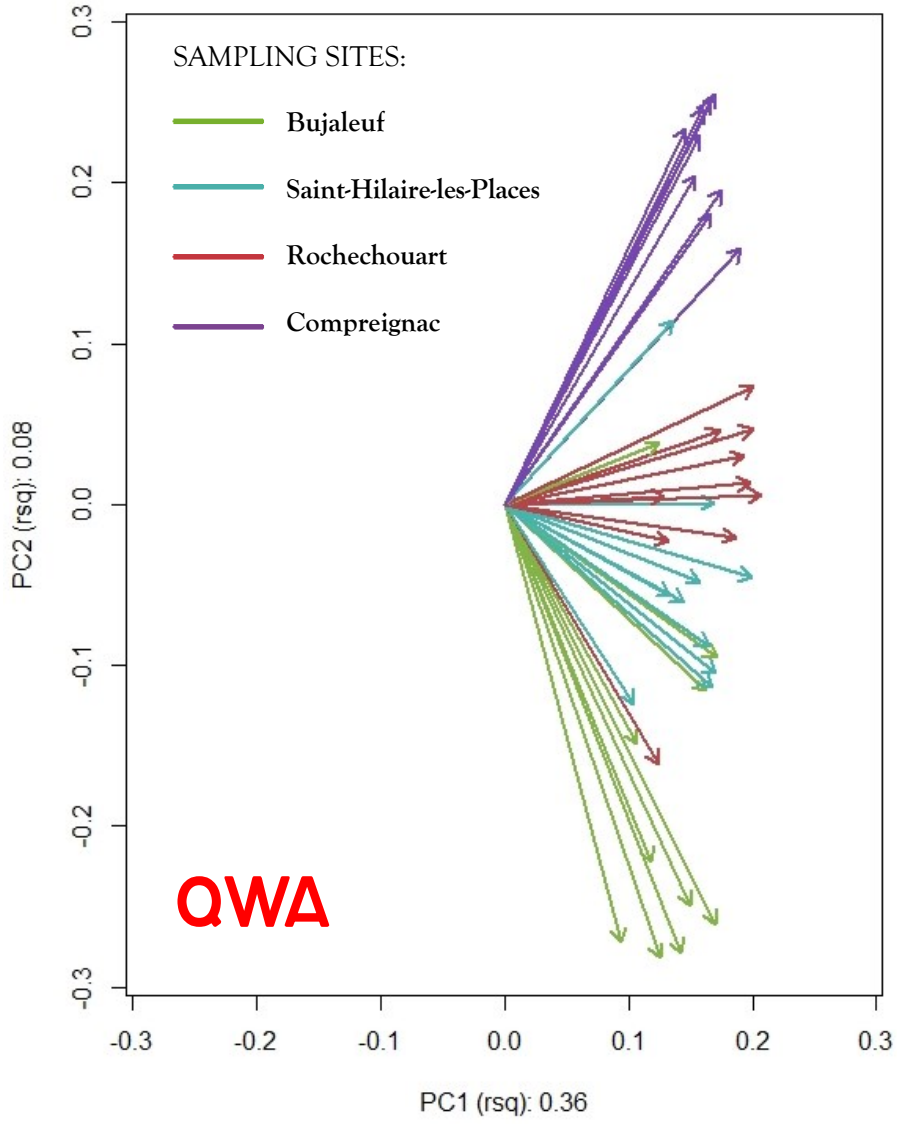
\* [allan@buras.eu](mailto:allan@buras.eu)







