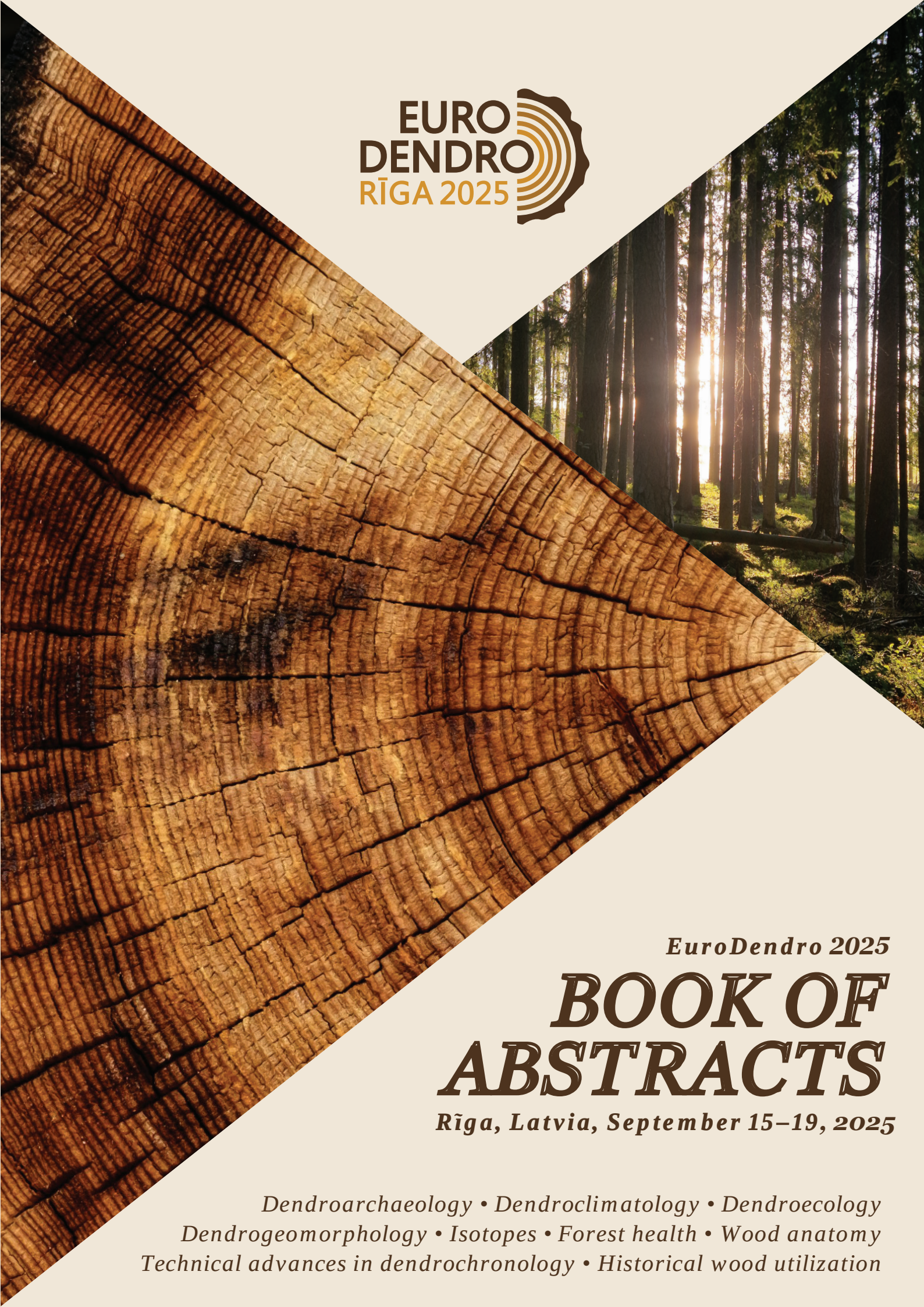

EURO DENDRO RĪGA 2025

EuroDendro 2025

BOOK OF ABSTRACTS

Rīga, Latvia, September 15–19, 2025

Dendroarchaeology • Dendroclimatology • Dendroecology
Dendrogeomorphology • Isotopes • Forest health • Wood anatomy
Technical advances in dendrochronology • Historical wood utilization

Book of Abstracts

EuroDendro 2025 Conference (September 15–19, 2025, Rīga, Latvia)

Organised by: **Latvian State Forest Research Institute "Silava"**

Scientific Editor: Didzis Elferts

eISBN 978-9934-603-22-8

Sponsors of the EuroDendro 2025 Conference

Table of contents

Programme

Monday, 15.09.2025. (Radisson Blu Hotel & Spa, Daugava Riga)

18:00–20:00 Registration
19:00–23:00 IceBreaker

Tuesday, 16.09.2025.

08:00–09:00 Registration
09:00–09:30 Conference opening
Session 1 – Dendroarcheology
Chair: **Tomasz Ważny**
09:30–10:30 Invited speaker – **Čufar, Katarina**: EuroDendro – a brief history and current challenges
10:30–10:45 **Weidemüller, Julia**: Let's talk archives
10:45–11:00 **Gmińska-Nowak, Barbara**: The story of the first printed book – the Gutenberg Bible and non-invasive dendrochronological research
11:00–11:30 Coffee break
Session 2 – Dendroarcheology
Chair: **Maks Merela**
11:30–11:45 **Yermokhin, Maxim**: 2,000 years of Neolithic pile-dwelling history at the Lin 3 site in Albania
11:45–12:00 **Crone, Anne**: Alder (*Alnus glutinosa*) and the chronology of Scottish wetland settlements
12:00–12:15 **Haneca, Kristof**: Tree-ring analysis and species identification on (post-)medieval wooden coffins
12:15–12:30 **Ważny, Tomasz**: Oak dendrochronology South of the Carpathians – research status as of 2025
12:30–12:45 **Sohar, Kristina**: Dendrochronological investigation of a 14th century shipwreck from Tallinn
12:45–13:00 **Gmińska-Nowak, Barbara**: Cistercian treasures in Pelplin (Poland): dendrochronological dating of the covers of medieval codices
13:00–14:00 Lunch
14:00–14:15 **Merela, Maks**: A multi-method approach to the scientific investigation of a wooden object
14:15–14:30 **Daly, Aoife**: A Rembrandt portrait and Baltic oak – large format DendroCT
Session 3 – Isotopes
Chair: **Kristof Haneca**
14:30–14:45 **Valūnas, Darius**: $\delta^{13}C$ and iWUE in *Pinus sylvestris* L. as indicators of tree response to environmental pollution
14:45–15:00 **Vitali, Valentina**: Disentangling soil and atmospheric drought effects with intra-annual $\delta^{13}C$ patterns in tree rings
15:00–15:15 **de Boer, Maaike**: Betting on diversity: enhancing resilience of temperate European forests by promoting rare native tree species (RareSpec project)
15:15–15:30 **Loader, N.J.**: Stable isotope dendrochronology
15:30–16:00 Coffee break
16:00–16:15 **Miles, Daniel**: Dating of Salisbury Cathedral spire and scaffold
16:15–16:30 **Domínguez-Delmás, Marta**: Forestry and wood culture in the continental Euro-Atlantic façade (1300-1600) – Challenging old narratives with new techniques
17:00–19:00 Poster presentations and poster session (with snacks)

Wednesday, 17.09.2025.

Session 4 – Dendroclimatology
Chair: **Kristina Sohar**
08:30–08:45 **Marín-Martín, Marcos**: Tree-ring-based precipitation reconstruction reveals recent intensification of extremes in the western Mediterranean over the last five centuries
08:45–09:00 **Jevšenak, Jernej**: Contrasting shifts in critical climate-sensitive periods for tree growth across cold and dry regions of the Northern Hemisphere
09:00–09:15 **Reinthal, Taavi**: Relationships between tree growth and resin duct formation in Norway spruce stands in Estonia
09:15–09:30 **Bijak, Szymon**: Turkey oak more vulnerable to water deficit than pedunculate oak at a riparian site in SW Poland
09:30–09:45 **García-González, Ignacio**: Tree-ring analysis of alder in northwestern Iberia highlights distinct biogeographical patterns
09:45–10:00 **Chinthala, Bency David**: Spatio-temporal variability in seasonal growth response of *Abies spectabilis* in the western Himalaya

10:00–10:30	Coffee break
10:30–10:45	**Matisons, Roberts**: Genetic control over growth sensitivity of Scots pine across edaphic gradient in hemiboreal conditions
11:00–22:00	Excursion

Thursday, 18.09.2025.

Session 5 – Dendroecology
Chairs: **Jacques C. Tardif, Alexandre F. Nolin**

09:00–10:00	Invited speaker – **Klisz, Marcin**: Acclimatisation of non-native tree species to Central Europe: The importance of local site vs regional conditions
10:00–10:15	**Arsalani, Mohsen**: Growth responses of Persian oak (*Quercus brantii* Lindl.) along latitudinal and altitudinal gradients in the Zagros Mountains, Iran
10:15–10:30	**Ruffner, Charles**: Uncovering fire history in Scots pine hemiboreal forests: A dendrochronology approach
10:30–10:45	**Burger, Andreas**: Detecting forest stress signals from space: Integrating mixed tree-ring chronologies with mixed pixels from satellite-derived vegetation indices at two resolutions in the WALD-Puls network
10:45–11:00	**Nolin, Alexandre F.**: Spruce budworm outbreaks in north-eastern Québec reconstructed from a subfossil black spruce tree-ring network
11:00–11:30	Coffee break

Session 6 – Dendroecology
Chair: **Ignacio García-González**

11:30–11:45	**Telążka, Mateusz**: Dendrochemistry in Picea abies in post-mining Uranium area in south-western Poland
11:45–12:00	**Zin, Ewa**: Was it always pine? – a multi-proxy reconstruction of peatland ecosystem dynamics in southeastern Poland
12:00–12:15	**Tomusiak, Robert**: Effect of drainage on Scots pine and Norway spruce radial growth in north-eastern Poland
12:15–12:30	**Kędziora, Wojciech**: A high abundance of mistletoe is affecting the tree growth of Scots pine
12:30–12:45	**Schlesinger, Filip**: Tree-ring eccentricity as a proxy for shallow creep activity on flysch slopes: Insights from the Javorníky mountains, Czech Republic
12:45–13:00	**Polášková, Lucie**: Dendrogeomorphology as a tool for reconstructing mining-induced subsidence dynamics
13:00–14:00	Lunch

Session 7 – Wood anatomy
Chair: **Cristina Nabais**

14:00–14:15	**Tardif, Jacques C.**: Dendrochronological signatures of the 2011 and 2014 record floods on *Fraxinus pennsylvanica* trees: current and historical perspectives
14:15–14:30	**Krapež, Daša**: Visualizing microscopic wood structures through micro-CT and 3D printing
14:30–14:45	**Marande, Camille**: Comparison of 14 native and non-native tree species climate-growth relationship in Copera, Switzerland
14:45–15:00	**Myśkow, Elżbieta**: The impact of diverse topoclimatic conditions on the intra-annual dynamics of secondary growth of Norway spruce (*Picea abies*) in the Western Sudetes
15:00–15:15	**Vērpēja, Vineta**: Silent witnesses of change: climate effects on annual ring variation in perennial herb *Viscaria vulgaris*
15:15–15:30	**Prokopuk, Yulia**: Hidden influence of the Chornobyl nuclear disaster on Scots pine xylem functionality: insights from quantitative wood anatomy
15:30–16:00	Coffee break
16:00–16:15	**García-González, Ignacio**: Recording cambial stages with XyloJ
16:15–16:45	Conference closing
19:00–23:00	Gala dinner

Friday, 19.09.2025.

Departure

Session:

Dendroarcheology

EuroDendro – a brief history and current challenges

Katarina Čufar[1]

[1]University of Ljubljana, Biotechnical Faculty, Department of Wood Science and Technology, Jamnikarjeva 101, 1000 Ljubljana, Slovenia

Keywords: EuroDendro, dendrochonological community, Dieter Eckstein, future challenges

In September 2019, a very successful EuroDendro 2019 with more than 120 participants from more than 30 countries and 6 continents was organised by the team of Mendel University in Brno, Czech Republic. At this event, participants were also invited to EuroDendro 2020, which should take place in Riga, Latvia. However, the EuroDendro community could not imagine that this traditional and successful conference series would be interrupted for an extended period of time. The Covid pandemic in combination with other circumstances was the main reason for this long hiatus. After 2019, the dendrochronology community has lost some significant members who have built dendrochronology and the dendrochronology community. Among the European dendrochronologists, Fritz Schweingruber (1936– 2020), Dieter Eckstein (1939–2021) and Mike Baillie (1944–2023) deserve special mention. Already in the early 1980s, they recognised that climatic teleconnections between regions influence the common tree ring signal. They realised that dendrochronologists needed to work together to understand these connections and develop different applications of dendrochronology. Their 1984 meeting in Athens can be seen as a precursor to the EuroDendro conferences. Between 1989 (Lourmarin, France) and 2019 (Brno, Czech Republic), 20 EuroDendro conferences were held at regular annual or biannual intervals. The driving spirit of the conferences was Dieter Eckstein with great support from Sigrid Wrobel. The presentation will show how the leaders and the community have built relationships that lead to co-operation and the resolution of common questions that are important to dendrochronology and other scientific disciplines and to meet the general needs of society. It will be discussed what the spirit of EuroDendro is, why it is unique and why we need it. The importance of basic dendrochronological knowledge, the constant need to standardise procedures and to preserve the samples, data and knowledge collected over the lifetime of dendrochronologists and dendrochronology laboratories will also be discussed.

References:

Crivellaro, A., Gärtner, H. 2020. Fritz Hans Schweingruber (1936-2020): dendroecologist and plant anatomist who taught us how to understand plants. IAWA Journal, 41(1): 125–127, https://doi.org/10.1163/22941932-00002113

Čufar, K., Liang, E., Smith, K.T, Ważny, T., Wrobel, S., Cherubini, P., …, Sass-Klaassen, U. 2024. Dieter Eckstein's bibliography and legacy of connection to wood biology and tree-ring science. Dendrochronologia, 83, 126165, https://doi.org/10.1016/j.dendro.2024.126165

Pilcher, J., Brown, D. 2024. In memoriam Michael Lockhart Baillie 1944–2023. Tree-Ring Research, 80(2), 52–54, https://doi.org/10.3959/TRR2024-5

Sass Klaassen, U., Wazny, T., Čufar, K., Krause, C., Kuniholm, P.I., Dean, J.S., … Leavitt, S.W. 2022. Bridging People, Countries and Continents to Promote Dendrochronology, In memoriam Dieter Eckstein 1939–2021. Tree Ring-Research, 78(2): 156–162, https://doi.org/10.3959/2022-3

Wazny, T., Sass Klaassen, U., Wrobel, S., Smith, K.T., Čufar, K. 2022. Dieter Eckstein – A cornerstone of European dendrochronology. Dendrochronologia, 73, 125943, https://doi.org/10.1016/j.dendro.2022.125943

Let's talk archives

Julia Weidemüller[1]

[1]Bavarian State Office for the Preservation of Monuments and Sites (BLfD), Thierhaupten Germany

Keywords: dendroarchaeology, dendroclimatology, archives, long time storage of waterlogged wood

Dendroarchaeological material, once removed from anaerobic conditions, is a ticking time bomb. The decay process of the organic material, which has been suspended for centuries or even millennia, resumes in the moment of excavation. At the same time, this material holds significant research value not only for archaeology or dendrochronological dating, but also for forest ecology, climate history or other scientific inquiries. Obtaining data, such as tree ring width, is not enough; it is essential to archive the entire piece of wood for future investigations.

This is where the challenges begin, as there are currently no adequate or affordable methods to restore the wood to a condition that closely approximates its previous state of conservation. The few dendroarchaeological laboratories are generally not affiliated with large institutions and large-scale, preferably air-conditioned archives remain a distant prospect. There is often a lack of time or space, as well as a shortage of funds or personnel to manage archiving. In addition to research and everyday work, little time is left for this crucial task.

In the coming years, we plan to requalify, maintain, and expand the sample archive of the Dendroarchaeological Laboratory of the BLfD. Our laboratory houses up to 60,000 waterlogged, charred, mineralized and dry wood samples from the last 12,000 years, making it one of the largest archives in Germany, systematically preserved and archived over the past 30 years. We are currently in the conceptualization phase and intend to reach out to additional monument offices, archives, and laboratories in Germany. To advance this initiative, we must also engage with the international Dendrocommunity and bring the important topic of archiving to the forefront.

In this presentation, I would like to introduce our laboratory and our methodology, highlight the significance of our collection, and stimulate a discussion to gather ideas and inquire about the methodologies and archiving practices of other laboratories. Additionally, I aim to discuss challenges and future prospects. My goal is to potentially establish or create an interdisciplinary network of professionals to improve the quality of our environmental archives.

The story of the first printed book – the Gutenberg Bible and non-invasive dendrochronological research

Barbara Gmińska-Nowak[1], *Juliusz Raczkowski*[2]

[1]Laboratory for Interdisciplinary Research into the Anthropocene, Institute of Geography and Spatial Organization, Polish Academy of Sciences, Toruń, Poland
[2]Faculty of Fine Arts, Nicolaus Copernicus University, Toruń, Poland

Keywords: Baltic oak, soft X-ray tomography, cover boards, Coster's bookbinding workshop

The Gutenberg Bible is considered the first printed book in history. It was produced with a printing press using movable metal types. The edition probably numbered one hundred and eighty copies, of which only forty-eight have survived to the present day. Only seventeen existing copies are preserved as two-volume sets. – One of the sets is the Gutenberg Bible belonging to the collections of the Diocesan Museum in Pelplin (Poland). The Pelplin volumes are among the first paper copies to come off the printing press – it is *editio princeps* (first edition, first printing) produced between 1452–1455.

The Bible was examined in detail in 2023. This was the first study conducted directly on this priceless object. The interdisciplinary project "Saving the Pelplin Gutenberg Bible" (PI: prof. Juliusz Raczkowski) combined material research, conservation works and dissemination of discoveries. It was attended by several dozen scientists from various fields as well as a group of conservators specializing in paper, leather and metal treatments.

An important element of the Project was the dendrochronological analysis of the cover boards. The binding of both volumes of the Bible was created in the workshop of Heinrich Coster in Lübeck. The oak boards were covered with goat skin dyed red and decorated with blind embossing. Getting the access to measure the width of tree rings was a huge challenge for us, not only because of the relatively good state of preservation of the leather coverings, but also because of the extraordinary historical and material value of the object.

We obtained direct access to the board only in the place of a large loss of leather covering, along the lower edge of the back board of volume II. For the measurements we used high-resolution photographs taken during conservation works.

Data from three other boards were obtained using non-invasive methods: The way the boards were cut from a trunk was observed on 2D and 3D computed tomography images. The measurements of tree ring width were performed based on soft X-ray tomography images. The sequence representing the back board of volume II is 272 rings long and covers the years 1164–1420. Measurements of this panel were repeated using X-Ray imaging to assess consistency and reliability of soft X-ray tomography images. The sequence representing the front cover board of volume II was dated back to1425.

Both boards of the binding of volume I of the Pelplin Gutenberg Bible contain more than 300 tree rings, however the sequences developed are: 302 rings long (1135–1436) in the case of the front cover board and 286 rings long (1138–1433) in the case of the back panel.

The high correlation between all four sequences indicates that the Bible bindings were made using boards cut from the trunk of a single tree that lived for over 320 years. Since there is no sapwood ring in any of the boards, all dating results obtained are *terminus post quem*. The earliest possible date of felling the tree – 1452 – is determined by the results of dating the front board of volume I of the Bible (with sapwood rings and one unmeasured, incomplete ring included).

