Book of abstracts

Baltic dendrochronologist conference "BaltDendro 2026"

Vētraine, Latvia, August 17th–19th, 2026

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

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Long-term scientific study of the old-growth forests and other landscape elements in Latvia

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Keywords: old-growth forests, iLand model, deadwood

The essential role of forests in achieving ambitious climate neutrality targets and ensuring the stability of biological diversity is confirmed by various European Union (EU) legal acts and policy planning documents, which stipulate that the results obtained must be based on high-quality scientific information. In 2024, the Nature Restoration Law entered into force, which provides that, using scientifically based monitoring, it will be necessary to assess various terrestrial ecosystems, including forests, to improve the quality of habitats where it is assessed as unsatisfactory. Overall, the goal of the Nature Restoration Law is to encourage EU Member States to implement extensive measures to restore nature and environmental values, and to ensure a sustainable, biologically diverse future for all EU inhabitants. To achieve this, before designating areas to be restored, it is necessary to carry out a qualitative and quantitative assessment of habitats, initially compiling data on the overall distribution of habitats, their areas, and their current locations in the national territory, and only thereafter assessing their condition. In Latvia, National Forest Inventory data are available, enabling assessment of several indicators of the Nature Restoration Law, such as standing and lying deadwood, the proportion of forests with an uneven age structure, tree-species diversity, and the share of forests dominated by autochthonous tree species.

The aim of the Study is to ensure monitoring in forest stands that have not been affected by economic activity for a long time, as well as the long-term scientific investigation of other landscape elements, in order to prepare and provide information to Latvian decision-makers and stakeholders on the balanced implementation of nature conservation and bioeconomy interests in the forest landscape.

To achieve the aim of the study, the following tasks are planned:

1) To assess the impact of climate change and natural disturbances on landscape development using the ecosystem dynamics simulation model iLand;
2) To collect data for reference values of the indicators defined in the Nature Restoration Regulation by characterising deadwood in forest stands that have been unaffected by economic activity for a very long time in Slītere National Park;
3) To maintain monitoring of old forest stands by ensuring remeasurement of old spruce stands (five-year cycle) and data collection in reference stands, and by analysing the dynamics of changes in biodiversity indicators (deadwood, stand structure, species).

Study is supported by the Forest Development Fund project (agreement No. 26-00-S0INZ03-000005).

Genetic and edaphic effects on sensitivity of Scots pine tree-rings

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Keywords: heritability, genetic interactions, tree-ring width, resilience components, tree breeding

The intensifying climatic changes require agile and adaptive management, in which tree breeding plays a crucial role. Assessment of G × E interactions is crucial for targeted breeding via improving coupling of the demands of genotypes and local conditions. The genetic effects are evaluated for morphometric traits, which can be outdated by climatic changes. In this study, the variability of increment and its relation to weather fluctuations were addressed as a climate-sensitive functional trait. Parallel Scots pine (*Pinus sylvestris*) progeny trials across productivity (edaphic) gradient in Lithuania were studied, combining tree-ring analysis and quantitative genetics. Scots pine progenies showed low environmental sensitivity, which, however, showed complex region-specific relationships with climatic variables. Negligible genetic controls were estimated for sensitivity of increment, yet the genetic controls manifested in response to the co-occurrence of meteorological extremes. The genetic control over the increment showed some relationships with productivity, being strongest under oligotrophic and eutrophic sites. Site productivity showed slight effects on climatic controls over heritability estimates. Hence, the observed relationships suggest some informativity of climate-sensitive functional traits for genotype selection at the strategic level.

Tree-ring $\delta^{13}C$ reveals climatic control and delayed industrial effects on Scots pine intrinsic water-use efficiency

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Tree-ring stable carbon isotopes provide valuable insight into long-term forest physiological responses to environmental change. We investigated inter-site divergence in intrinsic water-use efficiency (ΔiWUE) and radial growth (ΔBAI) of Scots pine (*Pinus sylvestris* L.) between a historically polluted site and a comparatively less affected control site in northern Lithuania during 1933–2022. Intrinsic water-use efficiency was reconstructed from tree-ring $\delta^{13}C$ measurements and analysed in relation to climatic variability and historical industrial emissions. Both ΔiWUE and ΔBAI showed increasing divergence beginning in the early 1990s. Mean ΔiWUE increased significantly after 1990, while ΔBAI shifted from negative to positive values, indicating a reversal in relative growth performance between the sites. Physiological and growth divergence were moderately correlated ($r = 0.45$, $p < 0.001$).