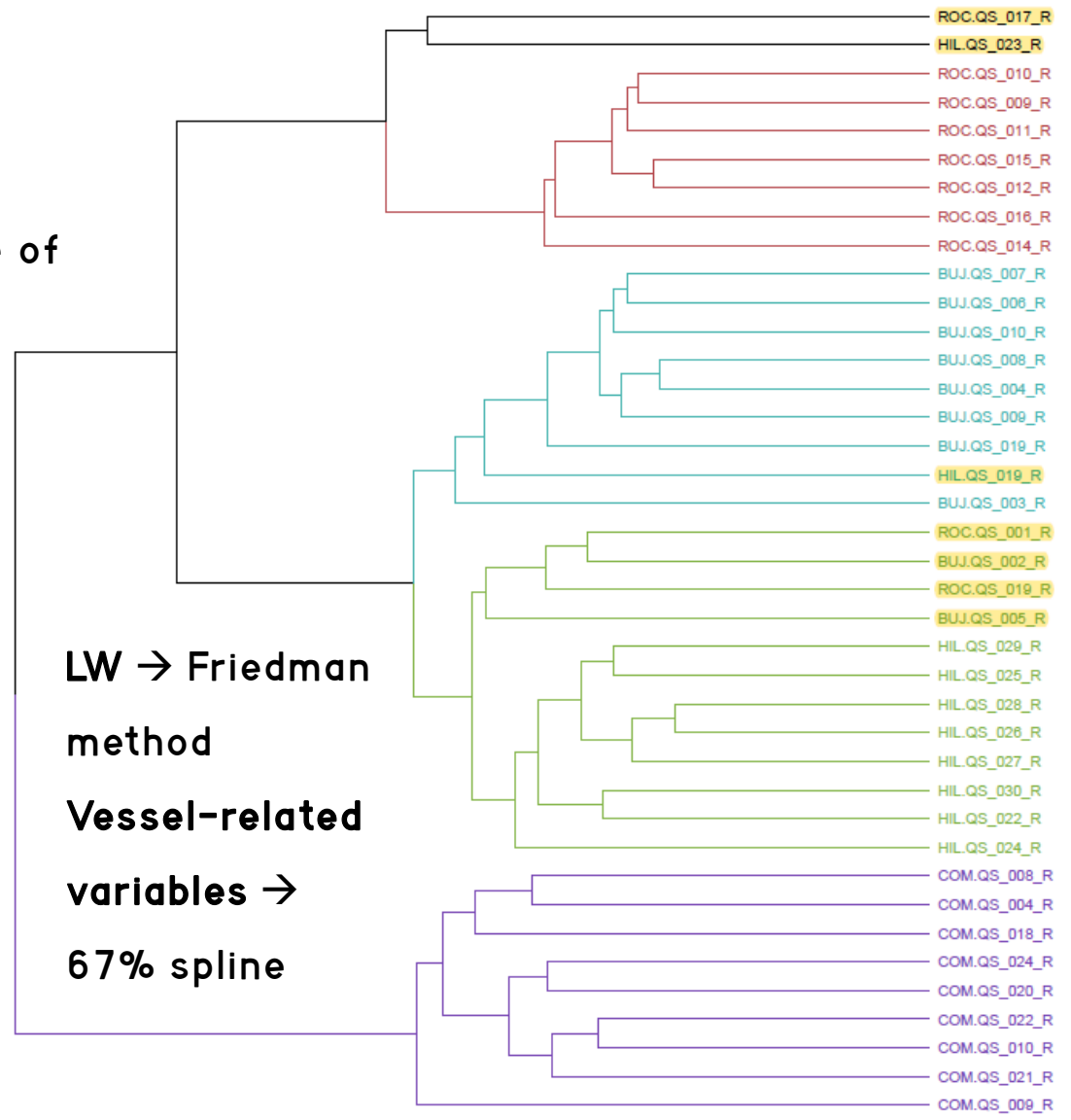




- (1) Latewood (LW)
- (2) Cell density (CD)
- (3) Mean percentage of conducting area (RCTA)