2,000 years of Neolithic pile-dwelling history at the Lin 3 site in Albania

Maxim Yermokhin[1], *Andrej Maczkowski*[1,2], *Matthias Bolliger*[1,4], *John Francuz*[1], *Adrian Anastasi*[3], *Krist Anastasi*[7], *Ariane Ballmer*[8], *Mirco Brunner*[1,2], *Ilirjan Gjipali*[3], *Tryfon Giagkoulis*[6], *Martin Hinz*[1,2], *Marco Hostettler*[1,2], *Johannes Reich*[1,2,4], *Sönke Szidat*[2,5], *Albert Hafner*[1,2]

[1]Institute of Archaeological Sciences, University of Bern, Switzerland
[2]Oeschger Centre for Climate Change Research OCCR, University of Bern, Switzerland
[3]Albanian Academy of Science, Institute of Archaeology, Tirana, Albania
[4]Archaeological Service Canton of Bern, Switzerland
[5]Department of Chemistry, Biochemistry and Pharmaceutical Sciences, University of Bern, Switzerland
[f]Aristotle University of Thessaloniki, Greece
[7]Research Center HiSoMA (History Sources of the Ancient Worlds), Lyon, France
[8]Independent researcher

Keywords: Southwestern Balkans, Neolithic pile-dwelling, settlement development, dendroarchaeology

During the 7th–6th millennium BCE, the southwestern Balkans was a key corridor for the spread of farming communities from Anatolia to Europe. Recent discoveries of new waterlogged prehistoric sites in the lakes region on the border of Albania, Greece, and North Macedonia, along with archaeological investigations in some of these sites in recent years, has yielded numerous wooden piles suitable for dendroarchaeological dating.

Wooden remains confirm Lin 3 in Albania, located on the shoreline of Lake Ohrid, as the earliest known Neolithic pile-dwelling site, with an exceptionally long history during 2000 years (early 6th to early 4th millennium BCE). Since 2021, systematic land and underwater excavations have uncovered hundreds of wooden piles from fourteen tree genera, with juniper, oak, and pine being crucial for developing long tree-ring chronologies.

Dated samples form 20 floating chronologies covering approximately 1850 years (from mid-7th to early 4th millennium BCE). Four main construction phases have been identified at the moment: Phase I – 5800– 5600 BCE, Phase II – 5200–4900 BCE, Phase III – 4600–4300 BCE, Phase IV – 4000–3900 BCE. For the first time in a waterlogged Neolithic settlement in the Balkans, a complex of palisades has been identified and dated. Additionally, the year-by-year development of three palisades built from pine piles over six decades (4404–4340 cal BCE) has been reconstructed.

Excavations also uncovered well-preserved juniper piles from the 6th millennium BCE, forming a 780-year tree-ring chronology ending around 5700 BCE. Cross-dating with the tree-ring chronology from the Penelopa site on the northeastern shore of Lake Ohrid has extended the Lake Ohrid juniper chronology to 963 years (mid-7th to mid-6th millennium BCE), making it one of the oldest tree-ring chronologies currently documented in the Balkans. Bridging the remaining gap (up to 50 years) with the already absolute dated Dispilio juniper chronology from the second part of 6th millennium BCE could soon establish a continuous 1300-year absolute tree-ring Balkans chronology covering 7th–6th millennia BCE.

Alder (*Alnus glutinosa*) and the chronology of Scottish wetland settlements

Anne Crone[1]

[1]AOC Archaeology Group

Keywords: *Alnus glutinosa*, crannogs, Scottish Iron Age, felling ranges

Alder (*Alnus glutinosa*) is the most commonly used wood species on every Scottish wetland settlement that has been investigated to date. While it cannot be used to establish exact calendar dates alder dendrochronology can be vital in establishing relative chronological relationships specific to the site being investigated. Alder chronologies have been usefully constructed on many Scottish crannogs and we have argued that the ease with which a large, robust site chronology can be constructed points to the type of woodland in which the timber originated. However, alder presents many problems for analysis, the main one being that as the tree gets older or is in competition with other coppiced stems for instance, the growth rings become increasingly compressed, to the point at which it becomes impossible to distinguish ring boundaries. This of course presents problems for the interpretation of felling dates, critical to the overall site chronology. Recent work on a large well-stratified assemblage of alder at the wetland settlement of Black Loch of Myrton in SW Scotland has brought some focus to this issue. At this site sample length and internal chronological consistency has enabled us to develop an approach in which end-dates are interpreted in terms of broad felling bands for building events. At the site of Hyndford, in Lanarkshire alder dendrochronology and wiggle-match dating were used in combination to date and demonstrate the single-phase construction of the settlement. This paper presents the use of alder in the construction of chronologies for Iron Age Scottish wetland settlements.

Tree-ring analysis and species identification on (post-)medieval wooden coffins

Kristof Haneca[1]

[1]Flanders Heritage Agency, Belgium

Keywords: dendroarchaeology, provenancing, graveyards

The burial ritual in (post-)medieval contexts often involved the construction of wooden coffins. Remains of those wooden coffins can survive in the archaeological record, sometimes as solid timbers, but in many cases only as decayed fragments or mineralized particles in the corrosion layers of metal fastenings or decoration. Such wooden remains can offer valuable insights into the chronology, spatam development, and ritual organization of the burial grounds, as well as aspects of past population dynamics and mortality.

This paper provides an overview of research on wooden coffins in the Low Countries and adjacent regions, with a focus on dendrochronological surveys and wood anatomical identifications. It highlights regional and temporal trends in wood selection and sourcing. A central case-study is a medieval burial ground in Ypres (Belgium), where more than 1.075 inhumation burials were documented. Many of the deceased were buried in wooden coffins, and the exceptional preservation enables detailed species identification and in-depth tree-ring analysis research. Most coffins were made exclusively of oak, although for some part poplar/willow and in rare cases beech, elm or alder was used (Haneca, De Groote, 2024). Notably, the coffins were often built from high-quality, imported timbers. Dendroprovenancing indicates that many oak boards originate from the Southern Baltic region, northwestern Germany, or the Rhine-Meuse valley. Very few timbers originate from local forests. Interestingly, osteoarchaeological analysis does not suggest that the cemetery served a privileged population, challenging assumptions about the exclusive use of imported Baltic oak for high-status purposes. Instead, this evidence points to the broader availability and use of quality timber, even for single-use burial objects, reshaping our understanding of medieval timber trade and funerary practices.

References:

Haneca, K., De Groote, K. 2024: Ieper – De Meersen. Deel 5. Houten grafkisten, tonnen en gebruiksvoorwerpen: dendrochronologie, typologie en houtonderzoek. Onderzoeksrapporten agentschap Onroerend Erfgoed 330, Brussel. https://doi.org/10.55465/CNJU8492

Oak dendrochronology South of the Carpathians – research status as of 2025

Tomasz Ważny[1] *and Brita Lorentzen*[2]

[1]Nicolaus Copenicus University in Toruń, Poland
[2]University of Georgia, Athens, USA

Keywords: dating, dendroarchaeology, dendroprovenancing, European oak, Southeastern Europe, cultural heritage

Southeastern Europe – the land area south of the Carpathians – was for many years an area almost untouched by dendrochronologists. The absence of any tree-ring laboratory, other than in Slovenia and Hungary, resulted in a lack of tree-ring chronologies. Only far to the south the Cornell Tree-Ring Laboratory developed tree-ring chronologies as an alternative to radiocarbon or archaeological-material culture dating in Turkey and later in Greece, extending the area of interest toward the Balkans and Italy. These chronologies have provided dates for numerous historic timbers and contributed to the reconstruction of the history of Byzantine and Ottoman monuments and cultural heritage. However, progress was limited only to the second millennium CE, and oak tree-ring chronologies developed for the first millennium CE can hardly be considered absolutely dated.

The 21st century brought remarkable progress especially in Romania with its three newly organized dendrochronological laboratories (Campulung Moldovenecs, Suceava and Miercurea Ciuc), which resulted in construction of multi-century oak chronologies for Maramures (initiative of the Lund University), Suceava region (Ștefan cel Mare University of Suceava) and Transylvania (Transylvanian Dendrochronological Laboratory). Independently the National Geographic-funded project, in cooperation with the Istanbul University, examining oak tree-ring growth variability in Southeast Europe has proven that Balkan oak chronologies form a bridge linking Mediterranean and Central European tree-ring datasets.

Oak is a widespread and durable wooden building material, which has been available across Southeast Europe for several millennia. Our dendrochronological research reveals well-documented oak timber usage by at least the Neolithic Period in North Greece (Four Lakes region) and in settlements along the Black Sea in Bulgaria, with continued use at preindustrial salt exploitation sites in Romania, early Byzantine harbour constructions at Yenikapı in Istanbul, and in more recent timber reinforcements in buildings, churches and fortifications or roof and ceiling constructions throughout Southeastern Europe.

This report presents the state of knowledge of oak dendrochronology in Southeast Europe in the year 2025, which is the result of systematic work on collecting and processing new material, as well as verification and reexamination of North Aegean-North Anatolian tree-ring chronologies previously developed by Peter Kuniholm and his team.

We also report on efforts using dendroprovenancing methods to source wooden heritage and reconstruct timber trading networks, especially in the northern and western Aegean, southern Balkans and Black Sea regions. We further demonstrate how sourcing wooden heritage is essential for interpreting dating results and in providing datasets suitable for accurate paleoclimatological and paleoecological research studies in the region.

Dendrochronological investigation of a 14th century shipwreck from Tallinn

*Aoife Daly[1], Alar Läänelaid[2], **Kristina Sohar**[2], Lisette Reinvars[3], Priit Lätti[3]*

[1]Dendro.dk, Dendro-archaeology Research Consultancy, Copenhagen, Denmark
[2]Department of Geography, Institute of Ecology and Earth Sciences, University of Tartu, Estonia
[3]Estonian Maritime Museum, Estonia

Keywords: tree-ring dating, shipwreck, cog, Baltic oak, moon rings

In 2022, a well-preserved medieval shipwreck was found in the former seabed at Lootsi Street 8 in Tallinn. The wreck, made of oak, was transported to the Estonian Maritime Museum in four portions for conservation and investigation. In February 2023 and November 2024, a total of 91 crosscuts and core samples were taken from different ship components for dendrochronological analysis. Tree-ring widths of the samples were measured, simultaneously at the dendrochronological labs of the University of Tartu, Estonia and Dendro.dk, Copenhagen and 88 timbers could be successfully dated. In addition, the occurrence of "moon rings" in several samples were recorded. Most of the tree-ring series were dated by recent Baltic oak references (2021BLT1, 2021BLT1B), suggesting an eastern Baltic source for the timber (Daly, Tyers, 2022). Although the investigations are still undergoing, the first results of the dendrochronological analysis allow us to see several groupings in the material, indicating that various timber sources were utilised for different components of the vessel. Fully or partly preserved sapwood in some of the oak samples enabled us to specify the cutting time of the oaks used, allowing a micro-interpretation of the building history of this astounding ship find. The ship is an example of the so-called 'Bremen Type', otherwise termed a 'Cog' and our analysis demonstrates that the oaks were felled in winter 1373–74 AD. This allows us to identify the Lootsi ship as one of the later examples of this ship-building tradition in the archaeological record. Furthermore, the provenance of the timbers place its building site in the eastern Baltic region. The opportunity to study the moon rings in such a large number of timbers has also allowed us to analyse the chronological occurrence of these, in this unique case study. In this talk, the results of our extensive analyses will be presented.

References:

Daly, A., Tyers, I. 2022. The sources of Baltic oak. Journal of Archaeological Science, 139, 105550, https://doi.org/10.1016/j.jas.2022.105550

Cistercian treasures in Pelplin (Poland): dendrochronological dating of the covers of medieval codices

Barbara Gmińska-Nowak[1], *Juliusz Raczkowski*[2], *Ewa Chebus*[3], *Karl Uwe Heussner*[4]

[1]Laboratory for Interdisciplinary Research into the Anthropocene, Institute of Geography and Spatial Organization, Polish Academy of Sciences, Toruń, Poland
[2]Institute of Visual Arts and Conservation of Works of Art, Faculty of Fine Arts, Nicolaus Copernicus University, Toruń, Poland
[3]Centre for Medieval Studies, John Paul II Catholic University, Lublin, Poland
[4]German Archaeological Institute DAI, Berlin, Germany

Keywords: Baltic oak, beech wood, cover boards, medieval bookbinding, manuscript

In the recent years, a number of interdisciplinary studies have been conducted on historical codices belonging to the collection of the Diocesan Library in Pelplin (Poland). One of the new directions of exploration of the collection applied is the inclusion of dendrochronological studies of the wooden covers of the codices.

Wood was used as the boards of the codices throughout the Middle Ages. The boards provided excellent protection for the vulnerable pages of the codices, and together with the fastenings attached to them, prevented the parchment folios from deforming due to changes in relative humidity.

The aim of our research was to fully use the informative potential of dendrochronological analysis. We focused on both, dating the wood used for bindings and determining the source of the wood. Subsequently, we verified the originally assumed age of the codices and assessed the integrity of the objects, combining information from the fields of materials science, book technology, formal analysis of decorations, paleographic analysis, analysis of text and analysis of historical written sources.

We examined four manuscripts written between the 12th and 14th centuries. Two of the studied codices, namely *Petrus Lombardus Comentarii*, PL-Pe 4(8) and *Processionale cistreciense* PL-Pe 156(204) were bound on beech boards. Other two – *Homiliarium*, PL-Pe 1(2) and *Biblia sacra* PL-Pe 11(25), were bound using oak boards.

The coverboards of the manuscript *Petrus Lombardus Comentarii* created in 13th century, were dated back to 1246 (*terminus post quem*). Although the binding was refurbished at least twice, the wooden boards are most likely part of the original binding. In the original chosen positioning of the panels, the direction of tree growth was towards the edges and the boards were probably slightly wider. During the first repair, the sewing supports were strengthened with new pieces of leather. During the second repair, the book was resewn and the boards were rotated and positioned with the front edge toward the spine. The damaged spine edges of both boards were slightly trimmed. The latter repair was most likely done in Pelplin at the end of the 15th century.

Three other manuscripts studied are complex codices. Moreover, they are examples of manuscripts rebounded using new boards.

Processionale cistreciense containing parchment folios from the 12th and 14th centuries (*codex copositus*) was rebound using beech boards dated back to 1340 (*terminus post quem*). The result of dendrochronological dating does not specify the time of introducing the additions and closing them with the older sheets in a new block. However, it is consistent with the palaeographic analysis of the manuscript and the analysis of the binding technique. The codex was bound in the fourth quarter of the 14th century in Pelplin.

Homiliarium, produced in 12th century was rebound using new oak boards acquired after 1346 (no sapwood preserved). The binding was created shortly afterwards. Both the waste paper used as endpapers and the binding technique confirm this dating.

Biblia sacra – a manuscript from the early 13th century has board covers dated back to 1365 (*terminus post quem*, no sapwood preserved). The codex was rebound in Pelpin in the third quarter of the 14th century.

The results of our research provided new information about each of the examined objects. Moreover, they showed that the Cistercian workshop in Pelplin had been rebinding codices since the 14th century, and indicate the sources of wood supply used in the workshop.

A multi-method approach to the scientific investigation of a wooden object

Maks Merela[1]*, Luka Krže*[1]*, Angela Balzano*[1]*, Daša Krapež*[1]*, Rožle Repič*[2]*, Vlado Fras*[3]

[1]Department of Wood Science and Technology, Biotechnical faculty, University of Ljubljana, Ljubljana, Slovenia
[2]The Department of Materials, Slovenian National Building and Civil Engineering Institute (ZAG), Ljubljana, Slovenia
[3]Institute for the Protection of Cultural Heritage of Slovenia, Restoration Centre – Slovenian Institute for the Protection of Cultural Heritage, Ljubljana, Slovenia

Keywords: culture heritage, dendrochronology, micro-CT, John the Baptist

The wooden sculpture of the Head of St. John the Baptist was subjected to a comprehensive conservation-restoration and scientific examination aimed at better understanding its material composition, age, and construction. The head and the base on the neck are made from different types of wood – microscopic analysis identified the head as being made of linden (*Tilia* sp.), while the lower part, representing blood on the neck, is made of spruce (*Picea abies*). Due to non-destructive methods used and the absence of suitable tree-ring chronologies for linden, dendrochronological analysis was not possible. However, accurate examination of growth rings was essential for interpreting the age of the wood, which was made possible only through micro-CT imaging.

Micro-computed tomography allowed detailed visualization of the internal structure of the wood, enabled ring counting, and guided the selection of sampling sites for radiocarbon dating. The combination of micro-CT and 14C analysis thus represented the only reliable method for dating this object. In addition, a high-resolution digital model of the sculpture was produced using structured-light 3D scanning. Based on this model, two replicas were created – one by 3D printing and another by CNC carving in linden wood. These replicas serve exhibition and conservation purposes, while the digital model supports documentation and provides a foundation for further research and interpretation.

A Rembrandt portrait and Baltic oak – large format DendroCT

Aoife Daly[1], *Jørgen Wadum*[2], *Carsten Gundlach*[3], *Jakob Sauer Jørgensen*[3], *Ulrik Lund Olsen*[3], *Jan Kehres*[3]

[1]Dendro.dk
[2]WATS (Wadum Art Technological Studies)
[3]Danmarks Tekniske Universitet

Keywords: dendroarchaeology, painted panels, DendroCT, Baltic oak

Since the first successful use of CT-scanning for non-invasive dendrochronological analysis around 15 years ago, this method has become ever increasingly utilised for analysis of culturally sensitive heritage objects. The remaining challenge has been CT of large wooden objects, the issue being whether we can attain virtual cross-sections of large objects, at a resolution high enough for analysis of the tree rings. Recently built X-ray CT equipment at the Technical University of Denmark (DTU) has allowed us to analyse 'Portrait of a 39-year-old Woman' oil on oval oak panel and signed by Rembrandt, from the Nivaagaard Collection (Denmark). A similar portrait, 'Portrait of a 40-year-old Man' also signed by Rembrandt, also on an oval oak panel (part of the collections at the Metropolitan Museum of Art), was re-examined dendrochronologically, to see to what extent analysis of the oak boards for these two works might indicate the relationship between them.

In this talk we will present the results of these analyses, and place them in the context of past trade in Baltic oak.

Session:

Isotopes

$\delta^{13}C$ and iWUE in *Pinus sylvestris* L. as indicators of tree response to environmental pollution

Darius Valūnas[1], *Jonas Mažeika*[1], *Rūtilė Pukienė*[1], *Miglė Stančikaitė*[1], *Žana Skuratovič*[1]

[1]Nature Research Centre, Akademijos g. 2, Vilnius LT-08412, Lithuania

Keywords: emissions

Increasing industrial activity, particularly nitrogen and sulphur emissions, has significantly impacted the natural environment, driving both extensive environmental research and investments in technological upgrades to mitigate adverse effects during routine operations and accidental releases. The stable carbon isotope ratio ($\delta^{13}C$) in tree rings and intrinsic water use efficiency (iWUE) – which reflects the balance between carbon assimilation and transpiration – serve as valuable proxies for reconstructing changes in climatic and environmental conditions influencing carbon uptake and wood formation. Additionally, variations in $\delta^{13}C$ and iWUE have been linked to industrial pollutant deposition. This study examines $\delta^{13}C$ and iWUE in Scots pine samples collected near Achema, a Lithuanian chemical plant specializing in nitrogen fertilizer production, to identify deviations from values observed at an unpolluted control site with comparable climatic conditions. The results suggest that variations in $\delta^{13}C$ and iWUE reflect a combination of adaptive gas exchange responses and reduced transpiration in reaction to industrial emissions and climatic factors.

Disentangling soil and atmospheric drought effects with intra-annual $\delta^{13}C$ patterns in tree rings

Valentina Vitali[1,2], *Jernej Jevšenak*[3,4], *Georg von Arx*[2,5], *Marina Fonti*[2], *Meisha Holloway- Phillips*[2], *Rubén D. Manzanedo*[5,6], *Kerstin Treydte*[2,5], *Lorenz Walthert*[2], *Roman Zweifel*[2], *Matthias Saurer*[2]

[1]Forest Ecology, Institute of Terrestrial Ecosystems, Department of Environmental Systems Science, ETH Zürich, 8092 Zürich, Switzerland
[2]Swiss Federal Institute for Forest, Snow and Landscape Research WSL, 8903 Birmensdorf, Switzerland
[3]Department of Forest and Landscape Planning and Monitoring, Slovenian Forestry Institute, 1000 Ljubljana, Slovenia
[4]TUM School of Life Sciences, Technical University of Munich, 80333 Freising, Germany
[5]Oeschger Centre for Climate Change Research, University of Bern, Falkenplatz 16, 3012 Bern, Switzerland
[6]Institute of Plant Sciences, University of Bern, 3015 Bern, Switzerland

Keywords: water availability, intra-annual growth, laser ablation, tree-ring isotopes, carbon isotopes

Carbon isotope ratios ($\delta^{13}C$) stored in tree rings has been used to gain insights into past growing conditions. However, using $\delta^{13}C$ at intra-annual resolution to reconstruct seasonal environmental variability remains challenging due to the complex nature of wood formation. We investigated $\delta^{13}C$ patterns across the growing season in three common conifer species, Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), and silver fir (*Abies alba*), across sites with different water limitations in the Swiss Alps.