Generalized additive models demonstrated that climatic variability was the dominant control on inter-site ΔiWUE divergence. Differences in growing-season precipitation explained the largest proportion of deviance among climatic predictors and exhibited significant nonlinear relationships with ΔiWUE. After accounting for temporal and climatic structure, industrial emissions showed additional delayed effects. Lagged sulfur dioxide emissions produced the strongest pollution-related response, whereas carbon monoxide had weaker effects and nitrogen oxides were not significant.

The results indicate that moisture availability is the principal driver of long-term physiological divergence in Scots pine, while industrial pollution exerts secondary but temporally delayed influences. The study highlights the importance of accounting for nonlinear temporal structure and legacy effects when interpreting tree-ring isotope records from industrially affected environments.

Climate signals of Scots pine (*Pinus sylvestris* L.) in different sites of the Rannametsa–Tolkuse coastal landform complex, Estonia

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Keywords: Scots pine, dendroclimatology, dunes, bog, moisture gradient

The aim of this study was to investigate the relationships between the radial growth of Scots pine (*Pinus sylvestris* L.) and climatic factors along a relief and moisture gradient in the Rannametsa–Tolkuse area in southwestern Estonia. The transect comprised seven plots extending from dry mineral soils on dune ridges to wet peatlands. At each plot, two increment cores were collected from 15 Scots pine trees, resulting in a total of 210 cores. Standardized tree-ring width chronologies were correlated with monthly temperature and precipitation data from the Pärnu meteorological station for the period 1956–2025. Both static and dynamic climate–growth relationships were examined, together with radial-growth responses during selected pointer years. The results show that local site conditions modify the climate signal recorded in tree rings. At drier dune sites, interannual growth variability was greater, and the signal of early-spring temperature was more pronounced than in wet peatland habitats. In the core of the peat bog, growth was controlled by late-summer precipitation, indicating sensitivity to drought. Contrary to expectation, top of the dune was not sensitive to drought.

When water returns: growth response of Scots pines in restored peatlands

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Keywords: rewetting, dendroecology, bog, growth change, *Pinus sylvestris* L.

Peatlands have been drained for centuries, primarily for forestry, agriculture, and peat extraction in Estonia. Drainage alters mire hydrology and vegetation over the long term by lowering the water table and thereby improving conditions for tree growth. Restoration aims to re-establish a near-natural hydrological regime by raising the water table, requiring trees to readapt to environmental conditions that may constrain growth. This study aimed to assess how Scots pine growth responds to restoration-induced increases in water-table levels across contrasting peatland sites.

Four restored peatlands were investigated in Estonia. Restoration measures included ditch blocking for a raised water table, tree thinning, and mechanical spreading of peat moss fragments. All study sites underwent restoration between 2019 and 2021. At one site, however, the water table had already been raised approximately five years earlier as a result of beaver damming. This provided an opportunity to evaluate tree-growth responses over a longer time, assessing post-restoration growth up to six years after water-level recovery. Increment cores were collected from Scots pine (*Pinus sylvestris* L.) growing in hydrologically contrasting locations across the peatland. Tree-ring series were analysed using dendrochronological methods to assess the effects of hydrological changes on tree growth.

Preliminary results indicate that trees respond rapidly to rising water levels. In the short term, this response may be primarily reflected in higher spatial variability in tree growth. In most peatlands, mean tree-ring chronologies exhibited long-term decline in growth within previously drained areas. However, some sites may show a temporary increase in growth following restoration, assuming light availability and short-term nutrient availability were simultaneously enhanced. Former peat-cutting areas and adjacent higher ground showed no significant differences in overall growth rates; however, clear differences were observed in the timing of growth initiation. The results also indicate that natural processes may be as effective as anthropogenic activities in raising water levels, although this requires further investigation.

The study highlights the strong influence of hydrological conditions on tree growth in restored peatlands, while also revealing substantial variation among sites. Such variability indicates that restoration outcomes cannot be predicted solely from changes in water-table levels and should be evaluated within the broader ecological context of each peatland. At the same time, the relatively rapid growth responses confirm the sensitivity of peatland trees to hydrological changes.