LW → Friedman method  
 Vessel-related variables →  
 67% spline





# PROS

# CONS

Climatic signals are

much higher in  
wood anatomical  
time series

↳ Variation in  
vessels size  
is linked to  
CLIMATE



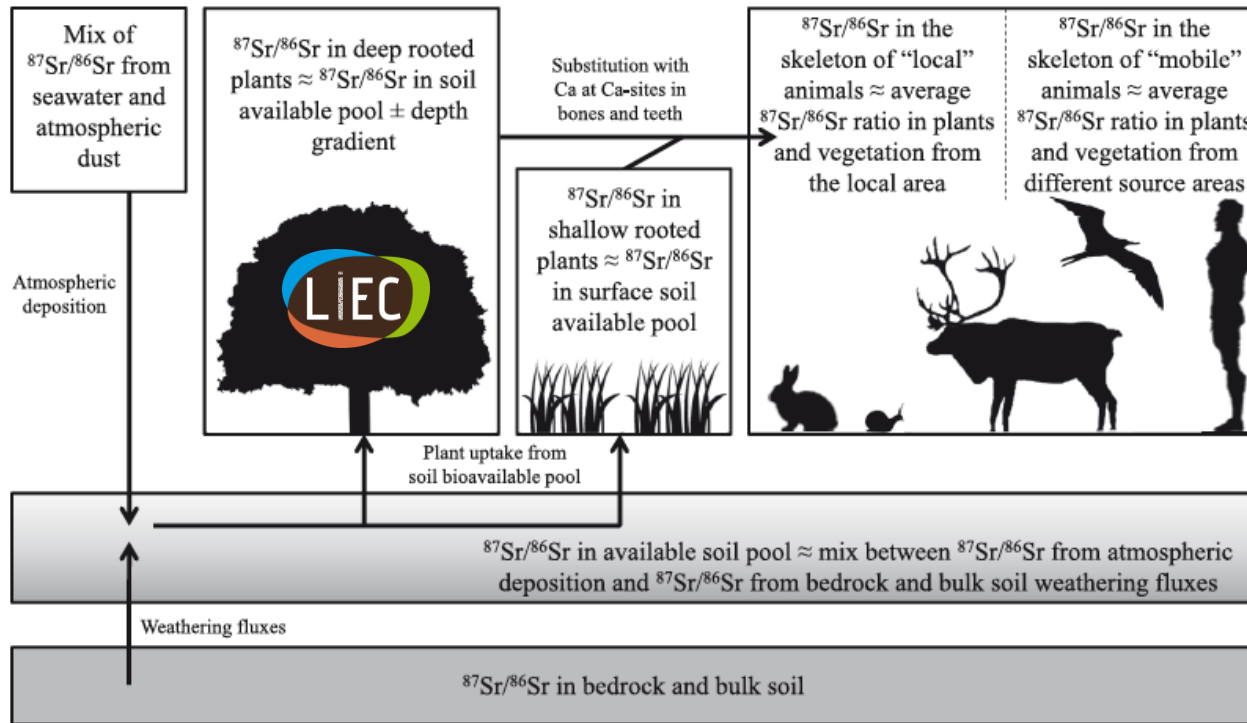
adds  
valuable  
information  
to TRW and can  
be easily measured  
with Coorecorder

TIME-  
CONSUMING

!!!  
...

# PROXY 3

# PROXY 4





# Haute-Vienne's forests



Where exactly did the wood come from?

How was timber transported?

How were forests managed?