Using laser-ablation isotope-ratio mass spectrometry, we analyzed ten $\delta^{13}C$ values within individual tree rings, allowing us to assess how closely $\delta^{13}C$ patterns align with key environmental drivers: soil water potential (SWP) and vapor pressure deficit (VPD).

$\delta^{13}C$ patterns were remarkably synchronous across trees, species, and locations, with distinct seasonal signatures. VPD and SWP seasonal changes were consistently traced in the $\delta^{13}C$ variation. However, dry years are marked by higher $\delta^{13}C$ values at the end of the ring, indicating a strong response to summer atmospheric dryness and premature cessation of growth. Scots pine responded most consistently to VPD and SWP, making it ideal for reconstructing past climates. Silver fir integrated carbon over a longer growing season, while Norway spruce showed variable responses depending on site conditions.

These findings not only enhance the interpretation of $\delta^{13}C$ data for seasonal climate reconstruction but also have implications for understanding tree growth dynamics under climate change. They point to species- and site-specific thresholds beyond which growth is inhibited, a critical knowledge for improving models of forest carbon sequestration. High-resolution $\delta^{13}C$ analysis offers a powerful tool to fill gaps in instrumental climate records and improve our understanding of tree responses to changing environments.

Betting on diversity: enhancing resilience of temperate European forests by promoting rare native tree species (RareSpec project)

Maaike de Boer[1], *Christof Bigler*[1], *Andreas Rigling*[1,2], *Valentina Vitali*[1,2]

[1]ETH Zürich
[2]Swiss Federal Research Institute WSL

Keywords: dendrochronology, stable isotopes, rare species, climate change, resilience

Forest ecosystems face increasing threats from climate-induced stressors, including severe droughts and heatwaves, leading to reduced growth and higher tree mortality. These changes reduce forest resilience and impact key ecosystem services such as carbon storage, water regulation, biodiversity conservation, and timber production. European forests are widely dominated by *Fagus sylvatica*, *Picea abies*, *Quercus* sp. and *Pinus sylvestris*, which have shown increasing vulnerability to climate change. Increasing tree species diversity and integrating drought-resistant tree species may enhance forest resilience. Thus, native tree species with higher stress tolerance should be considered as potential alternatives or additions to forest stands. In this context, we selected less studied species of the genera *Acer*, *Carpinus*, *Ostrya*, *Prunus*, *Sorbus*, and *Tilia* based on their lower sensitivity to droughts compared to common tree species. By analysing growth patterns and tree species interactions, we aim to provide a deeper understanding of growth and physiological responses of species of these genera to extreme climatic events by 1) assessing long-term growth patterns and climate sensitivity using dendrochronology of ten rare tree species compared to four common tree species, 2) evaluating species-specific physiology using stable isotope analysis, and 3) understanding the effect of neighbourhood diversity and mixing of rare tree species in mixed lowland forests. Fieldwork will be conducted in seven countries in Europe (France, Germany, Italy, the Netherlands, Norway, Romania, and Switzerland), to encompass a wide range of environmental conditions. Using dendrochronology and stable isotope analysis, our expected outcomes include i) identifying drought-resistant tree species that can enhance forest resilience, ii) understanding species compatibility in mixtures, and iii) providing insights for adaptive forest management of mixed forests in lowlands under future climate scenarios.

Stable isotope dendrochronology

N.J. Loader[1], *D. Davies*[1], *C. Bronk Ramsey*[2], *D. McCarroll*[1], *D. Miles*[2]

[1]Department of Geography, Swansea University, UK
[2]School of Archaeology, Oxford University, UK

Keywords: oxygen isotope, *Quercus*, dendrochronology, science-based dating

Stable isotope dendrochronology is an emerging precision dating technique in tree ring science. The technique, which compliments both ring width dendrochronology and radiocarbon dating is based upon the stable isotope analysis a tree ring series and its comparison with an isotopic reference chronology using a standard statistical framework.

Through a review of recent applications, we demonstrate how stable isotope dendrochronlogy can address some of the common challenges facing European ring width dendrochronology (e.g. species, fast grown invariant series and disturbance).

This talk presents an overview of the dating process and introduces new resources developed for those wishing to apply the technique or to establish an isotope dendrochronology facility.

Dating of Salisbury Cathedral spire and scaffold

D. Miles *FSA[1], K. Akcicek[1], C. Bronk Ramsey[1], D. Davies[2], D. McCarroll[2], N.J. Loader[2]*

[1]University of Oxford
[2]Swansea University

Keywords: dendrochronology, isotopic dendrochronology, radiocarbon

Salisbury Cathedral was constructed between AD 1220 and 1266, but the tower and spire were added in the 1320s. Inside the spire is a complex timber structure that had been thought to have been used to construct the spire from. However there has been significant debate as to the exact purpose of the scaffold and the date of its construction. Recent dendrochronology, isotopic dendrochronology and 14C studies have been employed to investigate the chronology of this enigmatic structure. New dating results refine the chronology of the scaffold and in doing so resolve this long-standing debate.

Forestry and wood culture in the continental Euro-Atlantic façade (1300-1600) – Challenging old narratives with new techniques

Marta Domínguez-Delmás[1]

[1]Cultural Heritage Agency of the Netherlands and Naturalis Biodiversity Research, The Netherlands

Keywords: historical wood utilisation, domestic forests, timber trade, construction timber, isotope dendrochronology

Tree rings in wooden material heritage hold stories about our ancestors, the environments they lived in, the challenges they faced, and their coping strategies. While dendrochronology has the potential to unlock these narratives, it also has its limitations.

In the continental Euro-Atlantic region, approximately 70% of timbers in historic buildings and shipwrecks dating between 1300 and 1600 CE contain few tree rings or exhibit complacent growth and remain undated. As a result, existing tree-ring datasets are mainly composed of timbers with over 100 rings, which are more likely to yield dates. This bias distorts historical analyses of construction activities and forest history, exaggerating building hiatuses and overemphasizing the role of timber trade while underestimating local resource management.

The ERC WoodCulture project (2025–2029) is going to address these biases and challenge the narratives derived from them. Implementing isotope dendrochronology, a technique that enables the exact dating of relatively short series with complacent growth, formerly undated timbers will be revisited and assigned exact dates. The firsts case studies in the Netherlands have already provided very promising results and will be presented in this communication.

Session:

Dendroclimatology

Tree-ring-based precipitation reconstruction reveals recent intensification of extremes in the western Mediterranean over the last five centuries

Marcos Marín-Martín[1], *Ernesto Tejedor*[1], *Gerardo Benito*[1], *Miguel Ángel Saz-Sánchez*[2], *Mariano Barriendos*[3], *Edurne Martínez del Castillo*[4], *Jan Esper*[4], *Martín de Luis*[2]

[1]Department of Geology, National Museum of Natural Sciences (MNCN-CSIC), Madrid 28006, Spain
[2]Departamento de Geografía y Ordenación del Territorio, Universidad de Zaragoza
[3]Instituto de Diagnóstico Ambiental y Estudios del Agua (IDAEA)
[4]Department of Geography. Johannes Gutemberg University, Mainz, Germany

Keywords: dendroclimatology, precipitation reconstruction, Iberian range, western Mediterranean, climate extremes

Understanding the full range of natural hydroclimatic variability is essential for managing water resources in the Mediterranean basin, a region recognized as highly vulnerable to climate change-induced extremes like severe droughts and floods. To provide this critical long-term perspective extending well beyond the instrumental era, we employed dendrochronology within eastern Spain's climatically sensitive Iberian range. A robust *Pinus* sp. tree-ring width chronology spanning 1505–2024 CE was developed. Following a careful evaluation of nine precipitation datasets for their resolution and temporal coverage, the chronology was calibrated using the high-resolution data exhibiting the strongest correlation with annual tree growth. We reconstructed accumulated precipitation for a 320-day period ending in the summer, identified as the most critical window influencing local tree growth dynamics.

This statistically robust ($r = 0.748$, $p < 0.01$) 519-year reconstruction reveals significant multi-centennial shifts in regional precipitation patterns. A key finding is the pronounced amplification in both the frequency and intensity of hydroclimatic extremes (both droughts and pluvials) during recent years compared to the longer-term average. The reconstruction demonstrates skilful performance based on validation metrics, possesses a clear spatial footprint primarily centred on eastern and central Iberia, and is independently corroborated by documentary evidence of historical droughts, such as those inferred from rogation ceremony records, showing notable agreement particularly during the late 18th and early 19th centuries.

Contrasting shifts in critical climate-sensitive periods for tree growth across cold and dry regions of the Northern Hemisphere

Jernej Jevšenak[1,2], *Flurin Babst*[3,4], *Jan Altman*[5,6], *Marcin Klisz*[7], *Andrei Popa*[8,9], *Ionel Popa*[8], *Jan Tumajer*[10], *Allan Buras*[2]

[1]Department for Forest and Landscape Planning and Monitoring, Slovenian Forestry Institute, Slovenia
[2]TUM School of Life Sciences, Technical University of Munich, Germany
[3]School of Natural Resources and the Environment, University of Arizona, USA
[4]Laboratory of Tree-Ring Research, University of Arizona, USA
[5]Institute of Botany, Czech Academy of Sciences, Czech Republic
[6]Faculty of Forestry and Wood Sciences, Czech University of Life Sciences, Czech Republic
[7]Dendrolab IBL, Department of Silviculture and Forest Tree Genetics, Forest Research Institute, Poland
[8]National Institute for Research and Development in Forestry "Marin Drăcea", Romania
[9]Faculty of Silviculture and Forest Engineering, Transilvania University of Brasov, Romania
[10]Department of Physical Geography and Geoecology, Faculty of Science, Charles University, Czech Republic

Keywords: climate-growth interactions, critical climate-sensitive periods (CSPs), seasonality shifts, climate change impacts

Global warming inevitably reshapes how trees respond to climate variability along bioclimatic gradients. Numerous studies have demonstrated spatial and temporal shifts in the strength of climate-growth interactions over recent decades. However, what remains unclear is how the seasonal timing of climate-growth effects has shifted in different climatic domains. Here, we identify critical climate-sensitive periods (CSPs) throughout the current or previous growing seasons that exert the strongest influence on annual radial growth across the Northern Hemisphere. We do so by correlating daily climate data from the ERA5-Land dataset with an extensive network of tree-ring width data from the International Tree- Ring Data Bank (ITRDB). We then assess temporal shifts in CSPs to determine whether their timing has advanced, delayed, or remained stable during recent periods of climatic change. We found a trend for CSPs to advance for trees from cold-limited regions under rising temperatures. These CSP shifts align with documented advances in the thermal growing-season onset across cold regions, likely driven by earlier snowmelt and advanced spring phenology. Most cold-limited trees exhibit delayed and short carry-over effects from the previous growing season. In stark contrast to cold-limited sites, drought- and heat-limited trees exhibited a pronounced delay in their peak sensitivity. Delayed CSPs in drought- and heat-limited environments reflect a conservative water-use strategy in which growth is postponed until moisture becomes available. These contrasting patterns suggest divergent adaptive strategies of energy- and water-limited trees to climate change, which directly influence the timing of phenological events and the magnitude of carbon uptake and release. Our findings underscore the importance of accounting for species-specific and region-specific growth strategies when predicting forest responses to ongoing climate change.

Relationships between tree growth and resin duct formation in Norway spruce stands in Estonia

Taavi Reinthal[1]*, Priit Kupper*[1]*, Maris Hordo*[2]*, Aleksei Potapov*[2]*, Arvo Tullus*[1]

[1]Department of Botany, Institute of Ecology and Earth Sciences, Faculty of Science and Technology, University of Tartu, J. Liivi 2, Tartu 50409, Estonia
[2]Chair of Forest and Land Management and Wood Processing Technologies, Estonian University of Life Sciences, Kreutzwaldi 5, Tartu 51006, Estonia

Keywords: Norway spruce, tree growth, tree rings, resin ducts, mixed stands, pure stands, dendroclimatology

Resin ducts in the Norway spruce (*Picea abies* (L.) H. Karst.) produce oleoresin, which is one of the most important parts of spruce defence system, e.g. against *Ips typographus*. Due to global climate changes, mixed forests may be a more preferred option to grow healthier trees more resilient to stress than pure stands due to varied interactions between species. However, there is little information on the effect of stand type and climatic factors across different forest site types on vertical resin duct production and how it is influenced by different growth parameters.

We conducted a study with 150 middle-aged (35–65 years old) spruce trees from 15 sample plots (10 trees per plot) established in managed hemi-boreal forest stands in Estonia. The stands were in five fertile forest site types typical for spruce: *Carex-Filipendul*a, *Filipendula*, *Hepatica*, *Oxalis*, *Oxalis drained swamp* (according to the Estonian forest site types classification). In each site type, one pure stand and two mixed stands (share of spruce 30–85%, *Betula pendula* as the main other species) were selected. Tree height and diameter (at 1.3 m) were measured, and increment cores (5.15 mm) were collected at 1.3 m for tree-ring width and resin duct measurements. Vertical resin duct (RD) number (estimated per 1 mm of each tree ring perimeter) and resin duct lumen areas (μm^2) for each tree ring in sapwood (years from 2006 to 2021 were common for all stands) were assessed from 30–50 µm thick transverse microsections, stained with Astra-Blue and Safranin solution.

Results show that larger (both in diameter and height) trees tend to produce significantly more RDs regardless of the stand composition and site type. At the same time, the species composition of neighbouring trees has an impact on RD production – the higher the proportion of deciduous trees, the more RDs are formed, which can be a result of increased light availability and better temperature conditions on early period of cambium activity. Average RD lumen area in years with high RD production did not differ between stands but was moderately positively correlated ($p < 0.01$) with tree height. RD production within and between trees and stands had high interannual variability. For example, only 2016 and 2018 from last decade point out as years where all spruces produced RDs, both years had warmer and drier spring than average. Tree growth was affected negatively in 2018, especially in drier *Hepatica* site, but no such reaction was seen in 2016 (drought period was shorter), suggesting possibility that spruce trees can produce large amount of RDs in warm and dry years both with and without growth reduction.

Turkey oak more vulnerable to water deficit than pedunculate oak at a riparian site in SW Poland

Szymon Bijak[1], *Kamil Pilch*[2], *Yulia Prokopuk*[3,4], *Marcin Klisz*[5]

[1]Institute of Forest Sciences, Warsaw University of Life Sciences, Warsaw, Poland
[2]Dendrolab, Forest Research Institute, Białowieża, Poland
[3]Institute for Evolutionary Ecology, National Academy of Sciences of Ukraine, Kyiv, Ukraine
[4]BIOGECO, University of Bordeaux, INRAE, Cestas, France
[5]Dendrolab, Forest Research Institute, Sękocin Stary, Poland

Keywords: radial growth response, drought, native vs alien species, *Quercus* sp.

Turkey oak (*Quercus cerris*, QC) is native oak species in south-eastern Europe and Asia Minor that was naturalised also in other parts of Europe. Despite its introduction to western Poland, abundance and use of this species in Polish forestry is still vestigal (Danielewicz et al., 2014), so is the knowledge about its adaptation to local climate and its growth potential. To fill this gap, our case study compares climate – radial growth relationships between QC and native pedunculate oak (*Q. robur*, QR) and analyses the response of oak species to water shortage events.

Material was collected in autumn of 2023, at a riparian site in Odra river valley near Lubiąż, south-western Poland (51°15′ N 16°28′ E), where 11 QC and 14 QR specimen were sampled. Increment cores were prepared on the Core-microtome and scanned with high resolution. Tree-ring widths were measured with CooRecorder software. The relationship between climate conditions and radial growth of oak species were analysed using the response function concept. Climate variables used in the analyses originated from the 0.1 × 0.1 E-OBS 30.0e database and cover the 1950–2023 period. Response of the analysed species to the drought events was assessed with measures proposed by Lloret et al. (2011) and Schwarz et al. (2020).

Despite quite high similarity of growth rate (T = 9.3, GLK = 72%) QR turned to grow better than QC as its mean tree-ring width was almost twice as high as in case of the non-native species ($t = 10.5$, $p < 0.001$). Analysed oaks showed a rather species-specific character of the relationship between tree-ring width and thermal conditions, but quite similar dependence on pluvial conditions. QC showed strong positive water availability signal. For QR, this relationship was also positive yet weaker. Both species share the significant impact of CWB on their radial growth in previous year July and August as well as current year March and July. Based on climatic water balance values, we identified five years with significant negative water balance (1992, 2003, 2004, 2015 and 2016). None of those years was a negative pointer year for any of the investigated oaks except 2015 for QC. However, analysed species differed significantly with average values of growth response parameters. In general QC showed significantly higher values for 2003, 2004 and 2015, while QR for 1992 and 2016.

Our case study indicates species-specific drought resilience as well as different climatic limitations of QC and QR growth in riparian conditions. Extending these studies to other climatic regions in Europe with varying site conditions seems crucial to understand the acclimatisation potential of QC outside its natural range in the context of climate change.

References:

Danielewicz, W., Kicinski, P., Antosz, L. 2014. Turkey oak (*Quercus cerris* L.) in Polish forests. Acta Scientiarum Polonorum. Silvarum Colendarum Ratio et Industria Lignaria, 2, 5–22

Lloret F. et al. 2011. Components of tree resilience: effects of successive low-growth episodes in old ponderosa pine forests. Oikos, 120, 1909–20, https://doi.org/10.1111/j.1600-0706.2011.19372.x

Schwarz, J. et al. 2020. Quantifying Growth Responses of Trees to Drought – a Critique of Commonly Used Resilience Indices and Recommendations for Future Studies. Curr Forestry Rep, 6, 185–200, https://doi.org/10.1007/s40725-020-00119-2

Tree-ring analysis of alder in northwestern Iberia highlights distinct biogeographical patterns

Ignacio García-González[1], *Manuel Souto-Herrero*[1], *Rosa Ana Vázquez-Ruiz*[1]

[1]BIOAPLIC, Departamento de Botánica, Universidade de Santiago de Compostela, Spain

Keywords: alder, riparian forests, climatic signal, Atlantic-Mediterranean boundary

Dendrochronological investigations of riparian forests are scarce, as tree-ring series are often short, severely affected by multiple disturbances, and tend to reflect local conditions rather than regional climate. In addition, most riparian forests across Europe are significantly damaged or have been destroyed.

The northwestern Iberian Peninsula, dominated by Atlantic climatic conditions, hosts a dense network of rivers and streams that supports multiple riparian forests. As a rule, alder (*Alnus lusitanica*) is the most representative tree species. However, these forests are now increasingly affected by a severe dieback process.

To characterize the radial growth of alder and its associated environmental signal over recent decades, we established a network of chronologies along the Miño Basin, the most representative river in the region. Although most trees showed short series with strong trends, due to their pioneer character, frequent physical damage, and strong growth reductions and releases, nearly all individual series could be successfully crossdated.

Our results revealed that most sites contained a relevant common signal. However, comparison among chronologies divided them into two distinct groups that were hardly correlated to each other. These clusters clearly reflected two contrasting types of riparian forest: one characteristic of the Atlantic Region and the other of the transitional zone toward the Mediterranean. The observed pattern highlights the strong biogeographical relevance of the signals recorded in these short ring series.

These findings constitute a milestone for the study of riparian forests in the region, and serve as a starting point for the application of dendrochronology to investigate alder dieback.

Spatio-temporal variability in seasonal growth response of *Abies spectabilis* in the western Himalaya

Bency David Chinthala[1], *Parminder S. Ranhotra*[3], *Jussi Grießinger*[2], *Achim Bräuning*[1]

[1]Institute of Geography, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
[2]Department of Environment and Biodiversity, Paris Lodron Universität, Salzburg, Austria
[3]BirbalSahni Institute of Palaeosciences, 53 University Road, Lucknow (UP), India

Keywords: *Abies spectabilis*, Indian summer monsoon, sea surface temperatures (SSTs), winter westerlies

We analyzed tree-ring $\delta^{18}O$ based growth behaviour of *Abies spectabilis* (fir) from the subalpine tree-line ecotone of two valleys, located in the South Asian Summer Monsoon (SASM) dominated region of the western Himalayas. These valleys also receive snow precipitation by western disturbances (WDs) during the winter months. The two 60-year tree-ring $\delta^{18}O$ chronologies (1960–2019 CE and 1961– 2020 CE respectively from Magguchatti and Tungnath valleys) were analysed for climate sensitivity using bootstrap correlation method, and the climate-growth relationship over time was assessed using the moving correlation function. Same species from two sites revealed differences in their seasonal responses to climate variables. Moreover, the response function and moving correlation analysis showed inconsistent relationship between climate and growth over time revealing changes in seasonal growth sensitivity of the species. Our findings partly contrast with the significant correlations between tree-ring $\delta^{18}O$ and summer precipitation and drought indices observed in other SASM dominated Himalayan regions. Spatial correlation analyses with sea surface temperatures (SSTs) and climate parameters showed subdued signals from the tropical Pacific at the sites, but a shift to increased moisture influx from the Arabian Sea during the last two decades. The rising temperature trend during the latter half of the 20th century and the elevation effect are important factors controlling the moisture source at the tree-line ecotone zones.