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

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

Radial growth of Scots pine (*Pinus sylvestris* L.) has preserved a multi-century record of both climatic forcing and discrete anthropogenic disturbances in the dry boreal forest of Soontaga, Estonia. The forest has experienced several human impacts, and this study paid particular attention to the effects of World War II defensive foxholes and pine resin tapping during the Soviet period. The study was based on increment core data from 95 Scots pines, including targeted sampling of stems affected by defensive foxholes and resin-tapping scars. Tree-ring width chronologies spanning more than 250 years were built. Mean standardised growth chronologies were constructed for different tree groups to analyse climate–growth relationships using long-term precipitation and temperature data. The impact of human-induced disturbances was assessed using raw tree-ring width series, which enabled the evaluation of disturbance-induced growth asymmetry. Consistent with previous studies, growth of Scots pine was predominantly controlled by February–April warmth, which exerted the strongest positive influence across all age and disturbance classes. Mechanical root and stem damage caused by trenching and resin tapping resulted in a local short-term suppression of radial growth in the affected parts of the stem, with growth reductions lasting up to a decade in several cases. During this period, climate sensitivity weakened slightly, particularly in the resin-tapped trees, before normal temperature-driven growth responses re-established.

Watching how wood forms: tracking weekly anatomical changes in Scots pine and Norway spruce

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Keywords: xylogenesis, critical dates, phenology, *Pinus sylvestris*, *Picea abies*, drought

Monitoring wood formation at high temporal resolution offers valuable insights into the environmental factors regulating tree growth. Weekly microcoring enables detailed characterization of xylem development throughout the growing season. To examine how temperature, precipitation, and other weather conditions influence wood formation, we determined the onset and cessation of cell enlargement and wall thickening and quantified cell production dynamics. This study was conducted in a hemiboreal forest stand in Järvselja, Estonia. Scots pine *(Pinus sylvestris*) and Norway spruce (*Picea abies*) were monitored over two growing seasons (2018–2019) to identify species-specific patterns and evaluate their relationship with weather conditions including the pronounced moisture deficit of 2018.

Results revealed clear differences between the two species. Scots pine started wood formation earlier (~ 4 May) and maintained a longer total period of xylem development (143 days). In contrast, Norway spruce showed a later onset (~ 14 May) and earlier cessation of wood formation after (110 days). Despite contrasting moisture conditions between the two years, no significant year effect on the timing of wood formation was detected, indicating relatively stable phenological patterns. While this high-resolution monitoring over two consecutive years establishes a baseline for the Baltic region, expanding long-term monitoring across additional sites will be essential to further scale these species-specific cellular dynamics and refine predictions of future forest responses under changing climatic conditions.

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Preliminary wood anatomical characteristics of Norway spruce

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Keywords: *Picea abies*, wood anatomy, plantation forestry, stand composition, climate

Plantation forestry offers the opportunity to produce wood on non-forest land, such as former or low-value agricultural areas or reclaimed quarry sites, thereby reducing pressure on natural forests. This study focuses on Norway spruce (*Picea abies*), one of the most important tree species in Estonia, and examines the main drivers shaping wood anatomical structure in plantation-grown trees.

Wood samples were collected from 20–25-year-old plantations established at three sites in southern Estonia (Valga, Tartu and Viljandi counties), including both pure spruce stands and mixed Norway spruce-silver birch stands. A total of 12 trees were sampled across six plots, with one smaller and one average-sized tree selected per plot. Transverse sections (10–15 μm thick) were prepared, and permanent microscopic slides were scanned (2.27 pixels μm^{-1}). Wood anatomical traits (cell lumen area, cell wall thickness and area, and wood density) were measured using ROXAS software. Climatic data (temperature and precipitation) were obtained from nearby weather stations, and used to derive the SPEI drought index. The influence of stand composition, tree size and growth rate, and climatic conditions on wood anatomical variation was evaluated using linear mixed-effects models.

Preliminary results indicate that radial development, reflecting tree height growth, was the dominant driver of wood anatomical variation. Ring width also explained a substantial portion of the observed variation. Climatic conditions influenced specific anatomical traits, particularly lumen area and cell wall thickness. For SPEI, climate–anatomy relationships differed among months and accumulation periods, suggesting that short- and longer-term moisture availability influences distinct stages of tracheid development. Stand composition contributed relatively little to overall anatomical variation.

These initial findings indicate that wood anatomical structure in Norway spruce is primarily controlled by growth and climatic factors, with only a minor influence of stand-level characteristics such as species composition. This suggests comparable wood quality between forest and plantation sites and supports the potential of plantation forestry as an efficient approach to wood production. As additional samples are analysed (including those from natural forests), these conclusions will be further verified.