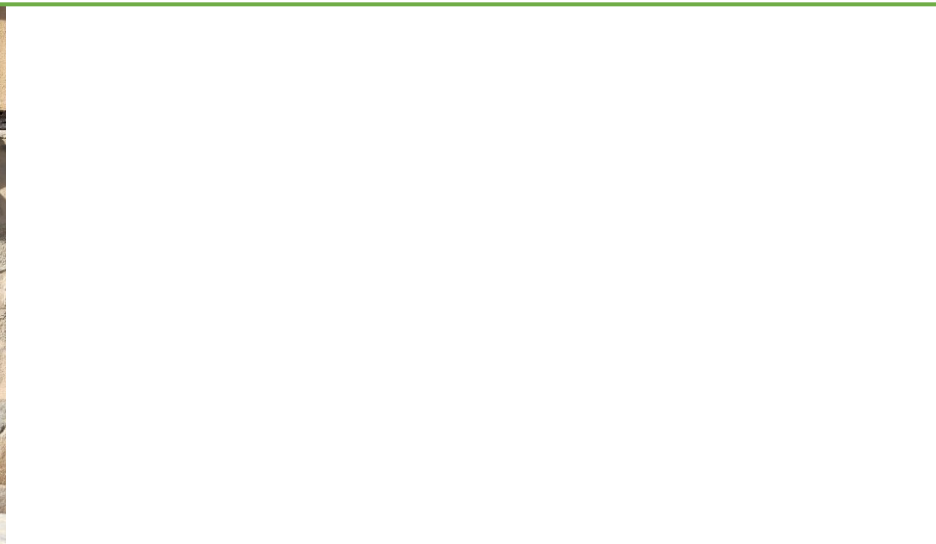
How did construction activities impact

Haute-Vienne's forests?