Genetic control over growth sensitivity of Scots pine across edaphic gradient in hemiboreal conditions

Pauls Zeltiņš[1], Diāna Jansone[1], Āris Jansons[1], Arnis Gailis[1], ***Roberts Matisons***[1]

[1]Latvian State Forest Research Institute "Silava", Salaspils, Latvia

Keywords: local genetic adaptation, functional traits, genetic control, local population, stress resilience

In Northern Europe, tree breeding as a part of adaptive management has a principal role for sustaining and increasing forest growth and sustainability, particularly in the light of the accelerating climatic changes. Although breeding programmes have traditionally focussed on the genetic effects on the economically important traits, the G × E interactions have been considered as "noise", yet the prediction of such effects can facilitate specific targeting of breeding programmes. Furthermore, quantification of the G × E interactions is crucial for comprehensive evaluation of the performance of genotypes across ecological gradients. In breeding programmes, the genetic effects have traditionally been evaluated for growth and stem quality traits, which are cumulative products of conditions in the past, and thus are dated under accelerating environmental changes. Accordingly, climate-related fictional traits (such as sensitivity of increment) can be more informative regarding performance of genotypes in projected future conditions. In this study, genetic control over the sensitivity of increment of Scots pine to normal and extreme weather fluctuations across edaphic gradient was analysed based on half-sib progeny trials in the hemiboreal forest zone by time series deconstruction and linear regression analysis. Genetic and environment effects on sensitivity traits were distinguished via variance partitioning according to the principles of quantitative genetics. The results are discussed in the context of climatic adaptability, sustainability and applicability.

Session:

Dendroecology

Acclimatisation of non-native tree species to Central Europe: The importance of local site vs regional conditions

Marcin Klisz[1], *Jernej Jevšenak*[2], *Radosław Puchałka*[3,4], *Marcin Jakubowski*[5], *Andrei Popa*[6,7], *Mathieu Magnier*[8,9], *Jakub Jeleń*[10]

[1]Dendrolab IBL, Forest Research Institute, Sękocin Stary, Poland
[2]Department for Forest and Landscape Planning and Monitoring, Slovenian Forestry Institute, Večna pot 2, 1000 Ljubljana, Slovenia
[3]Department of Ecology and Biogeography, Nicolaus Copernicus University in Toruń, Poland
[4]Centre for Climate Change Research, Nicolaus Copernicus University in Toruń, Poland
[5]Department of Forest Utilisation, Faculty of Forestry and Wood Technology, Poznań University of Life Sciences, Poland
[6]National Institute for Research and Development in Forestry "Marin Drăcea", Bucharest, Romania
[7]Faculty of Silviculture and Forest Engineering, Transilvania University of Brasov, Brasov, Romania
[8]Institut Agro Dijon, 26 Bd Dr Petitjean, 21079 Dijon, France
[9]UMR Silva – AgroParisTech – Campus de Nancy, 14 rue Girardet, 54042 Nancy, France
[10]Department of Forest Management, Dendrometry and Economics of Forestry, Warsaw University of Life Sciences, Poland

Keywords: introduced tree species, climate adaptation, drought resilience, local studies, region-wide studies

Species Distribution Models (SDMs) predict a significant loss of climatically suitable areas for most introduced conifers in the near future (2041–2060; Puchałka et al., 2023). *Pinus strobus* appears to be the only conifer species to benefit from climate change, while *Pseudotsuga menziesii*, the most widespread introduced species in Europe, will likely retreat from many regions across the continent. In contrast, introduced broadleaved species are generally expected to expand their habitats, with *Quercus rubra* and *Robinia pseudoacacia* being among the winners (positive net gain in the area) due to global warming. These shifts in the potential ranges of non-native species are linked to a contraction of the ecological niches of most native coniferous and some deciduous species in Central Europe, e.g. *Picea abies*, *Pinus sylvestris* (Dyderski et al., 2025). This prompts two key questions. First, can non-native species introduced as substitutes for Europe's declining natives actually cope with the continent's future climate? Second, will potentially invasive alien species spread uncontrollably into new regions of Europe under a changing climate?

Although SDMs pinpoint areas favourable for the persistence of specific species, those areas may not correspond to optimal growing conditions for mature trees, as species requirements may vary at different life stages. Therefore, an assessment of the spatio-temporal variation in climate sensitivity of non-native species in areas of projected contraction or persistence is crucial to understanding their acclimatisation capacity and contributes to our understanding of their future performance and growth limits.

Here, we present an overview of our recent findings on the acclimatisation of non-native coniferous and broadleaved tree species across the broad climatic gradient of Central Europe. We focus on *P. menziesii*, *P. strobus*, *P. rigida*, *P. nigra*, *R. pseudoacacia* and *Q. rubra* (Klisz et al., 2021, 202, 2023; Magnier et al., 2025). Our review draws on both region-wide tree-ring networks and local studies investigating selected aspects of growth response. To obtain a more objective picture of the acclimatisation of alien species in Europe, data needs to be complemented with research that (1) spans regional and local studies; (2) includes not only mature but also juvenile life stages of ontogenetic development, and (3) couple secondary growth with the physiological processes that determine developmental and reproductive processes.

References:

Dyderski, M.K., Paz-Dyderska, S., Jagodzinski, A.M., Puchalka, R. 2025. Shifts in native tree species distributions in Europe under climate change. Journal of Environmental Management, 373, 123504, https://doi.org/10.1016/j.jenvman.2024.123504

Klisz, M., Puchałka, R., Netsvetov, M., Prokopuk, Y., Vítková, M., Sádlo, J. et al. 2021. Variability in climate-growth reaction of *Robinia pseudoacacia* in Eastern Europe indicates potential for acclimatisation to future climate. Forest Ecology and Management, 492, 119194, https://doi.org/10.1016/j.foreco.2021.119194

Klisz, M., Jevšenak, J., Prokopuk, Y., Gil, W., Mohytych, V., Puchałka, R. 2022. Coping with Central European climate – xylem adjustment in seven non-native conifer tree species. Dendrobiology, 88, 105–123, https://doi.org/10.12657/denbio.088.008

Klisz, M., Puchałka, R., Jakubowski, M., Koprowski, M., Netsvetov, M., Prokopuk, Y. et al. 2023. Local site conditions reduce interspecific differences in climate sensitivity between native and non-native pines. Agricultural and Forest Meteorology, 341, 109694, https://doi.org/10.1016/j.agrformet.2023.109694

Magnier, M., Jevsenak, J., Puchałka, R., Klisz, M. 2025. The effect of soil conditions on climate-growth correlations at two *Pinus nigra* sites. Dendrobiology, 93, 60–68, https://doi.org/10.12657/denbio.093.004

Puchałka, R., Paź-Dyderska, S., Jagodziński, A.M., Sádlo, J., Vítková, M., Klisz, M. et al. 2023. Predicted range shifts of alien tree species in Europe. Agricultural and Forest Meteorology, 341, https://doi.org/10.1016/j.agrformet.2023.109650

Growth responses of Persian oak (*Quercus brantii* Lindl.) along latitudinal and altitudinal gradients in the Zagros Mountains, Iran

Mohsen Arsalani[1], *Achim Bräuning*[1]

[1]Institut of Geography, Friedrich-Alexander Universität Erlangen-Nürnberg

Keywords: dendroecology, earlywood width, latewood width, drought, oak dieback

Mountain ecosystems are dynamic and exceptionally sensitive to the adverse impacts of climate change. We developed nine standard site chronologies of Persian oak (*Quercus brantii* Lindl.) for each of the parameters tree-ring width (TRW), earlywood width (EWW) and latewood width (LWW) along humidity and altitudinal gradients in the Zagros Mountains, Western Iran. Our results showed high consistency among the three ring-width parameters of Persian oak. All the chronologies contain strong common signals and display several long-term positive and negative growth phases across the Zagros Mts. TRW, EWW, and LWW standard chronologies, along with the regional chronologies, exhibited strong climate signals being representative for larger areas in West Asia, North Africa, and the Mediterranean region. The results highlighted that the frequency of negative extreme events has significantly increased in the recent decades (1930–2022). Winter precipitation is the most important driving factor, exerting a strong positive effect on the growth of the native oak species in the Zagros Mts. Conversely, we found negative correlations between mean monthly maximum and mean monthly mean temperatures and TRW, EWW, and LWW of Persian oak during the previous and current growth years. Our findings confirmed the strong negative impacts of dry periods on oak forests, particularly for the central and southern parts of the Zagros Mts. The high frequency of negative extreme events imposes severe impacts on the resilience of oak trees, threatening the vitality of the native oak species which plays a crucial role in biodiversity, water regulation and soil protection in this drought affected region. Given the importance of soil moisture during both the pre-growing and actual growing seasons, we strongly recommend implementing watershed management strategies that enhance soil moisture capacity to support the future resilience of the native oak species under global warming conditions.

Uncovering fire history in Scots pine hemiboreal forests: A dendrochronology approach

Michael Manton[1], *Sarunas Kukcinavicius*[1], ***Charles Ruffner***[2]

[1]Vytautas Magnus University, Lithuania
[2]Southern Illinois University, Carbondale, USA

Keywords: tree ring analysis, fire archive reconstruction, climate, tree growth, forest management

Forest policy has emphasized the need for closer-to-nature forest management, which seeks to mimic natural ecological processes. Fire is a key forest disturbance that enhances biodiversity and ecosystem resilience, yet it has largely been excluded from modern forest management. This study reconstructs the dendrochronology fire history of Scots pine the most fire prone species in Lithuania. Using trees with visible tree ring fire-scars, we examine the fire events, the relationship between fire events and climate fluctuations, and pre- and post-fire tree growth responses using FHX2 software. The tree-ring analysis results showed that i) forest fires have been an important part of the Lithuanian forest landscape, with a mean fire return interval of 10–20 years over the last 150 years, ii) fire activity was influenced by climatic fluctuations preceding the fire years as well as anthropogenic events, and iii) the fire events had a profound effect on tree growth. The findings confirm that fire has played a crucial role in shaping Lithuania's hemi-boreal Scots pine forests. The dendrochronology historical fire archives provide essential insights for sustainable forest management, particularly in restoring natural disturbance regimes. Since modern forestry has largely excluded fire, leading to simplified forest structures, there is a need for educational programs to increase awareness of fire's ecological role. Dendrochronology studies can help to fill the gaps in understanding a landscape fire history and towards reintegrating integrating fire as a management tool, and a natural forest processes.

Detecting forest stress signals from space: Integrating mixed tree-ring chronologies with mixed pixels from satellite-derived vegetation indices at two resolutions in the WALD- Puls network

Andreas Burger[1], *Allan Buras*[2], *Martin Wilmking*[1]

[1]University Greifswald, Germany
[2]Technical University of Munich, Germany

Keywords: tree-ring growth, NDVI, remote sensing, mixed forest stands

Timely detection of forest stress via remote sensing is essential for effective forest monitoring and proactive management. The WALD-Puls network provides an innovative framework that integrates high-resolution ground-based observations with satellite-derived vegetation indices to assess forest health across spatial and temporal scales. Spanning over 25 research sites in pure and mixed stands in Mecklenburg-Vorpommern, Germany, the network includes 13 tree species and compiles a multi-sensor dataset – ranging from dendrometer and sap-flow measurements to minirhizotron imagery, micrometeorological and soil data, and tree-ring analyses – synchronized with satellite data from the German Forest Condition Monitor.

This study examines statistical relationships between annual tree-ring growth and the Normalized Difference Vegetation Index (NDVI) at two spatial resolutions (MODIS: 250 m; Sentinel-2: 10 m), with a focus on linking stem growth to crown-level vitality. To address spectral mixing effects inherent to satellite imagery in heterogeneous forests, we use weighted mixed-species tree-ring chronologies. Overall, more than 30 site-specific chronologies were developed from increment cores of deciduous and coniferous trees across pure and mixed stands, representative of diverse forest conditions in Germany. NDVI time series were derived from MODIS (2003–2023) and Sentinel-2 (2017–2023), spatially aligned with sampling plots.

Preliminary analyses indicate partial but meaningful correlations between NDVI and radial growth, especially in structurally homogeneous stands and potentially for mixed-species chronologies. To refine interpretation, additional forest structural variables such as canopy cover, stand density, species composition, and understory vegetation are being incorporated. While the longer MODIS time series supports robust statistical evaluation, interpreting the shorter Sentinel-2 time series remains more complex but offers potential through trend analyses. Overall, our findings highlight the value of integrating dendroecological data with remote sensing to support scalable, long-term assessments of forest condition and mixed-species growth dynamics.

Spruce budworm outbreaks in north-eastern Québec reconstructed from a subfossil black spruce tree-ring network

Alexandre F. Nolin[1]*, Audrey Lemay*[1]*, Yan Boucher*[1]*, Hubert Morin*[1]

[1]Département des sciences fondamentales, Laboratoire sur les écosystèmes terrestres et boréaux, Université du Québec à Chicoutimi, Chicoutimi, Québec, Canada

Keywords: dendrochronology, *Picea mariana*, *Choristoneura fumiferana*, insect defoliator, natural disturbance, boreal forest management

Spruce budworm (SBW, *Choristoneura fumiferana*) outbreaks are among the major natural disturbances shaping the Canadian boreal mixedwood forest, where balsam fir (*Abies balsamea*) is the primary host species. A handful of tree-ring reconstructions leveraging living and archaeological material have indicated strong temporal and spatial synchrony of SBW outbreaks over the past 300 years across central to eastern Québec. However, how the impacts of observed climate change and the combined effects of forest management affected the frequency, duration, severity and regional extent of outbreaks remains unclear. Longer reconstructions at the regional scale are thus needed to better assess how SBW dynamics have shaped the boreal mixedwood forest over past centuries, and to provide critical context for developing informed management strategies in the face of climate change. This study builds on several decades of black spruce (*Picea mariana*) tree-ring collections from living trees and subfossil wood recovered in lake sediments from the Saguenay region of Québec. Black spruce is less severely defoliated by SBW than balsam fir and provides distinct advantages as a tree-ring archive due to its wide distribution and longevity across the boreal forest. We aim to derive a unique regional and long-term perspective of SBW disturbance history encompassing three key regions north of the Saint Lawrence River – north of Baie-Comeau, north of Port-Cartier, and Monts-Valin. Results are yet to come but preliminary analyses of the chronologies already reveal coherent growth patterns and clear SBW signals in black spruce tree-ring records spanning the past 500–600 years across these regions. Over the past several centuries, the severity of 20th-century outbreaks appears unprecedented and may be linked to the decreasing frequency of fires since the end of the Little Ice Age, which has contributed to the expansion of fir. Early findings also point to the potential for extending the chronologies even further back in time, possibly reaching the Medieval Warm Period and offering an opportunity to explore SBW outbreak dynamics under climate conditions more comparable to those observed today. With this unprecedented dataset, we also hope to compare recent SBW dynamics with longer-term Holocene trends inferred from lepidopteran scales preserved in regional lake sediment cores.

Dendrochemistry in *Picea abies* in post-mining Uranium area in south-western Poland

Mateusz Telążka[1], *Piotr Owczarek*[1], *Magdalena Opała-Owczarek*[2], *Łukasz Stachnik*[1], *Aleksandra Proch*[2], *Jędrzej Proch*[2]

[1]Department of Physical Geography, Faculty of Earth Sciences and Environmental Management, University of Wrocław, plac Uniwersytecki 1, 50-137 Wrocław, Poland
[2]Institute of Earth Sciences, University of Silesia in Katowice, ul. Będzińska 60, 41-200 Sosnowiec, Poland
[3]Department of Analytical Chemistry, Adam Mickiewicz University, Uniwersytetu Poznańskiego 8, 61-614 Poznań, Poland

Keywords: uranium, Norway spruce, ICP-MS, anthropocene, *Picea abies*, dendrochemistry

Mining activities related to uranium extraction leave a lasting imprint on the environment, even decades after their cessation. This study examines the impact of historical uranium ore exploitation in Kletno (Eastern Sudetes) on the chemical composition of annual growth rings of Norway spruce (*Picea abies*). The aim was to assess the extent to which spruce responds to the presence of post-mining waste and whether its growth rings can serve as an archive of contamination by trace metals and radioactive elements. The uranium mine in Kletno operated between 1948 and 1958, significantly transforming the surrounding area. The amount of uranium extracted and the technical aspects of the operation remained classified for years, with any mention of uranium in this region treated by the Soviets as an act of espionage. In this study, increment cores collected from trees growing at various distances from mine tailings and adits were subjected to standard dendrochronological procedures to determine tree age and establish site chronology, as well as ICP-MS (inductively coupled plasma – mass spectrometry) analysis. Particular attention was given to the concentrations of uranium (U), nickel (Ni), lead (Pb), cadmium (Cd), and arsenic (As). The resulting dendrochemical profiles reveal locally elevated concentrations of uranium and associated metals in the tree rings of specimens growing in close proximity to mining waste dumps. Interestingly, some of the analysed cores showed increased uranium concentrations in the youngest rings, which may indicate ongoing leaching of uranium residues from the post-mining tailings, subsequently absorbed from the soil environment by the trees. The results suggest that Norway spruce can effectively reflect the chemical signature of soils in post-mining areas.

Was it always pine? – a multi-proxy reconstruction of peatland ecosystem dynamics in southeastern Poland

Ewa Zin[1,2], *Tomasz Związek*[3], *Marcin Klisz*[4], *Sandra Słowińska*[5], *Dominik Róg*[6], *Milena Obremska*[7], *Dominika Łuców*[8,9], *Jarosław Pietruczuk*[10], *Joachim Popek*[11], *Katarzyna Piotrowicz*[12], *Kamil Pilch*[1], *Krzysztof Szewczyk*[8], *Agnieszka Halaś*[8], *Michał Słowiński*[8]

[1]Dendrolab IBL, Department of Natural Forests, Forest Research Institute (IBL), Białowieża, Poland
[2]Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences (SLU), Alnarp, Sweden
[3]Laboratory for Interdisciplinary Research into the Anthropocene, Institute of Geography and Spatial Organization (IGiPZ), Polish Academy of Sciences (PAN), Warsaw, Poland
[4]Dendrolab IBL, Department of Silviculture and Genetics of Forest Trees, Forest Research Institute (IBL), Sękocin Stary, Poland
[5]Climate Research Department, Institute of Geography and Spatial Organization (IGiPZ), Polish Academy of Sciences (PAN), Warsaw, Poland
[6]Faculty of Humanities, The John Paul II Catholic University of Lublin (KUL), Poland
[7]Institute of Geological Sciences (ING), Polish Academy of Sciences (PAN), Warsaw, Poland
[8]Department of Past Landscape Dynamics, Institute of Geography and Spatial Organization (IGiPZ), Polish Academy of Sciences (PAN), Warszawa, Poland
[9]Department of Earth Sciences, Carleton University, Ottawa, Canada
[10]Faculty of Earth Sciences and Spatial Management, Maria Curie-Skłodowska University in Lublin, Poland
[11]Department of Economic and Social History, University of Rzeszów, Poland
[12]Department of Climatology, Institute of Geography and Spatial Management, Jagiellonian University (UJ), Kraków, Poland

Keywords: climate change, forest history, interdisciplinary approach, landscape dynamics

Peatlands support biodiversity, regulate hydrological systems, play a key role in the global carbon cycle, are important chronological archives of paleoenvironmental changes, and serve as climate microrefugia. These ecosystems have been significantly altered over millennia by human land use such as drainage, overgrazing or peat extraction. Understanding the long-term dynamics of peatlands is important for making predictions about their future conditions, e.g. response to climate change, vegetation changes, carbon sequestration potential and restoration and conservation needs. Therefore, we applied an interdisciplinary approach to study the interactions between tree growth, hydrology, climate and human activities in a peatland in one of the unexplored regions of Central Europe. A variety of proxy data from natural and human archives, including long-term meteorological data (1792–2020), tree-ring data (1729– 2022) from peatland pines, palaeoecological data from the peat sediment (pollen, plant macrofossils, testate amoebae and charcoal data) and archival sources (documents, historical maps and printed archival sources) were used to reconstruct local ecosystem dynamics and assess possible climatic and anthropogenic impacts. Our results documented a different temporal coverage of the studied archives, a multi-faceted interplay of various landscape shaping influences, a hydrological instability of the peatland during the last > 2,300 years and an ecosystem change from black alder bog forest to Scots pine bog forest related to local land use changes and, among others, associated fire activity. Our study highlights the complex interactions between different biotic and abiotic factors affecting peatlands and emphasises the need for interdisciplinary multi-proxy research on their history and dynamics.