Growth and late-frost damage among phenological forms of Norway spruce in Estonia

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Keywords: *Picea abies*, radial increment, height increment, frost rings, phenology

Norway spruce (*Picea abies* (L.) H. Karst.) trees within a population can be classified into phenological forms based on the timing of bud burst. In Estonia, bud burst in spruces occurs from May to June, and early- and late-flushing phenoforms (EF and LF, respectively) typically differ in bud break timing by two to four weeks, depending on spring temperatures. Because EF and LF trees experience different environmental conditions at the beginning of the growing season, EF trees, for example, may be more prone to late-frosts, and such conditions may contribute to differences in productivity between the phenoforms. However, studies considering phenological forms in Norway spruce are scarce.

We accounted for phenological forms in the analyses of tree growth measurements from the Free Air Humidity Manipulation (FAHM) experimental site in south-eastern Estonia and six stands located across Järvselja Training and Experimental Forestry District. In FAHM site, spruces planted in 2020 are growing in 9 study plots (diameter 14 m), which include 3 controls, 3 plots with elevated air humidity (by 5–7%), and 3 plots with elevated soil moisture (by 15%). These treatments follow the regional climate change projections by 2100 (IPCC). Trees in studied forest stands were planted in 2013, 2016 or 2021. Phenological forms were differentiated based on effective temperature sums (ETS, threshold +5°C) accumulated by the day of bud burst: ETS = 130 ± 18°C and 217 ± 26°C for EF and LF spruces, respectively (Sellin et al. 2024). We also conducted tree-ring analyses and inspected stems and crowns to detect possible late-frost damage that occurred at the beginning of June 2023.

After three growing seasons at the FAHM, differences between phenoforms were significant under the elevated air humidity treatment, with LF showing greater height and radial increment (Sellin et al. 2024). In forest stands, LF trees were significantly higher and had larger diameter irrespective of age class. Late-frost damage in 2023 was evident on stems in the forest stands, with EF spruces being more severely damaged. Distinct frost rings were formed in all studied EF trees, whereas frost rings in LF trees were either absent or only weakly developed. Our results indicate that late-flushing Norway spruce shows better growth performance and higher wood quality under changing climatic conditions.

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Introduced red oak vs common oak: insights into growth and climate sensitivity under changing climate conditions in Estonia

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Keywords: *Quercus rubra*, *Quercus robur*, tree-ring width, drought resilience, basal area increment, Baltic region

Introduced tree species are increasingly considered potential components of climate-adaptive forestry. Their successful use depends on multiple characteristics, including high productivity, resilience to climatic stress, survival, and other economically important traits. Northern red oak (*Quercus rubra* L.) is regarded as one of the most productive introduced broadleaved tree species in Europe, yet information on its long-term performance near the northern limit of its cultivation range remains scarce.

In Estonia, northern red oak has been present for more than a century, primarily in parks and manor estates, whereas its use in forestry has remained limited. Consequently, mature forest stands suitable for dendrochronological research are rare, and long-term studies under forest conditions remain scarce. Although studies from Central Europe and southern Sweden have demonstrated superior growth of northern red oak relative to native oaks, it remains unclear whether this growth advantage is maintained under Estonian climatic conditions or whether it is associated with differences in climate sensitivity and drought response compared with native common oak (*Quercus robur* L.).

To address this knowledge gap, we compared growth performance, climate sensitivity, and drought resilience of introduced northern red oak and native common oak at two forest sites in Estonia using basal area increment, tree-ring chronologies, climate-growth analyses and drought-response indices.

Preliminary results indicate that northern red oak maintains substantially greater stem productivity than common oak. However, drought-related analyses revealed species-specific growth responses, with northern red oak exhibiting lower drought resistance and resilience despite similar post-drought recovery. These findings suggest a trade-off between high productivity and drought resilience, highlighting the importance of considering both growth potential and climatic resilience when evaluating the long-term suitability of introduced tree species for forestry under future environmental conditions.

Bridging scales in dendrochronology: from cellular anomalies to landscape upscaling for climate-smart forestry in Estonia

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Keywords: dendrochronology, xylogenesis, blue rings, forest drainage, remote sensing, climate-smart forestry

In hemiboreal forest ecosystems, accelerating climate change alters site water balances, prolongs thermal growing seasons, and increases forest exposure to weather extremes (Kollo et al. 2023). To support climate-smart forestry, the dendrochronology research group at the Estonian University of Life Sciences has synthesized multi-scale retrospective tree-growth evidence to better understand forest resilience and adaptation.