# Limoges











LE CHATEAU

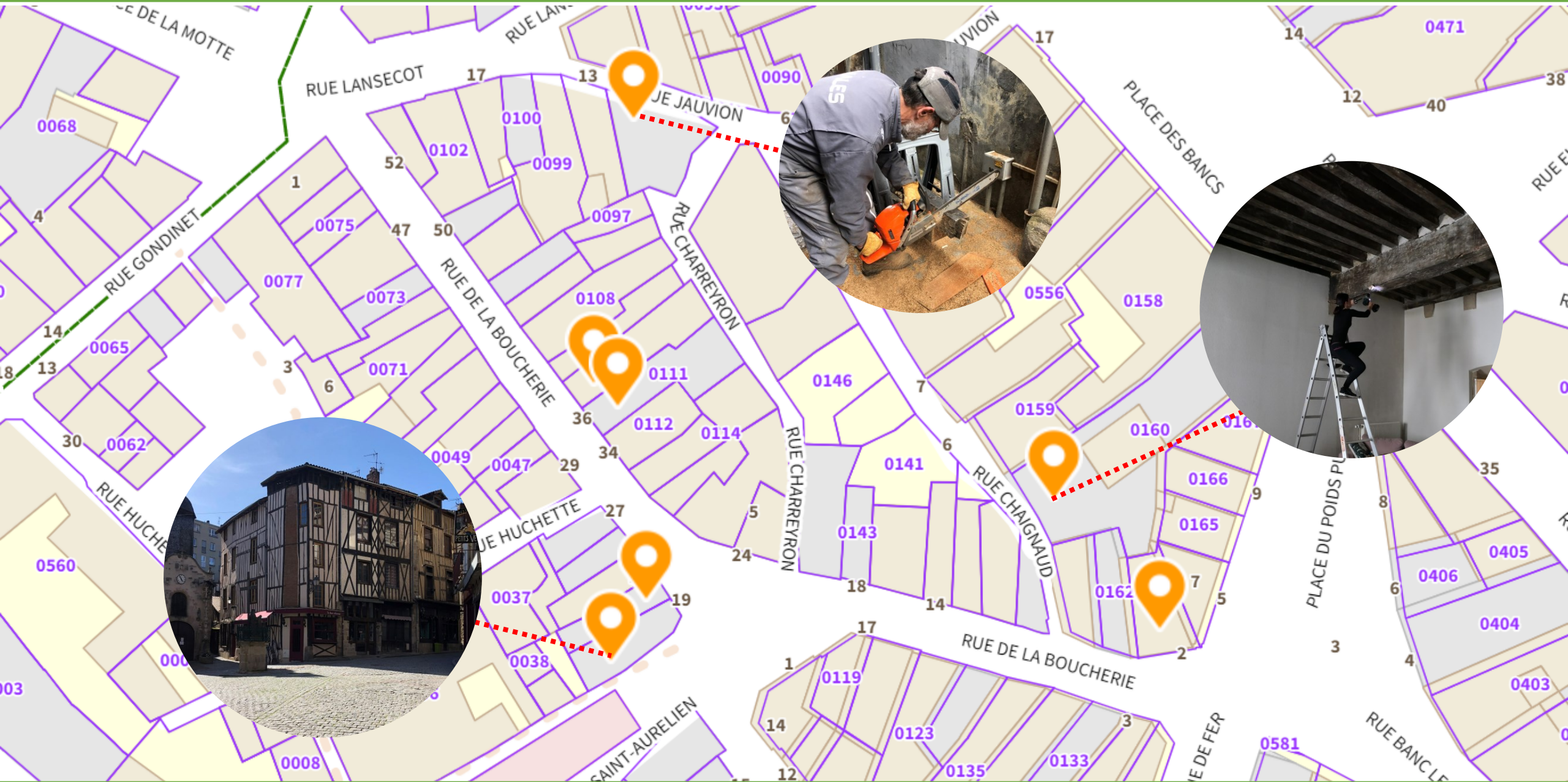
LA CITÉ

Carte de l'état major (1820-1866)