Effect of drainage on Scots pine and Norway spruce radial growth in north- eastern Poland

R. Tomusiak[1], *M. Orzechowski*[1], *M. Ksepko*[2], *W. Kędziora*[1], *R. Wójcik*[1], *D. Meko*[3]

[1]Institute of Forestry Sciences, Warsaw University of Life Sciences, Poland
[2]Bureau for Forest Management and Geodesy, Białystok Branch, Poland
[3]Laboratory of Tree-Ring Research, The University of Arizona, US

Keywords: tree rings, hydrogenic habitats, water deficit, dendrochronology, dendroecology

The issue of water deficit is becoming increasingly important in Polish forests. A significant reduction in the area of hydrogenic habitats (which develop and function under conditions of permanent or periodic excess water in the soil) is observed, along with irreversible changes in the condition of their soils and the composition of phytocoenoses. Forest management in humid and marshy areas, where changes in the groundwater table have occurred, faces challenges related to silviculture and forest utilization.

The objective of the study was to determine the impact of changes in the groundwater level, caused by forest drainage, on tree growth. The research was conducted in the Augustów Forest in north-eastern Poland. Five drainage facilities were selected, within which four research sites were established: for Scots pine and Norway spruce, both on mineral and hydrogenic soils. A total of 20 research sites were included, from which two samples were taken from 20 trees (a total of 800 sequences). Comparative analyses were conducted between species and types of habitats.

The results of the study indicate a significant impact of hydrotechnical treatments on tree-ring width in some of the analysed catchments. The difference in the size of radial increments in the adjacent hydrogenic and mineral habitats lasting at least several years can be considered a permanent trace of the drainage performed in the annual rings. Searching for such patterns may indicate the dates of hydrotechnical treatments for which documentation is lacking. Spruce exhibits a stronger incremental response to the drainage treatments, and after an extended period of weak growth, it can rapidly increase the width of annual rings in response to improved environmental conditions following drainage.

Different types of incremental reactions were observed in hydrogenic habitats. One of these is a decrease in the tree-ring width of spruce and an increase in pine. However, spruce more frequently responds with an increased increment, while pine tends to reduce the increment. Additionally, there were catchments in which both species experienced a decrease in increment in the period following drainage. Understanding the connections between the evolution of hydrogenic habitats and changes in other forest ecosystems enables the modification of management principles in forests and their immediate surroundings.

A high abundance of mistletoe is affecting the tree growth of Scots pine

Wojciech Kędziora[1]*, Robert Tomusiak*[1]*, Ramzi Touchan*[2]

[1]Institute of Forest Sciences, Warsaw University of Life Sciences, Poland
[2]Laboratory of Tree-Ring Research, University of Arizona, USA

Keywords: *Viscum album*, parasite infestation, growth reduction

Mistletoe (*Viscum album* L.), a semi-parasitic plant comprising four European subspecies, was historically not considered a threat to Scots pine (*Pinus sylvestris* L.). However, climate change in Central Europe – characterised by rising temperatures and irregular precipitation patterns – has made pine forests in Poland increasingly vulnerable to various threats, including mistletoe infestation.

Our investigation assessed 1,500 trees for mistletoe infestation using ground-level observations. We developed chronologies from samples collected with increment borers and processed using standard dendrochronological techniques to evaluate the parasite's impact on host tree growth.

The comprehensive assessment revealed that mistletoe affects up to 31% of trees in certain forest regions, with more than 35% of infected trees heavily compromised by six or more mistletoe specimens per tree. Importantly, our findings indicate that only these high infestation levels cause significant growth reduction in Scots pine, suggesting that moderate levels of infestation may be tolerated without substantial impact on tree increment.

Tree-ring eccentricity as a proxy for shallow creep activity on flysch slopes: Insights from the Javorníky mountains, Czech Republic

Filip Schlesinger[1], *Karel Šilhán*[1]

[1]Department of Physical Geography and Geoecology, University of Ostrava

Keywords: dendrogeomorphology, creep, tree-ring eccentricity, spatio-temporal analysis

Understanding the spatiotemporal dynamics of shallow creep remains a key challenge in geomorphology due to the process's low velocity and continuous character. This study applies a dendrogeomorphic approach to evaluate shallow creep activity using tree-ring eccentricity in Norway spruce (*Picea abies* (L.) H. Karst.) on a flysch slope in the Outer Western Carpathians (Javorniky Mts.). A total of 136 increment cores from 68 trees were analysed in relation to slope morphometry, weathering mantle thickness, and climatic variables. Spatial interpolation of eccentricity values revealed heterogeneous creep dynamics, with evidence of long-term continuity rather than episodic intensification. A significant positive relationship was found between stem inclination and mean eccentricity, while no significant correlation emerged for slope gradient, weathering mantle thickness, or annual precipitation. Notably, older trees (aged 71–90 years) exhibited heightened sensitivity to creep-induced growth asymmetry, suggesting that age-related physiological factors play a critical role in signal detection. These findings refine our understanding of tree growth responses to long-term geomorphic forcing and highlight both the potential and methodological limitations of using tree-ring eccentricity as a proxy for shallow creep.

Dendrogeomorphology as a tool for reconstructing mining-induced subsidence dynamics

Lucie Polášková[1]

[1]University of Ostrava

Keywords: dendrogeomorphology, subsidence, underground mining, tree-ring analysis, growth disturbances

Subsidence, defined as vertical and horizontal ground movements induced by underground mining, represents a major geomorphic process that significantly alters surface morphology and can lead to substantial environmental and infrastructural damage. Traditional subsidence studies, typically relying on engineering-based monitoring, are often limited by sparse spatial coverage and short observation periods linked to active mining phases. Consequently, knowledge of long-term subsidence dynamics across broader landscapes remains incomplete. Dendrogeomorphology offers a promising complementary approach, enabling the reconstruction of subsidence history through the analysis of growth disturbances in tree rings. Anatomical anomalies such as reaction wood formation and abrupt growth suppression provide valuable proxies for the timing, magnitude, and spatial extent of past subsidence events. When combined with geomorphological and geodetic mapping, dendrogeomorphic methods allow for a more comprehensive understanding of surface changes associated with mining activities. Expanding the application of dendrogeomorphological techniques contributes significantly to improving the reconstruction of historical subsidence processes and enhances the ability to assess geomorphic and ecological impacts in mining-affected landscapes worldwide.

Session:

Wood anatomy

Dendrochronological signatures of the 2011 and 2014 record floods on *Fraxinus pennsylvanica* trees: current and historical perspectives

Jacques C. Tardif[1], *Alexandre Nolin*[2,3], *France Conciatori*[1]

[1]Centre for Forest Interdisciplinary Research (C-FIR), The University of Winnipeg, Department of Biology, Environmental Studies & Sciences, 515 Avenue Portage, Winnipeg, Manitoba R3B 2E9, Canada
[2]School of Geography, Development & Environment, University of Arizona, Tucson, AZ, USA
[3]Laboratory of Tree Ring Research, University of Arizona, Tucson, AZ, USA

Keywords: flood rings, earlywood vessels, tree-ring width, blue intensity, spring versus summer floods, flood gradient, Assiniboine river, central Canada

In central Canada the 2011 and 2014 floods were unprecedented in modern hydrological records. In Brandon (near our study area), the 2011 spring flood reached the highest water levels and flows in modern history. Flooding near Brandon was reported to have lasted 120 days. In contrast to the 2011 event, the 2014 flood occurred in the summer and was the second highest in modern record. The 2014 flood was unique in that it was a summer flood largely driven by rainfall. Both floods were of higher amplitude than the 1976 spring one; the third largest flood on the Assiniboine river since that of 1882. In this study, we compare the response of green ash (*Fraxinus pennsylvanica* Marsh.) trees to the 2011 spring and 2014 summer floods. We also put this response in perspective with that of the 20th century high-magnitude floods. In the summer of 2023, two floodplain green ash stands were sampled in Spruce Wood Provincial Park, Manitoba. In each stand, flood rings were visually identified, both earlywood vessels and ring width were measured, and blue intensity determined. The tree-ring signature associated with the 2011 spring versus the 2014 summer floods will be established. The results will also be compared to that of green ash trees sampled in early 2000 and for which tree-ring signatures have been established (Tardif et al., 2023; Tardif et al., 2025). For example, the Assiniboine river spring flow in the 20th century was linearly and positively associated with the frequency of flood rings and with earlywood density as determined by blue intensity measurements. During these major flood events, earlywood porosity decreased (more vessels of smaller size) and earlywood width did increase. Results for the 21th century are yet to come but we hypothesize i) that the flood signature associated with the 2011 spring and 2014 summer floods will be dissimilar, and ii) that these signatures will be distinct or discernible from those observed during the 20th century floods. The exceptionality of the 2011 and 2014 floods offers a unique context allowing to better the identification and classification of tree-ring features in a ring-porous species and along a gradient ranging from low to high magnitude floods. Understanding the dendrochronological responses of trees to extreme flood events is critical to improve paleoflood reconstructions and regional flood risk analyses.

References:

Tardif, J.C., Conciatori, F., Smith, D.L. 2023. Flood rings, earlywood vessels and hydrological signal in *Fraxinus pennsylvanica* trees growing along the central Assiniboine river floodplain, southcentral Canada. Canadian Water Resources Journal, 49(3), 313–328, https://doi.org/10.1080/07011784.2023.2290962

Tardif, J.C., Kaczka, R.J., Conciatori, F. 2025. Blue intensity, tree-ring dimensions, earlywood vessels and flood rings in floodplain *Fraxinus pennsylvanica* trees, central Canada. Dendrochronologia, 91, 126311, https://doi.org/10.1016/j.dendro.2025.126311

Visualizing microscopic wood structures through micro-CT and 3D printing

Daša Krapež[1], *Angela Balzano*[1], *Rožle Repič*[2], *Maks Merela*[1]

[1]Department of Wood Science and Technology, Biotechnical faculty, University of Ljubljana, Ljubljana, Slovenia
[2]The Department of Materials, Slovenian National Building and Civil Engineering Institute (ZAG), Ljubljana, Slovenia

Keywords: wood anatomy, X-ray microtomography, 3D-printed models

Advancements in educational technology are reshaping the way complex anatomical structures are studied and understood. In our recent work, we developed an innovative tool for studying wood anatomy by combining X-ray microtomography with 3D printing. This approach enables the creation of accurate, enlarged physical models of wood's microscopic architecture, offering a tangible and engaging way to explore anatomical details that are otherwise invisible to the naked eye.

Using the Xradia µCT-400 tomograph (Xradia, USA), we scanned the internal structures of four wood species – spruce, pine, beech, and oak – at submicron resolution. Each sample was imaged through 1601 projections during a 360° rotation, generating high-resolution data that was processed with Avizo Fire software (Thermo Fisher Scientific, USA) for image filtering, segmentation, and 3D model preparation. The resulting digital reconstructions were then 3D-printed at a scale of 1 : 500 using a sustainable filament blend containing 40% wood particles and 60% biodegradable PLA.

The outcome is a cost-effective, reproducible, and ecologically mindful teaching tool that enhances anatomical learning through tactile interaction. These 3D-printed models make the microstructure of wood accessible for detailed study and open new possibilities for both visual and hands-on exploration. The resulting physical models accurately represent microstructural features such as tracheid arrangements, vessel distribution, and parenchyma patterns, offering tactile and visual accessibility to complex internal morphologies. This tool exemplifies how non-destructive imaging and digital fabrication can be leveraged to improve the teaching and learning of anatomical sciences.

Comparison of 14 native and non-native tree species climate-growth relationship in Copera, Switzerland

Camille Marande[1], *Maaike de Boer*[1], *Valentina Vitali*[1,2], *Christof Bigler*[1], *Georg von Arx*[2], *Andreas Rigling*[1,2]

[1]ETH Zürich
[2]Swiss Federal Institute for Forest, Snow and Landscape Research WSL

Keywords: dendrochronology, wood anatomy, non-native species, climate change, resilience

Forest ecosystems are threatened by climate change that is characterized by the increasing occurrence of extreme droughts and heatwaves. Those increasingly stressful conditions are leading to unprecedented mortality of forests. Thus, solutions to increase their resilience are urgently needed. A strongly advocated option for forest management is to increase tree species diversity which could be achieved by introducing non-native tree species with high adaptation potential to future climate. However, only limited information on their autecology and growth performance is available, making it difficult to predict their performances in this scenario. This study aims to explore the climate-growth relationship of native and non-native tree species to assess their potential to increase the resilience of future Central European forests. The site of Copera (Ticino, Switzerland) represents a unique opportunity to explore this subject as more than 70 native and non-native tree species were planted in homogeneous conditions between the 1950ties and the 1970ties, making interspecific comparisons possible. Dendrochronological analyses were performed on 273 trees from 14 species representing coniferous, diffuse-porous and ring-porous hardwood trees. Pairs of native and non-native species of the same wood type were selected to explore the differences in climate-growth relationship and response to droughts. The analyses highlighted interspecific differences of resilience components, as well as in climate-growth relationships despite the relatively good growth conditions of the site. Quantitative wood anatomy will be used to show wood functional traits responses to climate which will help unravel the climate-growth relationship of 14 native and non-native tree species. This is one of the few systematical assessments of native and non-native species which will help informed decision making on forest management in Central Europe in the face of accelerating climate change.

The impact of diverse topoclimatic conditions on the intra-annual dynamics of secondary growth of Norway spruce (*Picea abies*) in the Western Sudetes

Elżbieta Myśkow[1]*, Aleksandra Słupianek*[1]*, Marek Błaś*[2]*, Tatiana Bukowiec*[1]*, Bartosz Jasiński*[2]

[1]Department of Plant Developmental Biology, University of Wrocław, Poland
[2]Department of Climatology and Atmosphere Protection, University of Wrocław, Poland

Keywords: micro-core, cambium, secondary xylem formation, intra-annual growth dynamics, spruce, the Sudetes

The current knowledge is insufficient to make an unambiguous assessment of the performance of various forest ecosystems in the age of global climate change. A high degree of uncertainty applies particularly to ecosystems that, due to their history, are characterized by lower stability and tolerance. The aim of the study was to compare the intra-annual changes in cambial activity and secondary xylem formation as well as growth rate of spruce (*Picea abies*) between measurement sites representing diverse topoclimatic conditions in the Western Sudetes (medium size mountain barrier).

The 12 sampling locations were chosen and grouped into 5 landform categories at different altitudes: foothills (340 m a.s.l.), slopes facing north (800–900 m a.s.l.), slopes facing south (800–900 m a.s.l.), flat valley-basins (820–850 m a.s.l.) and ridges (1,250 m a.s.l.). Most of the analyzed sites (10) were located at an altitude of 800–900 m above sea level, where the greatest variability of topoclimatic conditions is observed. For example, the average date of the last spring frost varies from the end of April (south-facing slopes) to the summer optimum (flat valley basins), and the length of the growing season varies from 107 to 146 days. The diverse topoclimatic conditions were also influenced by specific weather conditions. The individual months of the growing season in years 2022 and 2023 were characterized by significant thermal anomalies (from –2.9 to 4.3°C) and precipitation anomalies (from 25 to 209% of the norm).

The analysis was based on microcores taken during the growing seasons of year 2022 and 2023. At each site, between April and September, three trees were sampled every 10–12 days. Transverse sections were prepared from the collected microcores and an intra-annual analysis of changes occurring in the cambium and secondary xylem was done. On this basis, the beginning, end, and duration of cambium activity and subsequent stages of secondary xylem differentiation were determined. The air temperature and humidity, daily precipitation and soil moisture were recorded. At three sites, changes in trunk circumference were measured using electronic band dendrometers (growing season 2023).

Climate-growth correlations revealed the inter-seasonal influence of climatic conditions, in particular precipitation deficit and soil moisture decline, on short-term tree responses. During periods of spring and partial summer drought, spruce trees showed premature cessation of cambium activity and reduced growth rates. This was most pronounced in the foothills and least pronounced in the ridge areas. On the contrary, in sites located at an altitude of 800–900 m a.s.l., the growth rate of trees was correlated primarily with thermal and light conditions. The longest period of cambium division activity and the highest number of cells in annual growth were observed on south-facing slopes (80 days and 47 cells). The most difficult conditions for tree growth occurred within wide and concave landforms with flat bottoms, which create optimal conditions for the occurrence of frequent, very deep nighttime temperature drops (even in the optimum summer) and extreme daily temperature ranges (52 days and 30 cells). The average radial growth width was 1.67 mm on south-facing slopes and 0.92 mm in flat valley basins.

Silent witnesses of change: climate effects on annual ring variation in perennial herb *Viscaria vulgaris*

Vineta Vērpēja[1], *Iluta Dauškane*[1]

[1]University of Latvia, Faculty of Medicine and Life Sciences

Keywords: *Viscaria vulgaris*, climate signals, annual rings, rhizome anatomy, perennial herbs

Dry grasslands are particularly sensitive to climate variability, yet long-term species-specific responses to climatic drivers remain understudied – especially in perennial herbaceous plants. This study investigates how the grassland biodiversity indicator species *Viscaria vulgaris* (sticky catchfly) responds to climate by examining rhizome growth ring width variation and underlying anatomical structures.

A total of 132 rhizome samples, aged 2 to 11 years, were collected from five semi-natural dry grassland sites on calcareous substrate in southern Latvia and five in northern Latvia. Chronologies were constructed for the period 2014–2023 and analysed in relation to climate data (precipitation and air temperature). To assess anatomical features, cross, radial, and tangential sections were examined. Dendrochronological methods were adapted for herbaceous species with inherently shorter lifespans than trees, including adjustments in sample preparation, growth ring boundary identification, chronology construction and quality assessment (e.g., EPS).

Before the climate effect could be determined several anatomical structures were identified to correctly date the growth rings. The presence of missing rings, wedging rings, excentric growth and inclusions was detected. Growth rings in *V. vulgaris* showed variable xylem porosity and a band of thick-walled latewood fibres.

The year 2021 stood out as a major negative pointer year, marked by reduced ring widths and missing rings. This year was climatically extreme, characterized by an unusually cold and wet spring followed by hot and dry conditions in summer (June, July), which severely hindered plant germination and growth.

The findings show that perennial herbs like *V. vulgaris* can serve as effective bioindicators of climate change, if methods are carefully adapted. This work contributes valuable methodological insights and ecological understanding of herbaceous plant responses to climatic stress in grassland ecosystems.