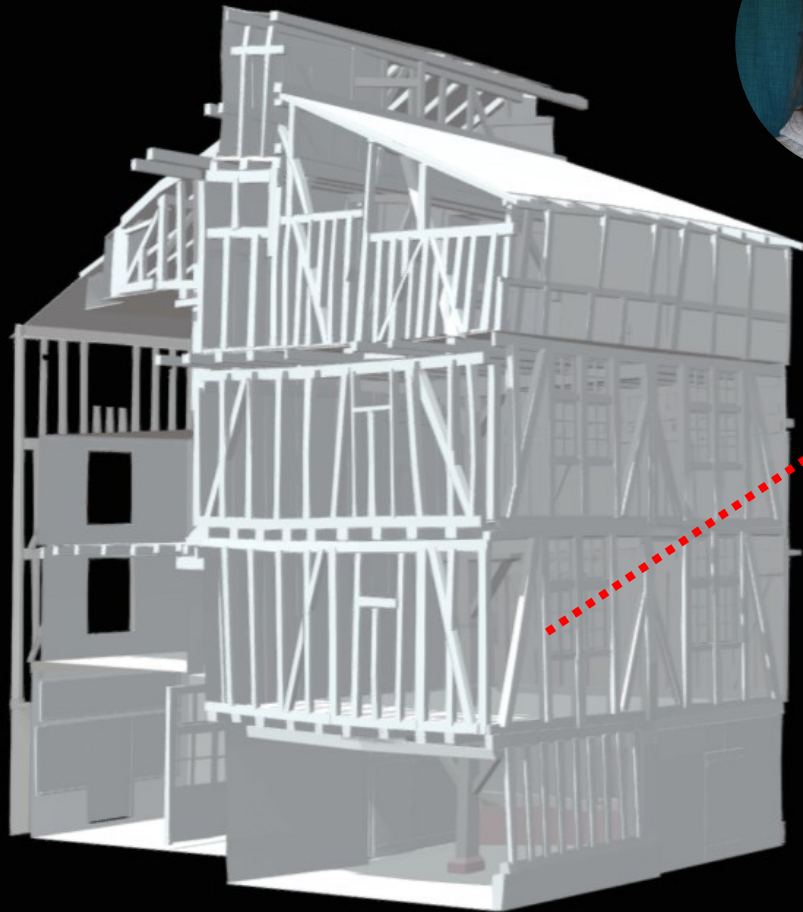












3D model of the «*maison de la Boucherie*», Pauline Bessaguet

More than 50 core samples

Dated to the **XV century**

Two felling dates: **1447** and **1462**







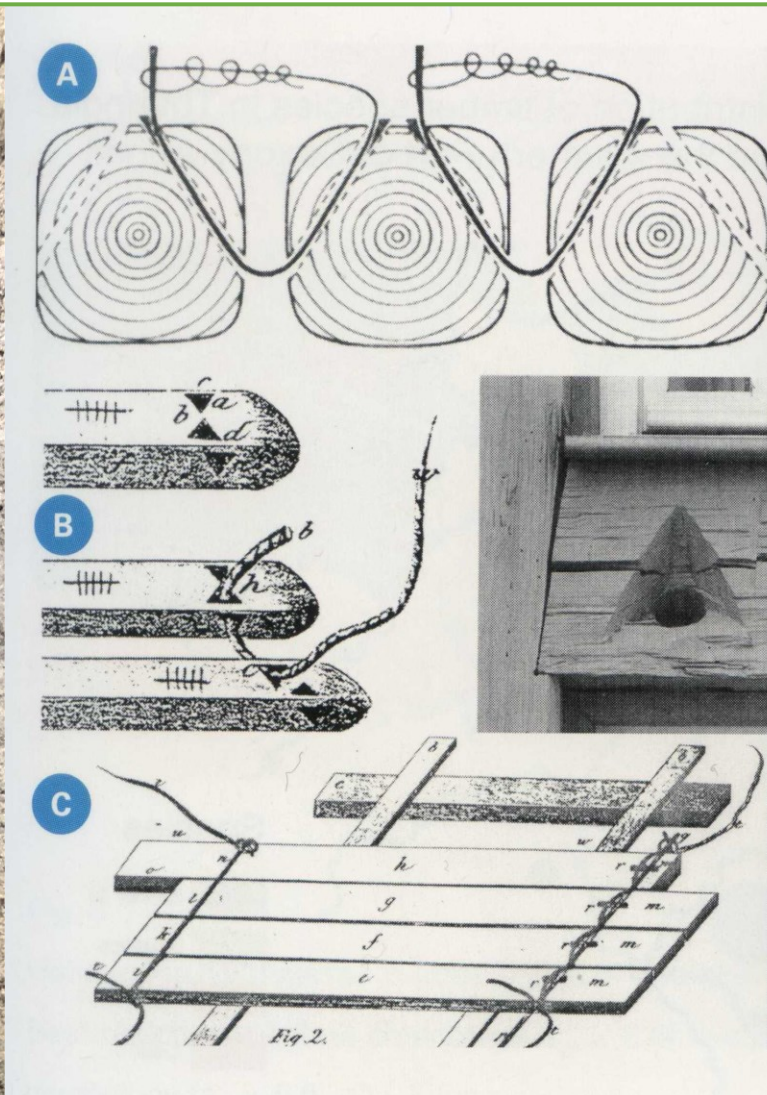
# EXPECTED RESULTS







Strasbourg,  
Ponts Couverts



D









? ? ? ? ?



Were coppice stools and standard trees used for the construction of timber-framed buildings in Limoges

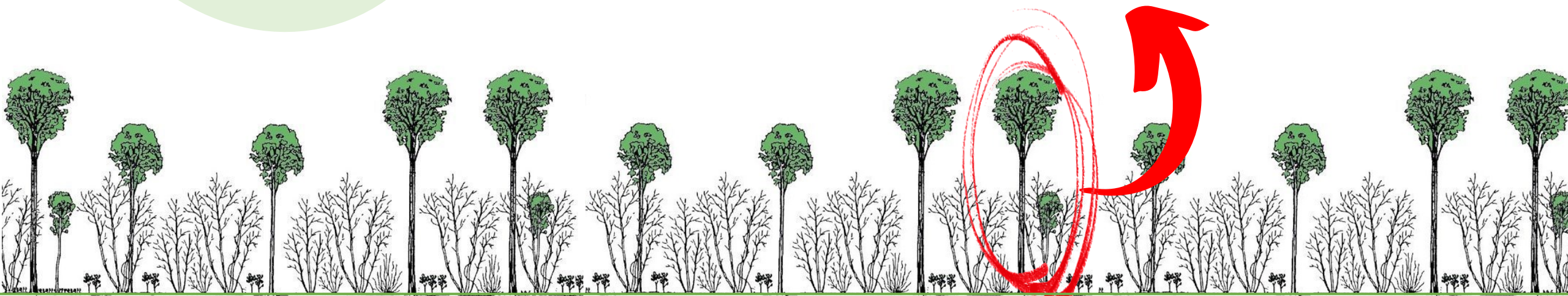
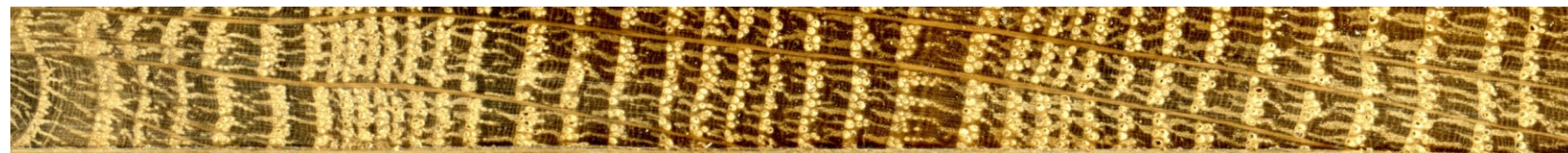
# Coppice-with-standards