Hidden influence of the Chornobyl nuclear disaster on Scots pine xylem functionality: insights from quantitative wood anatomy

Yulia Prokopuk[1,2], *Annabel J. Porté*[2], *Marcin Klisz*[3], *George von Arx*[4,5], *Holger Gärtner*[4], *Alan Crivellaro*[6,7], *Maksym Netsvetov*[1,2]

[1]Department of Phytoecology, Institute for Evolutionary Ecology, National Academy of Sciences of Ukraine, Kyiv, Ukraine
[2]BIOGECO, University of Bordeaux, INRAE, Cestas, France
[3]Dendrolab IBL, Department of Silviculture and Genetics, Forest Research Institute, Raszyn, Poland
[4]Swiss Federal Research Institute WSL, Research Unit Forest Dynamics, Birmensdorf, Switzerland
[5]Oeschger Centre for Climate Change Research, Bern, Switzerland
[6]Department of Agricultural, Forest and Food Sciences. University of Torino, Largo Paolo Braccini 2, Grugliasco, Torino 10095, Italy
[7]Forest Biometrics Laboratory, Faculty of Forestry, "Stefan cel Mare" University of Suceava, Str. Universitatii 13, Suceava 720229, Romania

Keywords: *Pinus sylvestris*, radiation exposure, ROXAS, QWA, hydraulic safety and efficiency traits

The Chornobyl nuclear accident occurred at the beginning of the 1986 growing season (26 April) and led to acute and chronic radiation exposure in the forests of the Chornobyl Exclusion Zone (CEZ). Surviving trees exhibited several morphological abnormalities (Kozubov, Tashkaev, 1994), however, many of the visually recognizable features diminished over time, making it difficult to assess long-term radiation effects. In terms of tree-ring width, signs of damage were inconsistent: while some studies have reported pronounced suppression of radial growth with increasing radiation dose rates (Netsvetov et al., 2023), others found no significant effects (Holiaka et al., 2020). At the cellular level, radiation impact showed as a deterioration in the xylem structure of Scots pine (*Pinus sylvestris* L.) (Skuterud et al., 1994; Tulik, 2001). However, it remains unclear whether the observed anatomical changes compromise tracheid function. To address this, we applied a quantitative wood anatomy (QWA) using ROXAS software to analyse cross-sections from 38 Scots pine increment cores collected from three sites along the "western trace" of fallout. The tree sampling sites represent an external radiation dose rate gradient comprising conditionally lethal, sub-lethal, and moderate levels. Based on the xylem functionality inferred from QWA, radiation impaired both water transport and mechanical support functions at the conditionally lethal and sub-lethal contaminated sites, while only marginal effects were observed at the moderately contaminated site, where no obvious xylem abnormalities were detectable. The patterns at the moderate site exhibited similar temporal fluctuations in safety and efficiency traits to those observed at the sub-lethal site. In the first post-accident growing season, trees at lower doses followed a typical recovery pattern (Schweingruber, 2007), prioritizing the formation of functionally efficient structures. By contrast, trees exposed to conditionally lethal doses exhibited an inverted trajectory that emphasized safety over efficiency, indicating divergent adaptive strategies under extreme stress. Our findings contribute to a better understanding of tree responses to severe radiation at critical developmental stages and highlight the value of QWA for detecting subtle, event-specific impact that conventional dendrochronological or qualitative assessments may overlook.

References:

Kozubov, G.M., Taskaev, A.I. 1994. Radiobiological and radioecological studies of woody plants. Nauka, Saint Peterburg

Holiaka, D., Fesenko, S., Kashparov, V., Protsak, V., Levchuk, S., Holiaka, M. 2020. Effects of radiation on radial growth of Scots pine in areas highly affected by the Chernobyl accident. J Environ Radioact, 222, 106320

Netsvetov, M., Prokopuk, Y., Holiaka, D., Klisz, M., Porté, A.J., Puchałka, R., Romenskyy, M. 2023. Is there Chornobyl nuclear accident signature in Scots pine radial growth and its climate sensitivity? Science of the Total Environment, 878, 163132

Skuterud, L., Goltsova, N.I., Næumann, R., Sikkeland, T., Lindmo, T. 1994. Histological changes in *Pinus sylvestris* L. in the proximal-zone around the Chernobyl power plant. Science of the Total Environment, 157, 387–397

Tulik, M. 2001. Cambial history of Scots pine trees (*Pinus sylvestris*) prior and after the Chernobyl accident as encoded in the xylem. Environ Exp Bot, 46, 1–10

Schweingruber, F.H. 2007. Wood structure and environment. Springer Berlin Heidelberg, Berlin, Heidelberg.

Recording cambial stages with XyloJ

Ignacio García-González[1]*, Daniel Irimia*[1]*, Gonzalo Pérez-de-Lis*[1]

[1]BIOAPLIC, Departamento de Botánica, Universidade de Santiago de Compostela, Spain

Keywords: xylogenesis, cambium, wood formation, ImageJ

The analysis of xylogenesis involves observing, identifying, and often quantitatively measuring multiple stages of cambial activity. This is typically carried out on microscopic slides, either through direct observation or by analysing their corresponding digital images. However, no dedicated tool currently exists for the systematic and efficient recording of these stages.

To address this gap, we developed and thoroughly tested XyloJ, a plugin specifically designed for this purpose. XyloJ runs within ImageJ, a widely used, open-source, cross-platform image analysis software. The plugin operates on any standard laptop or desktop and allows users to annotate and measure various xylogenesis stages directly on pre-saved images, which can be processed sequentially in batch mode.

XyloJ includes three main modules:

i) marking and labeling cambial stages,

ii) counting different cell types, and

iii) identifying and measuring growth zones.

Users can define or modify the variables recorded according to their specific needs. All measurements are saved along with the annotated images, and pooled datasets from multiple samples can be exported for further analysis.

With the public release of XyloJ, we hope it will serve as a standard platform for future studies on xylogenesis.

Session:

Posters

Carbon-water interactions in beech forest: Insights from eddy covariance, tree-ring stable isotopes, and modelling

Paulina F. Puchi[1,2], *Daniela Dalmonech*[1,3], *Daniele Castagneri*[4], *Marco Lehmann*[5], *Matthias Saurer*[5], *Stefan Klesse*[5], *Alessio Collalti*[1,3]

[1]Forest Modelling Lab., Institute for Agriculture and Forestry Systems in the Mediterranean, National Research Council of Italy (CNR-ISAFOM), Italy
[2]Institute of Bioeconomy, Italian National Research Council (CNR-IBE), Italy
[3]National Biodiversity Future Center (NBFC), Italy
[4]Università degli Studi di Padova, Department TESAF, Italy
[5]Swiss Federal Institute for Forest, Snow, and Landscape Research (WSL), Switzerland

Keywords: eddy covariance, water use efficiency, 3D-CMCC-FEM, carbon water fluxes, GPP, stable isotopes

Understanding the interplay between carbon and water fluxes is critical for assessing forest ecosystem functioning, particularly under changing climatic conditions. We used a multi-proxy approach that combines eddy covariance (EC) data, tree-ring width (TRW), tree-ring stable isotopes, and modelling to investigate carbon and water flux dynamics across multiple temporal scales. Carbon and water fluxes were quantified using EC data, providing insights into gross primary production (GPP), ecosystem respiration, and evapotranspiration. Intrinsic water use efficiency ($_i$WUE), derived from carbon stable isotope analysis ($\delta^{13}C$), was examined to assess physiological responses to environmental stress. The study was conducted in a mixed forest dominated by *Fagus sylvatica* L. at the EC site Laegeren (CH- LAE) in Switzerland, spanning from 2000 to 2023.

Our results indicate that both GPP and $_i$WUE showed a significantly increasing trend over the study period ($p < 0.0001$), suggesting a potential stomatal closure response to environmental conditions. Although this increase in $_i$WUE might contribute to a reduction in TRW, this effect was not statistically significant ($R^2 = 0.14$, $p > 0.05$).

Simulated $_i$WUE values obtained for the period 2004 to 2023 yielded a mean of 96.3 ± 21.1 μmol mol^{-1}, while measurements based on stable isotopes yielded a mean of 99.2 ± 5.5 μmol mol^{-1}. An inter-annual correlation between simulated and measured $_i$WUE was, conversely, significant ($r = 0.50$, $p < 0.05$).

Additionally, we observed a strong and significant correlation between modelled and measured fluxes at daily, mean seasonal cycle, and intra-annual scales. To further investigate these interactions, an integrated approach combining oxygen stable isotope analyses ($\delta^{18}O$) and process-based modelling will be employed to disentangle carbon and water flux relationships at different temporal scales. This study advances our understanding of how forests regulate carbon and water exchange under variable environmental conditions, providing critical insights for future forest management strategies and climate change mitigation efforts.

Oak species dendroclimatic patterns and resilience to drought in south- eastern Romania

Ionel Popa[1,2]*, Andrei Popa*[1,3]

[1]National Institute for Research and Development in Forestry Marin Drăcea, Romania
[2]Center for Mountain Economy, Romania
[3]Faculty of Silviculture and Forest Engineering, Transilvania University of Brasov, Brasov, Romania

Keywords: tree ring, growth-climate relationship, forest-steppe, water deficit

Increasing warming-related drought frequency and severity impact tree growth in lowland forest ecosystems. Oak species are the key species in forests in steppe and forest-steppe regions, ensuring high biodiversity levels and ecosystem functionality under limited climatic conditions.

In this study, we evaluate the effect of climatic factors on the basal area increment and drought resilience of five native oak species (*Quercus robur*, *Quercus pedunculiflora*, *Quercus frainetto*, *Quercus pubescens*, *Quercus cerris*) and one exotic oak species (*Quercus rubra*) in the forest-steppe zone of southeastern Romania. To assess the climate-growth relationships we used bootstrap Pearson correlation between BAI and aggregated daily climatic factors (i.e., temperature, precipitation, Standard Evapotranspiration-Precipitation Index). The temporal shift of climate sensitivity was evaluated through the difference in climate response between two periods (i.e., 1961–1990 and 1991–2020). For resilience to extreme drought (SPEI < –1.5), we used classical Loret resilience indices.

All oak species exhibit a significant response to previous autumn, spring, and summer drought, with an increasing correlation intensity in recent decades. A negative correlation with summer temperature is observed only after 1990, for all native oak species. *Q. rubra* has no significant correlation with temperature. Growth synchrony between trees is higher and stable over time for *Q. cerris* and *Q. rubra*. In contrast, *Q. robur* and *Q. pedunculiflora* show a decline in inter-series correlation after 1990. *Q. frainetto* shows the highest resistance to extreme drought, while *Q. rubra* has the lowest. The recovery rate after water deficit periods is high for *Q. robur* and *Q. pubescens*. Overall, *Q. frainetto* fully recovers after extreme drought (mean resilience index > 1), whereas the lowest resilience is observed in *Q. cerris* and *Q. rubra*.

Our results indicated similar resilience and adaptability to extreme drought conditions for *Q. robur*, *Q. pedunculiflora*, *Q. frainetto*, and *Q. pubescens*, while *Q. cerris* and *Q. rubra* are the most vulnerable ones in the forest-steppe zone of South-Eastern Romania.

An 831-year Scots pine chronology from northern Belarus as a new basis for dendroprovenancing studies

***Maxim Yermokhin*[1], *Māris Zunde*[2]**

[1]Institute of Archaeological Sciences, University of Bern, Switzerland
[2]Institute of Latvian History, University of Latvia

Keywords: Dzvina, Daugava, tree rings, dendroprovenancing, medieval and modern times

The River Zapadnaya Dvina (in Russia), Dzvina (in Belarus), Daugava (in Latvia), which flows through these three countries, was one of the important trade routes from the early medieval time. This large, slow-moving river, with numerous tributaries passing through forested landscapes, remained the primary route for rafting timber from the vast plains of the upper and middle Dzvina basin, as well as a part of the Dnieper basin to Riga and exported to Western Europe for centuries. Thus, timber also from present-day territory of Belarus can be find in the collections of "Baltic oak" and "Riga pines" in many European countries.

We used tree-ring series from living trees, as well as historic and archaeological timber from northern Belarus, to develop the new multi-century tree-ring chronology of Scots pine (*Pinus sylvestris* L.) for the middle Dzvina basin. The chronology (BY03b) covers 831 years (1186–2016 AD). Archaeological timbers were discovered during excavations in Polatsk and Vitsebsk between 1970 and 2022, while historic timbers were collected from the Jesuit Collegium and the Savior Transfiguration Church in Polatsk. The chronology also includes timber from the Dannenstern House in Riga, which shows very high correlations (t-value reaches 8.6) with archaeological wood from Vitsebsk and Smolensk, confirming that it originated from the middle or upper Dzvina basin.

The section of the BY03b chronology based on living trees shows a high correlation with chronologies from eastern Latvia and northwestern Belarus (t-value > 7), but the common signal weakens significantly closer to the Baltic coast. Similarities between the chronology BY03b and chronologies of archaeological timber from Riga begin to show a start of timber trade between the upper and lower parts of Dzvina basin in the 14th century. The strongest correlation between time series occurs in the 16–17th centuries and declined in 19th century. So, this new Belarusian multi-century pine chronology provides an exclusive basis for tracing precisely in time the trade connections of pine timber exported from the Dzvina (and possibly Dnieper) basin to Western Europe via Riga in 14th–19th centuries.

The influence of climatic conditions on the tree-ring width of the wild cherry (*Prunus avium* L.) in western Poland

Anna Cedro[1]*, Bernard Cedro*[1]

[1]University of Szczecin, Poland

Keywords: tree-ring width, dendroclimatology, W Poland

The wild cherry (*Prunus avium* L.) is one of the most valuable native trees in the forests of Central Europe. The northern limit of the range of this species runs through Poland. However, it is also observed far north of this border, which is the result of the artificial introduction of the species as an admixture to forests. The subject of the study were five populations of wild cherry growing in the western part of Poland. The tree-ring width was measured, the dynamics of tree growth and the growth-climate relationship were studied. The main factor shaping the tree-ring width is the sum of summer precipitation. High total precipitation and sufficient water supply of the habitat cause a positive growth response and an increase of tree-ring width. In turn, rainfall deficiency and drought caused a decreasing growth trend and growth depressions.

Funding: Co-financed by the Minister of Science under the "Regional Excellence Initiative" Program for 2024–2027 (RID/SP/0045/2024/01)

Postwar history of the *Pinus* genus stand on the degraded by exploitation peat bog "Bór na Czerwonem" (Orava-Nowy Targ Basin, S Poland)

Anna Cedro[1], *Bernard Cedro*[1], *Katarzyna Piotrowicz*[2], *Anna Hrynowiecka*[3], *Tomasz Karasiewicz*[4], *Michał Mirgos*[5]

[1]University of Szczecin, Poland
[2]Jagiellonian University in Kraków, Poland
[3]Polish Geological Institute - National Research Institute, Marine Geology Branch, Poland
[4]Nicolaus Copernicus University in Toruń, Poland
[5]Nadleśnictwo Nowy Targ, Poland

Keywords: age structure, tree-ring width, pith eccentricity, raised bog, drainage, renaturalization, S Poland

Dendrochronological studies were conducted on the foothill raised peat bog "Bór na Czerwonem" in the Orava-Nowy Targ Basin (S Poland). In the past, the peat bog was drained and peat was extracted there, and in recent years a number of actions have been taken on it as active protection (including the construction of embankments, gates, filling of drainage ditches and cutting down most of the trees on the peat bog dome). The subjects of the studies were *Pinus* x*rhaetica* (bores) and *P. sylvestris*, *P. mugo* and *P. xrhaetica* (discs). The aim of the study was to determine the age of the stand and its age structure, as well as to determine the factors influencing the tree-ring width. The age of the trees indicates a post-war rapid succession of trees (after massive drainage in 1942), although individual trees were present on the peat bog dome already at the end of the 19th century. High values of pith eccentricity at ground level indicate the instability of the substrate and the influence of strong winds on the formation of tree-rings. Growth-climate relationships change with the ongoing climate change: the importance of insolation increases, while the importance of absolute minimum temperature decreases. However, the thermal and pluvial conditions of the previous growing season primarily affect the tree-ring width in the next season. Probably, as a result of the constant rise in the water level in the peat bog, the trees left will be in increasingly poor health condition and it will be possible to observe a decreasing number of seedlings. However, a full assessment of the renaturalization activities carried out will be possible in a few/a dozen or so years thanks to the monitoring conducted on the peat bog.

Funding: Co-financed by the Minister of Science under the "Regional Excellence Initiative" Program for 2024–2027 (RID/SP/0045/2024/01)

Spatial and temporal variability of tree-ring dendroecological indicators in oak trees in Europe in relation to species distribution models

*Andrei Popa[1,2], Jernej Jevšenak[3], Marcin Dyderski[4], Radosław Puchałka[5,6], Allan Buras[7], Ionel Popa[1,8], Martin Wilmking[9], Aleksandra Kalisty[10], Catalin-Constantin Roibu[11], Marcin Jakubowski[12], Eric Thurm[13], Martin Šenfeldr[14], Marko Smiljanić[9], Jan Esper[15,16], Edurne Martinez del Castillo[15], Vaclav Treml[17], Jan Tumajer[17], Tzvetan Zlatanov[18], Roberts Matisons[19], Gheorghe Florenta[20,21], Veronica Florenta[21], Maksym Netsvetov[22,23], Vladislav Grati[11,21], Andreas Burger[9], Karolina Janecka[24], Saša Kostić[25], Kamil Pilch[26], Diāna Jansone[19], Agnese Liepiņa[19], Yulia Prokopuk[22,23], Oleksandr Sylenko[22], Mátyás Árvai[27], Achim Bräuning[28], Cristina Marques[29], Martin Häusser[28], Emil Horváth[30], Jakub Jeleń[31], Ryszard Kaczka[16], Zoltán Kern[32], Tomáš Kolář[33], Marcin Koprowski[5,6], Sandra Metslaid[29], András Morgós[34], Oleksandr Khodosovtsev[35], Aleksei Potapov[29], Michal Rybníče[33], Irena Sochova[33], Kristina Sohar[36], Vasyl Budzhak[22,37], Ewa Zin[26,38], Tassilo Schneider[9], Wojciech Gil[39], **Marcin Klisz**[40]*

[1]National Institute for Research and Development in Forestry “Marin Drăcea”, Bucharest, Romania
[2]Faculty of Silviculture and Forest Engineering, Transilvania University of Brasov, Brasov, Romania
[3]Department for Forest and Landscape Planning and Monitoring, Slovenian Forestry Institute, Ljubljana, Slovenia
[4]Institute of Dendrology, Polish Academy of Sciences, Poznan, Poland
[5]Department of Ecology and Biogeography, Faculty of Biological and Veterinary Sciences, Nicolaus Copernicus University, Toruń, Poland
[6]Centre for Climate Change Research, Nicolaus Copernicus University, Toruń, Poland
[7]Land Surface-Atmosphere Interactions, TU Munich, Freising, Germany
[8]Center for Mountain Economy, Vatra Dornei, Romania
[9]Institute for Botany and Landscape Ecology, University of Greifswald, Greifswald, Germany
[10]Forsite Consultants Ltd, Prince Albert, Canada
[11]Forest Biometrics Laboratory, Faculty of Forestry, “Stefan cel Mare” University of Suceava, Romania
[12]Faculty of Forestry and Wood Technology, Poznań University of Life Sciences, Poland
[13]Landesforstanstalt Mecklenburg-Vorpommern, Department of Forest Planning/Forest Research/Information Systems, Research Unit Silviculture and Forest Growth, Schwerin, Germany
[14]Department of Forest Botany, Dendrology and Geobiocoenology, Faculty of Forestry and Wood Technology, Mendel University in Brno, Brno, Czech Republic
[15]Department of Geography, Johannes Gutenberg University, Mainz, Germany
[16]Global Change Research Institute of the Czech Academy of Sciences (Czech- Globe), Brno, Czech Republic
[17]Charles University, Faculty of Science, Department of Physical Geography and Geoecology, Prague, Czech Republic
[18]Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Bulgaria
[19]Latvian State Forest Research Institute “Silava”, Salaspils, Latvia
[20]Forest Research and Management Institute, Chisinau, Moldova
[21]Moldova State University, Chisinau, Moldova
[22]Institute for Evolutionary Ecology of the National Academy of Sciences of Ukraine, Kyiv, Ukraine
[23]BIOGECO, INRAE, University of Bordeaux, Cestas, France
[24]University of Geneva, Institute for Environmental Sciences, Switzerland
[25]Institute of Lowland Forestry and Environment, University of Novi Sad, Serbia
[26]Dendrolab IBL, Department of Natural Forests, Forest Research Institute (IBL), Białowieża, Poland
[27]Institute for Soil Sciences, HUN-REN Centre for Agricultural Research, Budapest, Hungary
[28]Institute of Geography, Friedrich-Alexander-Universität Erlangen-Nürnberg
[29]Chair of Forest and Land Management and Wood Processing Technologies, Estonian University of Life Sciences, Estonia
[30]independent researcher, Sárkeresztes, Hungary
[31]Department of Forest Management, Dendrometry and Economics of Forestry, Warsaw University of Life Sciences, Poland
[32]Institute for Geological and Geochemical Research, HUN-REN Research Centre for Astronomy and Earth Sciences, Budapest, Hungary
[33]Faculty of Forestry and Wood Technology, Mendel University in Brno, Brno, Czech Republic
[34]Consart Bt., Budapest, Hungary
[35]Kherson State University, Ivano-Frankivsk, Ukraine; M.G. Kholodny Institute of Botany, Kyiv, Ukraine
[36]Department of Geography, Institute of Ecology and Earth Sciences, University of Tartu, Tartu, Estonia
[37]Poltava V.G. Korolenko National Pedagogical University, Poltava Oblast, Ukraine
[38]Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences (SLU), Alnarp, Sweden
[39]Department of Silviculture and Genetics, Forest Research Institute (IBL), Sękocin Stary, Poland
[40]Dendrolab IBL, Department of Silviculture and Genetics, Forest Research Institute (IBL), Sękocin Stary, Poland

Keywords: *Quercus robur* L., climate–growth relationships, growth synchrony, climatic water balance, vapor pressure deficit, range contraction, climate change scenarios

Climate is a primary, but non-stationary, driver of tree growth as climate change is altering the sensitivity of forest growth to water availability and temperature over time. It is thought that pedunculate oak (*Quercus robur* L.) will be able to cope with the changing conditions in Europe in the near future. However, while species distribution models of this species project expansion zones, they also identify reductions in its occurrence at the dry and warm edges. Whereas species distribution models primarily rely on occurrence data, tree rings – –given their long-term perspective and empirical models – can provide a mechanistic view of forest growth dynamics, including temporally changing climate responses. Increased climate sensitivity and growth synchrony are key dendroecological indicators of tree stress. Here, we used an unprecedented network of 150 *Q. robur* sites (over 3,300 trees), covering the full projected range of contracting to persistent areas across Europe, to assess the dendroecological indicators over recent decades in relation to species distribution model predictions. We reveal that oaks in areas projected to experience range contraction exhibited greater sensitivity to current growing season climatic conditions, whereas those in persistence areas responded more strongly to previous season conditions. Growth synchrony among trees was higher in the contraction areas, but showed no significant increasing trend over the last 70 years, as expected from ecotone theory. Temporal shifts in climate sensitivity were stronger for temperature and vapor pressure deficit in the persistence areas, whereas the climatic water balance gained importance in the contraction zones. These findings suggest that *Q. robur* growth is not yet being severely affected by climate change, and that the species is currently coping well with the changes in climate, even in regions with projected range contractions, thereby challenging statistically derived scenarios of range shift based on species distribution models.