Suppression

Release

Suppression

Release





Veget Hist Archaeobot (2005) 00  
DOI 10.1007/s00334-005-0022-x

ORIGINAL ARTICLE

scientific reports

Kristof Haneca · Ilse Boeren · Joris Van Acker ·  
Hans Beeckman

**Dendrochronology in suboptimal conditions: tree rings from medieval oak from Flanders (Belgium) as dating tools and archives of past forest management**

Received: 1 March 2005 / Accepted: 11 August 2005  
© Springer-Verlag 2005

The influence of historic forest management practices on oak chronology building in Flanders

**Kristof Haneca**

Flanders Heritage, Brussels, Belgium

**Key words** dendrochronology / forest history / wood anatomy / archaeology

KRISTOF HANECA

Check for updates

OPEN

**Tree rings reveal signs of Europe's sustainable forest management long before the first historical evidence**

Bernhard Muigg<sup>1,2</sup>, Georgios Skiadaresis<sup>2</sup>, Willy Tegel<sup>3</sup>, Franz Herzig<sup>4</sup>, Paul J. Krusic<sup>5</sup>, Uwe E. Schmidt<sup>1</sup> & Ulf Büntgen<sup>5,6,7,8</sup>

To satisfy the increasing demand for wood in central Europe during medieval times, a new system of forest management was developed, one far superior to simple coppicing. The adoption of a sophisticated, Coppice-with-Standards (CWS) management practice created a two-storey forest structure that could provide fuelwood as well as construction timber. Here we present a dendrochronological study of actively managed CWS forests in northern Bavaria to detect the radial growth response to cyclical understorey harvesting in overstorey oaks (*Quercus* sp.), so-called *standards*. All modern *standards* exhibit rapid growth releases every circa 30 years, most likely caused by regular understorey management. We further analyse tree-ring width patterns in 2120 oak timbers from historical buildings and archaeological excavations in southern Germany and north-eastern France, dating between 300 and 2015 CE, and succeeded in identifying CWS growth patterns throughout the medieval period. Several potential CWS *standards* even date to the first millennium CE, suggesting CWS management has been in practice long before its first mention in historical documents. Our dendrochronological approach should be expanded routinely to identify the signature of past forest management practices in archaeological and historical oak wood.