The diurnal radial growth of Scots pine and Norway spruce in north-eastern Lithuania from 2019 to 2024: Preliminary results

Adomas Vitas[1]*, Rūtilė Pukienė*[1]

[1]The State Scientific Research Institute Nature Research Centre, Akademijos St. 2, LT-08412 Vilnius, Lithuania

Keywords: point dendrometers, air and soil temperature, precipitation, soil water potential

The use of dendrometers to measure the circumference growth of trees has a long-standing tradition in Lithuania (Pukienė et al., 2021). From 1976 to 2017, manual band dendrometers were employed in an experimental plot in the Aukštaitija National Park. In 2018, automatic point dendrometers were installed on eight trees, with the number of monitored trees increasing to 28 by 2024. The forest stand comprises Scots pine, Norway spruce, silver birch, Norway maple, pedunculate oak and small-leaved lime. Because of the sandy soil conditions, Scots pine is the dominant species.

Dendrometers have been installed on 14 pines and five spruces. Nine pines, with a mean age of 120 years, grow in a primary forest, while five younger pines (mean age: 69 years) are located in a planted monoculture area. The spruces have a mean age of 90 years. This study presents preliminary findings on the diurnal growth of Scots pine and Norway spruce from 2019 to 2024.

For dendroclimatological analysis, diurnal tree growth was correlated with air and soil temperatures, precipitation and soil water potential, which were measured at the nearby meteorological station. Air temperature was measured at a height of two metres above the ground, while soil temperature and water potential were measured at depths of 10 cm and 30 cm. The stability of climate-growth relationships was accessed using moving ten-day correlations.

The average onset of growth occurred on the 13th of May for pines and the 9th of May for spruces, with growth ceasing on the 29th of August and the 24th of August, respectively. The growing season of premature pines lasted an average of 244 days, compared to 239 days for mature pines. Accordingly, the growth onset for premature pines started nine days earlier and ceased five days later than the growth of mature counterparts.

The minimal air temperature and the amount of precipitation are the most influential variables affecting diurnal tree growth. Typically, the strongest correlations with minimal air and soil temperatures were observed at the onset of the growing season, whereas correlations with precipitation were higher in the latter half. These relationships fluctuated with prevailing meteorological conditions. Extended periods of hot weather increased the positive influence of precipitation and soil water availability while reducing the positive effects of air and soil temperatures. Conversely, during wetter summer periods, the influence of precipitation on growth diminished. Overall, the patterns of climate-growth relationships were comparable between Scots pine and Norway spruce.

References:

Pukienė, R., Vitas, A., Kažys, J., Rimkus, E. 2021. Four-decadal series of dendrometer measurements reveals trends in *Pinus sylvestris* L. inter- and intra-annual growth response to climatic conditions. Canadian Journal of Forest Research, 51, 445–454, https://doi.org/10.1139/cjfr-2020-0211

Anthropogenic disturbances of pines in a city forest in Helsinki

Alar Läänelaid[1], *Samuli Helama*[2], *Juha Raisio*[3]

[1]University of Tartu, Estonia
[2]Luke, Rovaniemi, Finland
[3]City of Helsinki, Finland

Keywords: *Pinus sylvestris*, radial increment, growth change, effect of dogs

The annual radial growth of Scots pines in an urban forest of Helsinki was investigated in order to determine possible anthropogenic effects on tree growth. Altogether, one hundred standing pine trees along six transects were sampled by increment borer. Sample trees were grouped by their habitats in the forest. Trampling, dog walking and traffic pollution were taken into focus as the main anthropogenic influences. This study used an ecological disturbance approach to identify human impacts.

It was found that the growth rate of pines varies among ecological habitats, but the highest average growth occurs in most human-impacted habitats – in the vicinity of walking pathways. This phenomenon can most likely be related to walking dogs in the forest. Although certain trees appear to become favourite for dogs to urinate, there is a clear pattern in the location of these trees. From the disturbance study we learned that there occurred two main positive disturbance waves in pine growth – in 1973 and in 2003– 2006. These disturbances can be related to increased human settlement (with dogs) in the neighbourhood of the forest.

Comparing pine growth of trees growing between high traffic roads with that at distance from roads did not reveal any growth suppression in close-to-traffic trees.

As in every tree population, there are also dead pines in a forest patch. Standing dead trees characterized by low radial increment for a decade or more before death. Some of the dead sample trees grew in ecologically unfavorable sites (rocks with very thin soil), but some grew near walking pathways. Their death may be due to a combination of several factors (e.g. old age of trees, unfavorable microhabitat, drought, etc.).

References:

Nowacki, G.J., Abrams, M.D. 1997. Radial-growth averaging criteria for reconstructing disturbance histories from presettlement-origin oaks. Ecological Monographs, 67(2), 225–249

Human footprint in forest ecosystems: $\delta^{13}C$ and intrinsic water use efficiency trends

Slawomira Pawelczyk[1]

[1]Silesian University of Technology, Institute of Physics Center for Science and Education

Keywords: $\delta^{13}C$, tree rings, anthropogenic impact, intrinsic water use efficiency (iWUE)

Human activity has significantly changed the composition of the atmosphere, affecting plant physiology and carbon isotope signatures. One of the key effects is the decline of $\delta^{13}C$ in atmospheric CO_2 due to fossil fuel combustion – known as the Suess effect – which is recorded in tree rings. However, $\delta^{13}C$ in tree-ring cellulose can also be influenced by pollutants such as SO_2 and NO_x that affect photosynthesis by altering stomatal conductance and enzyme activity.

This study analyses $\delta^{13}C$ in α-cellulose extracted from tree rings of spruce and pine in two regions of Poland: the industrially affected Sudetes and the relatively unpolluted Suwalki region. The $\delta^{13}C$ values reflect both climatic and anthropogenic signals and cover the periods 1850–2010 (Sudetes) and 1850– 2003 (Suwalki). The results show regional differences related to pollution intensity, with higher $\delta^{13}C$ values often corresponding to periods of increased industrial emissions. The data also provide insight into long-term trends in water-use efficiency and environmental stress in forests.

Funding: Participation in the conference is financial supported by EU within "The modern methods of the monitoring of the level and isotopic composition of atmospheric CO_2" (project no. FESL.10.25-IZ.01-06C9/23-00)

Higher winter precipitation and temperature are associated with smaller earlywood vessel size but wider latewood width in *Quercus faginea* Lam.

I. García-Gonzalez[1], F. Campelo[2], J. Vieira[3], ***C. Nabais***[2]

[1]BIOAPLIC, Departamento de Botánica, EPSE, Universidade de Santiago de Compostela, Campus Terra, 27002 Lugo, Spain
[2]Centre for Functional Ecology, Associate Laboratory TERRA, Department of Life Sciences, University of Coimbra, Calçada Martim de Freitas s/n, 3000-456 Coimbra, Portugal
[3]Forest Wise CoLab ForestWISE, Quinta de Prados, Campus da UTAD, 5001-801 Vila Real, Portugal

Keywords: mediterranean climate, Portuguese oak, quantitative wood anatomy

Quercus faginea Lam. mainly occurs in the Iberian Peninsula, growing under Mediterranean climate, and it is considered a winter-deciduous species, although it can also behave as a marcescent oak. In order to identify the main variables controlling radial growth, we sampled wood cores of *Q. faginea* and compared the climatic signal between tree-ring width and wood anatomical traits. Winter conditions had an impact on both latewood width and earlywood vessel size in the first row. Latewood was positively correlated to precipitation and temperature, with a long-term positive effect of winter water supply evidenced by SPEI. Correlations of vessel size with winter precipitation and temperature were negative, also confirmed by a long-term negative effect of winter precipitation. Considering the climate projections for the Mediterranean Region, the increase in temperature will probably lead to an earlier start and a late ending of the growing season, but lower precipitation, especially in winter, will reduce water availability for the growing season. According to our results, lower precipitation in winter will increase earlywood vessel size, but a higher winter temperature will have the opposite effect. Thus, the final vessel size will depend on the balance effect of these two parameters, affecting the hydraulic conductivity and susceptibility to embolism. Although high winter temperatures have a positive effect on latewood width, low winter precipitation will have a strong negative effect. Latewood has an important mechanical role to sustain the weight of a tree and a lower production of latewood can eventually lead to more fragile trees, with a potential increase on mortality. This will have an impact on the distribution areas of *Q. faginea*, which will probably be restricted to areas with high water availability, or it will tend to behave more as a deciduous oak to avoid water stress.

Understanding how competition status shapes tree resilience to drought

Rebecca Partemi[1], *Tom Levanič*[1,2], *Jernej Jevšenak*[1]

[1]Slovenian Forestry Institute, Ljubljana, Slovenia
[2]University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies, Koper, Slovenia

Keywords: tree-rings, climate, resilience, drought, competition

Climate change poses a significant threat to forest ecosystems worldwide, intensifying the frequency and severity of extreme droughts that challenge tree survival and growth. One of the most significant factors affecting tree growth is competition, which ultimately shapes resource availability, stand structure, and microclimatic conditions. However, our understanding of how species-specific traits and stand-level characteristics influence tree resilience to climate stressors remains limited. While competition is recognized as a key driver of tree growth dynamics, its impact on the climate sensitivity and drought tolerance of trees is poorly understood.

In this study, we investigate how tree resilience to drought is affected by competition, species-specific traits and microclimatic conditions. By combining field-measured competition data with dendrochronological analyses, we were able to assess how current competition status affects the climate sensitivity and growth-based resilience of Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*) and silver fir (*Abies alba*) across four different sites in Slovenia.

Preliminary results showed that trees under higher competition exhibit weaker climate sensitivity and overall lower resilience to drought. Dendrochronological analyses also revealed that trees under lower competitive pressure show similar values of recovery and resistance across sites compared to trees under higher competitive stress, which instead show higher variability within those indices.

This study provides novel and important insights into the relationship between stand dynamics and tree resilience to climate stressors. By understanding how competition and tree status interact to shape climate sensitivity and drought tolerance, our findings contribute to a more nuanced perspective on forest management. These insights can inform strategies to promote forest resilience in the face of increasing climatic variability, ensuring sustainable and adaptive forestry practices.

The impact of climate change on the cambium activity and incremental response of spruce (*Picea abies*) in the middle mountains of central Europe in relation to altitude

Aleksandra Słupianek[1], *Elżbieta Myśkow*[1], *Marek Błaś*[2], *Bartosz Jasiński*[2]

[1]Department of Plant Developmental Biology, University of Wrocław, Poland
[2]Department of Climatology and Atmosphere Protection, University of Wrocław, Poland

Keywords: dendrochnology, micro-core, cambium activity, secondary xylem formation, growth dynamics, spruce, the Sudetes

The spruce ecosystems of the Western Sudetes are an interesting and unique research area, characterized on the one hand by highly diverse climatic conditions and on the other by exceptionally intense anthropogenic pressure, with a rich history of exploitation and restructuring of tree stands. Consequently, these ecosystems are extremely valuable to analyse their response to contemporary climate change. In the mountainous regions of central Europe, the following phenomena can be observed: unprecedented scale of warming, a downward trend in precipitation totals in spring, decreasing snowiness of winters and constantly growing threat of drought.

The aim of the study is to decipher the intra-annual changes in cambial activity and secondary xylem formation as well as growth rate of spruce (*Picea abies*) between measurement sites representing different high zones: foothills (300–500 m a.s.l.) and upper forest border zone (1,200–1,300 m a.s.l.).

The analysis of intra-annual changes in cambial activity and secondary xylem formation was based on microcores taken during the growing seasons (between April and September) of years 2022 and 2023. The sampling sites included two locations representing the foothills and upper forest zone, three trees were sampled every 10–12 days. On this basis, the beginning, end, and duration of cambium activity and subsequent stages of secondary xylem differentiation were determined. To examine the response of trees to climatic factors influencing their growth, around 246 core samples from 11 locations (6 representing the foothills and 5 from the upper forest boundary zone) were collected between September 2022 and November 2023 using the increment borer MORA CORETAX with the auger 400 mm long. To ensure proper quality and to eliminate the age factor in the gathered data, the measured tree-ring width values were transformed through quality checking with COFECHA software as well as the ARSTAN program. In addition, meteorological data was used to calculate two drought indices: SPI (Standardized Precipitation Index) and SPEI (Standardized Precipitation Evapotranspiration Index) for the period 1961–2020. The series of tree-ring width values and drought indices values were tested using regression analysis, then linear trends were determined together with their equations, R^2 and p level with R packages. Then the data series were additionally tested for the presence of trends by the Mann-Kendall test.

Microcore analysis showed that in the foothills zone, where the cambium division period exceeded 85 days and included a very dry spring, the number of cells in the annual growth averaged 37. In contrast, in the upper forest boundary zone (1,000 m higher), where the period of cambium division activity was more than 3 weeks shorter and fell during a period with no precipitation deficit, the number of cells in the annual increment reached 57. It is worth mentioning that the width of radial growth throughout the season was almost identical in both sites. These relationships are confirmed by dendrochronological studies, which include an analysis of tree growth over the last 80 years. They indicate that the progressive increase in air temperature contributes to the improvement of forest ecosystems in the upper parts, and in particular in the forest boundary zone, where spruce expansion is taking place. For the vegetation period the width of annual growth rings is directly proportional to the temperature and inversely proportional to precipitation. These dependencies are reversed in the foothills zone. Therefore, the rising

temperature is responsible for the fact that thermal conditions in the lowest parts of the mountains are not optimal for the development of spruce, and in the abnormally warm and dry years even oppressive.

Growth response of silver birch and Norway spruce to climate and drought in young plantations on former agricultural land in southern Estonia

Sandra Metslaid[1]*, Cristina Marques*[1]*, Maris Hordo*[1]*, Aleksei Potapov*[1]

[1]Chair of Forest and Land Management and Wood Processing Technologies, Institute of Forestry and Engineering, Estonian University of Life Sciences, Estonia

Keywords: plantation forestry, drought resilience, land-use change, radial growth, climate adaptation

Understanding how tree growth responds to climate variability, and drought events in particular, is essential for predicting forest resilience in the face of global change. In the Baltic states, more afforestation has been initiated on former agricultural lands into new forest plantations in the 1990s following the restoration of independence. Although these plantations are still relatively young, they are becoming increasingly important for timber production, and mitigating climate change via carbon sequestration.

This study explores whether the change in land-use, specifically, the transition from agriculture to forest, affects the growth and drought resilience of two native tree species: silver birch (*Betula pendula*) and Norway spruce (*Picea abies*). It also examines how these effects are influenced by stand composition, comparing pure and mixed stands.

We assessed the relationship between radial growth and climatic variables, including temperature, precipitation and SPEI drought index, in trees sampled from multiple plantation stands of pure and mixed species. Using linear mixed-effects models, we assessed species-specific climate sensitivity and evaluated whether differences appeared in growth response to climate variation with regard to land use or stand composition.

Despite the relatively short time frame of the growth records, modelling approach allowed for robust comparisons by accounting for individual variability. Preliminary findings suggest that land-use change influences radial growth dynamics, particularly in spruce, and that mixed-species stands are associated with greater resilience to drought. These results contribute to a better understanding of the ecological implications of afforestation and underscore the potential of well-designed mixed plantations to support climate-adaptive forest management in the Baltic region.

Under pressure: How sand burial and climate shape Scots pine tree ring growth in wooded dunes at Cape Kolka

Megija Džeriņa[1], ***Madara Margita Muceniece***[1], *Iluta Dauškane*[1]

[1]University of Latvia, Faculty of Medicine and Life sciences, Department of Ecology

Keywords: sand-buried, *Pinus sylvestris*, Cape Kolka, wood anatomy

Wooded dunes along the Baltic Sea coast in Latvia constitute one of the most dynamic terrestrial ecosystems, where tree growth is strongly affected by intermittent sand burial and variable climatic factors. *Pinus sylvestris* is the dominant species in wooded dunes along the Baltic Sea coast. Despite their ecological significance, dendroecological studies of trees that have been sand-buried for multiple decades remain limited. Understanding growth patterns and quantitative anatomical characteristics of these trees is crucial for reconstructing past climate conditions, assessing long-term ecological changes, and detecting potential adaptations in wood anatomy associated with sand burial.

This study combines classical dendrochronological techniques with quantitative wood anatomy, focusing on parameters such as tracheid lumen area, which reflect xylem function and microstructural adaptation to environmental stress. Core samples were collected from four fallen or exposed trees, taken at three different heights: at the base, 10 centimetres below the sand-buried line, and 130 centimetres above it. A control group of five trees, visually still sand-buried, was also sampled with similar features. Tree cores from the control group were extracted as close to the ground as possible. Anatomical sections were prepared from cores at each height for one of the buried trees. The data series covers the period from 1907 to 2024.

While radial variation was observed, no consistent pattern emerged among the different radii at the same high. Preliminary analysis indicates that the average ring width of sand-buried trees is lower compered to control group. Despite difficulties encountered during core extraction and anatomical sectioning, the integration of quantitative anatomical data (lumen area) into dendroecological analysis enhances the resolution of growth response interpretation and offers new insight into tree functioning within morphodynamically active landscapes.

Wood densities of increment cores of tree species in Slovenia: preliminary results

Iza Petek[1], *Jožica Gričar*[1], *Philippe Jacquin*[2], *Jean-Michel Leban*[3], *Luka Krajnc*[1]

[1]Slovenian Forestry Institute, Večna pot 2, 1000 Ljubljana, Sloveni
[2]Université de Lorraine, AgroParistech, INRAE, SILVA, F-54000 Nancy, France
[3]INRAE, BEF, F-54000 Nancy, France

Keywords: wood density, X-ray tomography, increment cores, Slovenia

Wood density plays a key role in the mechanical, physical and technological properties of wood (Zhang, 1997; Polanc, Leban, 2004; Krajnc et al., 2020). Among other properties, it is an important indicator of wood quality (Polanc, Leban, 2004; Krajnc et al., 2020; Zhang et al., 2020), it is essential for biomass assessment and carbon cycle research (Knapic et al., 2014; Bouriaud et al., 2015), calculations of carbon stocks, and in tree biomechanics and the rate of decomposition of dead biomass (Chave et al., 2009).

To study the influence of site and stand conditions on the wood density of the most common tree species in forests across our country, we analysed 5 mm wide increment cores taken as part of sampling in the National Forest Inventory (NFI) plots in Slovenia. To obtain average wood density values for the samples, we used X-ray computed tomography (CT) on our data for the first time. Images of the samples, taken with a GE BrightSpeed Excel scanner, were analyzed with CarDen software (Jacquin et al., 2019).

A total of 621 tree cores belonging to 19 different tree species were analysed. The highest average values are achieved by pubescent oak (*Quercus pubescens*), namely 750 kg/m^3, and the lowest by Eastern white pine (*Pinus strobus*) with 410 kg/m^3. Interestingly, the average wood density values of sessile oak (*Quercus petraea*) and pedunculate oak (*Quercus robur*) differ by more than 50 kg/m^3. The average value for Norway spruce (*Picea abies*) is 420 kg/m^3, for silver fir (*Abies alba*) 430 kg/m^3, and for common beech (*Fagus sylvatica*) 610 kg/m^3.

References:

Bouriaud, O., Teodosiu, M., Kirdyanov, A.V., Wirth, C. 2015. Influence of wood density in tree-ring-based annual productivity assessments and its errors in Norway spruce. Biogeosciences, 12(20), 6205–6217, https://doi.org/10.5194/bg-12-6205-2015

Chave, J., Coomes, D., Jansen, S., Lewis, S.L., Swenson, N.G., Zanne, A.E. 2009. Towards a worldwide wood economics spectrum. Ecology Letters, 12(4), 351–366, https://doi.org/10.1111/j.1461-0248.2009.01285.x

Jacquin, P., Mothe, F., Longuetaud, F., Billard, A., Kerfriden, B., Leban, J.-M. 2019. CarDen: A software for fast measurement of wood density on increment cores by CT scanning. Computers and Electronics in Agriculture, 156, 606–617, https://doi.org/10.1016/j.compag.2018.12.008

Knapic, S., Pirralho, M., Louzada, J.L., Pereira, H. 2014. Early assessment of density features for 19 Eucalyptus species using X-ray microdensitometry in a perspective of potential biomass production. Wood Science and Technology, 48(1), 37–49, https://doi.org/10.1007/s00226-013-0579-y

Krajnc, L., Hafner, P., Vedenik, A., Gričar, J., Simončič, P. 2020. Meritve gostote lesa v slovenskih gozdovih. Gozdarski vestnik, 78(5–60), 234–241.

Polanc, J., Leban, I. 2004. Les – zgradba in lastnosti: učbenik za predmet Tvoriva v programu srednjega tehniškega oz. strokovnega izobraževanja za 1. letnik – lesarski tehnik. Ljubljana, Zveza lesarjev Slovenije, Lesarska založba, 176 str.

Zhang, S.Y. 1997. Wood specific gravity – mechanical property relationship at species level. Wood Science and Technology, 31(3), 181–191, https://doi.org/10.1007/BF00705884

Zhang, S., Belien, E., Ren, H., Rossi, S., Huang, J.-G. 2020. Wood anatomy of boreal species in a warming world: a review. iForest – Biogeosciences and Forestry, 13(2), 130, https://doi.org/10.3832/ifor3230-013

The effects of selective thinning on increment and earlywood vessel lumen area of *Quercus robur* L.

Kristaps Rutkovskis[1], *Agnese Anta Liepiņa*[1,2], *Roberts Matisons*[2]

[1] University of Latvia, Faculty of Medicine and Life Sciences, Jelgava Str. 1, Rīga, Latvia
[2] Latvian State Forest Research Institute "Silava", Rīga Str. 111, Salaspils, Latvia

Keywords: earlywood vessels, radial growth, pedunculate oak, cluster analysis

To enhance the survival and regeneration of pedunculate oak in hemiboreal forests, a selective removal of competing tree species and shrubs in the vicinity of oaks is practised. This specific management increases light availability for the remaining trees and their associated species, potentially improving growth. However, thinning can also alter the microclimate and introduce physiological stress, contributing to uncertainty regarding its long-term sustainability.

While tree-ring width is a common proxy for assessing growth and climatic responses, wood anatomical traits – such as earlywood vessel lumen area – may provide greater sensitivity to environmental variability. This study aimed to characterise the effects of thinning on both the tree-ring and earlywood vessel lumen area increment dynamics for pedunculate oak.

Increment cores were collected from 38 oak trees across two selectively thinned stands. The cores were prepared using a microtome and enhanced with black marker and white chalk to improve visual contrast. High-resolution scanned images were obtained using an 8-bit colour mode at 2,400 dpi. Tree ring width and area, as well as vessel lumen areas, were quantified from scanned radial increment cross-sections using CARROT (Resente et al., 2024). A chronology of tree ring width, mean vessel lumen area, mean vessel lumen area of the 20% of largest vessel lumens, and ratio of tree-ring area and total vessel lumen area was created for each stand. A chronological cluster analysis was performed for each proxy to determine whether thinning had altered growth trends or vessel sensitivity to environmental fluctuations. The observations of vessel lumen area variation were compared with previous measurements from local oak stands.

In the chronologies of both tree-ring series and vessel lumen area, a sudden decrease in their size was observed right after the year of stand thinning, however, the tree-ring width recovered within a few years and their size began to increase. The cluster analysis showed a slightly delayed change in the sensitivity of radial growth, while no significant effect was observed in the formation sensitivity of earlywood vessels.

References:

Resente, G., Fabio, A. di, Scharnweber, T., Gillert, A., Crivellaro, A., Anadon-Rosell, A., Trouillier, M., Kreyling, J., Wilmking, M. 2024. The importance of variance and microsite conditions for growth and hydraulic responses following long-term rewetting in pedunculate oak wood. Trees, 38, 1161–1175, https://doi.org/10.1007/s00468-024-02543-4

Effects of water level changes on Scots pine (*Pinus sylvestris* L.) growth in restored Estonian peatlands

Kärt Erikson[1], *Kristina Sohar*[1], *Ain Kull*[1]

[1]University of Tartu, Estonia

Keywords: dendroecology, peatland, *Pinus sylvestris* L.

Peatlands in Estonia have been, and continue to be, heavily affected by human activity, mainly through drainage. The main drivers of drainage have been forestry, agriculture, and peat extraction. Drainage alters mire hydrology and vegetation for decades, and when restoration efforts begin, the trees must again adapt to new environmental conditions in the mire.

In this study five Estonian peatlands located in southern, central, and western parts of the country were under investigation. All studied peatlands had undergone recent restoration works. Tree-ring samples were collected from Scots pines (*Pinus sylvestris* L.) growing in hydrologically and morphologically diverse study sites within each peatland. The samples were subsequently analysed using dendrochronological methods to assess the impact of climatic conditions and hydrological changes on tree growth.

Preliminary results indicate that trees can respond to rising water tables quickly. In one site, temporary increase in radial growth following the restoration works was observed. Interestingly, after the restoration works, growth patterns in control areas – specifically former peat extraction fields – closely resembled those found deeper in intact sections of the bog. Trees growing next to historic peat extraction pits (active in the early 20th century) in another site, did not benefit from the drainage. This suggests that over-irrigation may hinder rather than help tree growth in certain hydrological settings.

The findings highlight the complexity of peatland hydrology and the importance of site-specific approaches in restoration planning.

Legacy of human activities in tree-rings: Effects of war trenches and resin tapping on the growth and climate sensitivity of Scots pine (*Pinus sylvestris* L.) in Soontaga, Estonia

Liis Getliin Kala[1]*, Kristina Sohar*[1]

[1]Department of Geography, Institute of Ecology and Earth Sciences, University of Tartu, Estonia

Keywords: dendroecology, forest disturbance, anthropogenic impact, warfare dendrochronology, climate- growth relationships

Tree rings record historical growth conditions. Most of changes in growth conditions are weather-related but growth patterns of trees under direct human impacts also reflect cultural legacies. The dry boreal pine forest in Soontaga, Estonia has experienced several human impacts: regulation of moisture regime by damming and drainage in the late 19th century, II World War time defensive foxholes next to the trees, and pine resin extraction during the Soviet period since the 1950s. The resin tapping removed the bark and cambium from the trees and stopped growth at the scar while the rest of the stem stayed alive and continued to grow. The growth patterns of the former resin-tapped stands and overgrown defensive foxholes depict the landscape dynamics in Soontaga. In this study, we analysed 93 Scots pines (*Pinus sylvestris* L.) and built > 250-year tree-ring width chronologies for the Soontaga forest. We seeked to find out: (1) how climate influences radial growth at the forest stand; (2) how the mechanical root and stem damages caused by military trenching and resin tapping, respectively, affect the subsequent growth and climate sensitivity of Scots pine.

Drought sensitivity of oak trees in Romania under climate change

Cosmin Ilie Cuciurean[1]*, Cristian Gheorghe Sidor*[1]*, Mihai Lupescu*[1]

[1]National Institute for Research and Development in Forestry 'Marin Dracea', Bucharest, Romania

Keywords: dendrochronology, oak, drought sensitivity, climate change

Forest ecosystems are increasingly vulnerable to climate change, particularly due to rising temperatures and more frequent droughts, which significantly impact the adaptability and resilience of ecosystem services. Climate variability also directly influences tree growth dynamics. Although oaks are generally tolerant to drought episodes, they remain vulnerable to severe water stress. Successive drought events disrupt physiological processes such as water transport and carbon metabolism, making trees more susceptible to additional abiotic and biotic stresses. Together, these factors may contribute to progressive tree mortality.

To improve our understanding of the dendroclimatic responses of oaks to climate variability, we analysed the radial growth of oak trees across an elevation gradient in Romania. Growth samples were collected from 30 plots, categorized into three elevation groups. We assessed oak responses to temperature and precipitation variability using bootstrap Pearson correlations, based on aggregated daily climatic data and residual growth chronologies. Preliminary results show a positive relationship between radial growth and summer precipitation, particularly at lower elevations, and a negative relationship with summer temperatures, again most pronounced at lower elevations.

Within each elevation group, we identified negative pointer years based on the percentage of sites recording significantly reduced growth. Our results reveal divergent growth patterns along the elevation gradient but also highlight shared drought-impacted years (notably 1968, 2003, 2013, and 2020). For these years, we calculated resilience indices, finding that oak trees below 300 m elevation exhibit lower drought resistance compared to those between 300–450 m and above 450 m.

The observed increased sensitivity of oaks to drought suggests that projected climate change could significantly alter forest ecosystem dynamics in Romania.

Adapt or fall: species-specific wind resistance in the Eastern Baltic region

Andris Seipulis[1], *Roberts Matisons*[1], *Oskars Krišāns*[1]

[1]Latvian State Forest Research Institute "Silava", Salaspils, Latvia

Keywords: European beech, silver birch, wind damage, static tree-pulling test, mechanical stability

Wind is the major cause of the steadily increasing damage to the growing stock of European forests, presenting both socioeconomic and ecological challenges. To a certain extent, this can be mitigated through adaptive, close-to-natural forest management, accounting for species-specific differences in mechanical stability. Tree resistance to wind loading, referred to as mechanical stability is the ability of trees to withstand fatal failure such as uprooting or stem breakage. It can be effectively quantified using static tree-pulling test.

The aim of this study, conducted in the hemiboreal forest zone of the Eastern Baltic region, was to compare the wind-loading resistance of Eurasian aspen, silver birch, Scots pine, Norway spruce, European beech, and pedunculate oak. Uprooting was the prevailing failure type of fatal failure for most of the studied species, suggesting that stems being stronger than roots, yet this was species-specific. The loading resistance of beech and birch differed significantly from that of aspen, oak, pine, and spruce. Beech exhibited a logarithmic relationship between tree size and mechanical stability, indicating reduced loading resistance for larger individuals. In contrast, birch showed an exponential relationship, with resistance increasing as trees aged and became dominant.

As hemiboreal stands in the Eastern Baltic region face intensifying natural disturbances driven by climate change and a northward shift in species distribution, the expansion of more thermophilic species such as beech is expected. However, the rapid decline in mechanical stability among older and larger beech individuals may point to an incomplete adaptation to local conditions – potentially making mature beech stands more vulnerable to wind damage compared to birch.

Guidelines on minimum requirements for dendrochronological analyses and reports

Niels Bleicher[1], François Blondel[2], Matthias Bolliger[3], John Francuz[4], Ronny Friedrich[5], Raymond Kontic[6], Fabien Langenegger[7,8,9], Markus Leibundgut[3], Andrej Maczkowski[4], Sebastian Million[10], Bernhard Muigg[11,12], Oliver Nelle[10], ***Monika Oberhänsli****[13], Klaus Pfeifer[14], Erhard Preßler[15], Martin Schmidhalter[16], Kirsten Schwabe[5], Till Seibert[17,18], Mathians Seifert[19], Markus Stoffel[2], Willy Tegel[11,12], Felix Walder[1]*

[1]Competence Centre for Underwater Archaeology and Dendrochronology, 8008 Zurich, Switzerland
[2]Climate Change Impacts and Risks in the Anthropocene (C-CIA) Chair, Institute for Environmental Sciences, University of Geneva, 1205 Geneva, Switzerland
[3]Laboratory for Dendrochronology, Archaeological Service of Canton of Bern, 2572 Sutz-Lattrigen, Switzerland
[4]Laboratory for Dendrochronology, Institute of Archaeological Sciences, University of Bern, 3012 Bern, Switzerland
[5]Research Laboratory CEZA, Curt-Engelhorn-Zentrum Archäometrie gGmbH, 68159 Mannheim, Germany
[6]Dendron, 4056 Basel, Switzerland
[7]Office du patrimoine et de l'archéologie, 2000 Neuchâtel, Switzerland
[8]Woodcenter Sàrl, 1452 Les Rasses, Switzerland
[9]Laboratoire de Dendrochronologie, Musée du Laténium, 2068 Hauterive, Switzerland
[10]Tree-ring Laboratory, State Office for Cultural Heritage Baden-Württemberg, 78343 Gaienhofen-Hemmenhofen, Germany
[11]Chair of Forest History, Institute of Forest Sciences, University of Freiburg, 79106 Freiburg, Germany
[12]Laboratory for Dendrochronology, Archaeological Service of Canton of Thurgau, 8510 Frauenfeld, Switzerland
[13]Laboratory for Dendrochronology, Archaeological Service of Canton of Grisons, 7001 Chur, Switzerland
[14]Laboratory for Dendro(chrono)logy, 6863 Egg, Austria
[15]Erhard Preßler, Preßler GmbH, Planung und Bauforschung, 49838 Gersten/Emsland, Germany
[16]Dendrosuisse, Laboratory for Dendrochronology, 3900 Brig, Switzerland
[17]Bau- und Verkehrsdepartement des Kantons Basel-Stadt, Kantonale Denkmalpflege, Bauforschung, 4058 Basel, Switzerland
[18]Till Seiberth Dendrochronologie und Bauforschung, Basel, Switzerland
[19]Laboratory for Dendrochronology, 7001 Chur, Switzerland

Keywords: dendroarchaeology, guidelines, transparency, open data

Dendrochronology is a scientific method and has to be carried out according to scientific criteria, which implies transparency, logic and replicability. Out of the need to define and establish standards for practical scientific work in dendroarchaeology, in 2024 various laboratories in Switzerland and neighbouring countries have jointly agreed on minimum standards for dendrochronological analyses and reports. The fact sheet in German, French, Italian and English is available at the following permalink:

https://www.gr.ch/DE/institutionen/verwaltung/ekud/afk/adg/dienstleistungen/untersuchen/Seiten/factsheet-dendro.aspx

Participation is open to all interested dendroarchaeologists and institutions. To become part of our community, please send an email with your name(s) and affiliation to the above email address.

Radial growth response to meteorological factors in native pedunculate oak and introduced Northern red oak

Diāna Jansone[1]*, Roberts Matisons*[1]*, Didzis Elferts*[1]*, Āris Jansons*[1]

[1]Latvian State Forest Research Institute "Silava", Salaspils, Latvia

Keywords: oak, meteorological factors, growth response

Climate change is exerting a profound influence on global weather patterns, necessitating adaptive strategies to support the resilience of forest ecosystems. Among the proposed approaches are assisted migration, the enhancement of gene flow, and the introduction of non-native species that may contribute to the establishment of forests better equipped to withstand future climatic stresses. The Northern red oak (*Quercus rubra* L.) has emerged as a particularly promising candidate for such efforts, owing to its rapid growth rate, wide-ranging applications in timber production, and presumed high tolerance to climatic variability. The objective of this study was to evaluate the climate sensitivity of the native pedunculate oak (*Quercus robur* L.) in comparison with the introduced Northern red oak, with a focus on identifying key climatic factors that constrain growth. Six forest stands were selected for analysis, two of which included both oak species. A total of 240 increment core samples were extracted using a Pressler borer – 120 per species and 30 per site. Sampling was limited to dominant, visibly healthy trees, and measurements of tree height and diameter were recorded. The cores were progressively sanded and analysed for annual ring width using the LINTAB 5 system in conjunction with TSAP software. Tree-ring series were subsequently crossdated, detrended, and prewhitened. Statistical analyses included bootstrapped Pearson correlation to evaluate the relationship between ring width and meteorological variables, followed by cluster analysis and linear mixed-effects modelling. Findings indicated that summer precipitation and the standardized precipitation evapotranspiration index (SPEI) were the principal climatic constraints for both oak species. Cluster analysis generally revealed similar responses to climatic variables across species; however, one notable exception indicated that growth responses were more strongly influenced by site-specific conditions than by species identity, suggesting a dominant effect of local environmental factors on tree growth dynamics.

The effect of wildfire on radial growth of Scots pine (*Pinus sylvestris* L.) in Slitere National Park

Māra Kitenberga[1]*, Roberts Matisons*[1]*, Ieva Jaunslaviete*[1]*, Didzis Elferts*[1]

[1]Latvian State Forest Research Institute "Silava", Rīgas Str. 111, Salaspils LV-2169, Latvia

Keywords: wildfire, tree-rings, sensitivity, climate, hemiboreal forests

The short- and long-term impact of wildfire on forest ecosystems is strongly influenced by the intensity and severity of burning event. In the European hemiboreal forest zone, majority of forest fires are low-to-medium severity, driving development of cohort dynamics. Mature Scots pine (*Pinus sylvestris* L.) trees can survive several forest fires due to their adaptive traits, however, the effect of non-lethal forest fires on climate-growth relationships is scarcely studied. We aimed to assess the effects of non-lethal wildfire on the subsequent formation of the increment of Scots pine and its sensitivity growing in nutrient-poor sandy soil conditions in the hemiboreal forest zone. Tree-ring width chronologies of Scots pine from Slitere National Park, which was affect by forest fire in 1992, were used. We sampled mature Scots pine trees, which have survived the severe wildfire of 1992, yet did not have severe fire-caused damages like visible fire scars. The control area was located nearby in a mature Scots pine-dominated forest stand unaffected by the wildfire. For data analysis, we used tree-ring width time series from 48 burnt pines, and 23 from the control trees. The analysis was conducted over the common period 1970– 2014. To estimate the sensitivity of TRW in relation to the wildfire hierarchical clustering was used. The bootstrapped (non-parametric, stationary) Pearson correlation analysis and mixed-effect model were employed to reveal effects of wildfire on responses of increment to meteorological variables.

Hierarchical clustering revealed two distinct periods for the burned pines (1970–1992 and 1993–2014), whereas in the control areas, a rather similar division was estimated (1970–1991 and 1992–2014). The bootstrapped Pearson's analysis showed 18 significant correlations, the most stable over the common, pre- and post-fire periods were monthly amount of precipitation in previous August, and drought in previous August and September. The linear mixed effect model showed that fire had significant influence on weather-growth relationships, and the most important weather factors were precipitation amount in August, precipitation amount in previous August and mean temperature previous in autumn (November) and winter (December).

Can drainage facilitate drought?

Kārlis Bičkovskis[1], *Guntars Šņepsts*[1], *Jānis Donis*[1], *Āris Jansons*[1], *Diāna Jansone*[1], *Ieva Jaunslaviete*[1], *Roberts Matisons*[1]

[1]Latvian State Forest Research Institute "Silava", Salaspils, Latvia

Keywords: drained forest, ditch network maintenance, increment analysis, anthropogenic disturbance, forest hydrology

Drainage networks are widely applied to enhance forest productivity in the hemiboreal zone, yet their maintenance can have both positive and negative consequences for tree growth and site hydrology. Radial increment of Scots pine, Norway spruce, and silver birch on drained organic and mineral soils following ditch network maintenance (DNM) was examined. Growth responses were analysed in relation to species, site type, and stand characteristics. The study aimed to assess whether DNM enhances stem growth, particularly for conifers, while testing the hypothesis that it may also increase the risk of over-drainage under increasing drought effects.

Funding: This study was conducted as part of the Latvia Council of Science national research program "Forest4LV – Innovation in Forest Management and Value Chain for Latvia's Growth: New Forest Services, Products and Technologies" (No. VPP-ZM-VRIIILA-2024/2-0002).