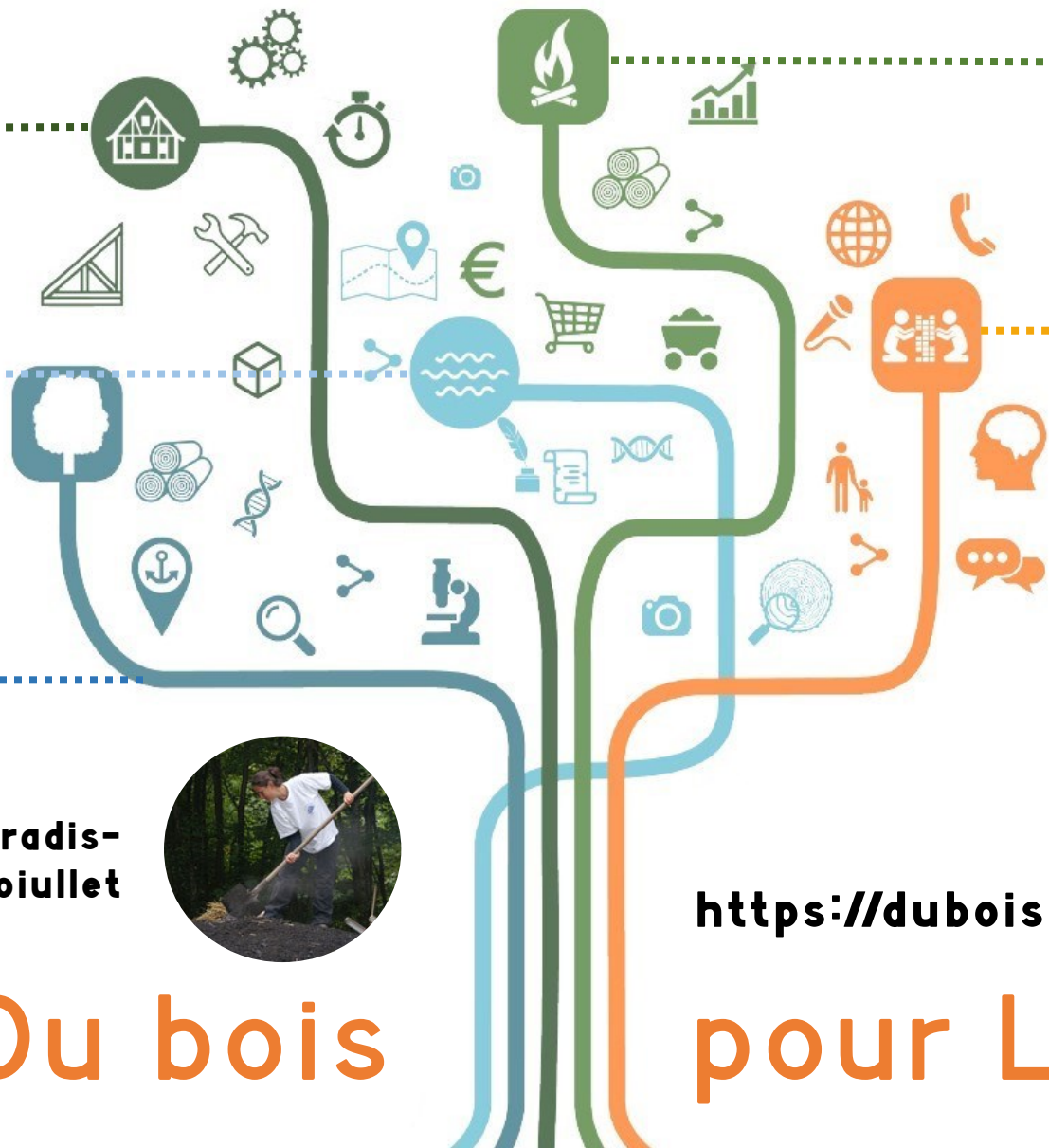
**ATELIER 1**  
Timber for construction

**ATELIER 2**  
Fuel wood

**ATELIER 3**  
Timber trade networks

**ATELIER 5**  
Participative research

**ATELIER 4**  
Forest landscape evolution



**Sandrine Paradis-Grenoiullet**



**PCR Du bois**

<https://duboispourlimoges.wixsite.com>

**pour Limoges**





**From Forests  
to Heritage**

A conference on historical timbers  
and wooden cultural heritage

19-21 April 2022  
Amsterdam, The Netherlands

Thank you  
for your  
attention!