At the microscale, intra-annual monitoring of xylogenesis indicates that the timing of wood-formation onset and cessation remained relatively stable between two years with contrasting moisture conditions (Marques et al. 2026). However, cell production rates and the duration of successive wood-formation phases varied with annual moisture conditions and climatic variability. Under extreme temperature events, such as the severe autumnal cooling of 1976, latewood cell-wall lignification may remain incomplete, resulting in distinct blue rings (Greaves et al. 2023). Quantitative confocal fluorescence microscopy confirmed a marked reduction in the lignification of latewood tracheid walls within a Scots pine blue ring (Greaves et al. 2025). These cellular observations demonstrate that short-term climatic extremes can modify wood formation and chemical maturation even when their effects are not clearly expressed in annual ring width, making blue rings valuable anatomical indicators of environmental stress.

At the mesoscale, these cambial responses aggregate into stand-level dynamics mediated by site hydrology, forest structure, and genetic origin. Height growth models demonstrate direct and carry-over temperature effects, with conditions during the preceding late summer and autumn influencing current-season terminal leader growth; however, the strength and direction of these relationships vary regionally (Matisons et al. 2023).

Long-term peatland forestry studies demonstrate drainage can induce a non-linear and time-lagged increase in the basal area growth of Scots pine (*Pinus sylvestris* L.; Potapov et al. 2023). The modelled additional basal area increment reached its average maximum approximately 16 years after drainage. Smaller trees showed a greater relative growth response, whereas larger and previously faster-growing trees tended to respond more rapidly. The magnitude and timing of the response also depended on pre-drainage tree and stand structure. Recent studies of ditch-network reconstruction complement these long-term findings by examining short-term changes in groundwater level, tree height growth, and wood density (Potapov et al. 2022, 2024). Regional peatland chronologies also show synchronous growth releases across Estonia, Belarus, and Sweden, suggesting that broad-scale hydroclimatic fluctuations influence peatland pine growth alongside local drainage history (Potapov et al. 2019).

Stand structure and genetic origin further mediate forest growth and adaptive responses. A common-garden evaluation of Baltic Norway spruce (*Picea abies* (L.) Karst.) provenances in Estonia revealed substantial differences in survival, growth, and stem quality. Several southern and intermediate-latitude provenances combined strong growth performance with favourable stem quality and a relatively low incidence of stem cracks, emphasizing the importance of provenance-specific assessment when selecting reproductive material for future forests (Maaten et al. 2025).

At the macroscale, tree-ring observations from individual plots and regional chronology networks can be spatially upscaled by integrating them with satellite remote sensing, topographic information, and high-resolution climate data (Jevšenak et al. 2024). Species-specific models combining Sentinel-1 and Sentinel-2 variables with topographic and gridded climate data were used to generate spatially continuous estimates of annual tree-ring width, including a landscape-scale growth map for Central and Eastern Europe for 2021.

Overall, this multiscale framework demonstrates that optimizing the timing of silvicultural interventions, species and provenance selection, the assessment of hydrological interventions, and regional growth monitoring requires mechanistic knowledge of tree growth to be integrated with site-specific hydrological and ecological conditions. Together, these studies show that forest climate responses cannot be inferred from species identity alone. Linking cellular mechanisms with multi-year stand responses and spatial monitoring provides an empirical basis for site-specific silviculture, evidence-based assessment of drainage and ditch-reconstruction effects and regional forest-growth assessment under increasing climatic uncertainty.

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Fast growth, higher sensitivity? *Quercus rubra vs Quercus robur* in Latvia

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Keywords: Quercus, non-native tree species, climate-growth relationships, radial increment, dendrochronology

Forest management strategies require a clear understanding of how different tree species respond to climatic variability, particularly as climate change continues to modify environmental conditions and increase the frequency of biotic stressors. Evaluating the adaptive potential of both native and introduced species is therefore important for maintaining forest productivity and resilience. This study investigates the radial growth dynamics and climatic responses of the introduced northern red oak (*Quercus rubra*) and the native pedunculate oak (*Quercus robur*) within the hemiboreal forests of Latvia. Tree-ring analyses were used to quantify growth patterns and assess relationships between annual growth and climatic factors. The results indicate that *Q. rubra* achieved greater radial growth and responded more strongly to interannual climatic variation, whereas growth of *Q. robur* was more strongly associated with local site characteristics. Moisture availability, especially precipitation during June and July and the occurrence of drought, represented the main climatic constraint on growth for both species, while temperature exerted a comparatively weaker influence. These contrasting growth responses suggest that *Q. rubra* has the potential to increase stand productivity where moisture conditions are favourable, whereas *Q. robur* may provide more consistent growth under environmentally variable or less favourable sites. The study provides evidence to support species selection and silvicultural planning for climate adaptation in Latvia's hemiboreal forests, indicating that *Q. rubra* could serve as a valuable complementary species under suitable site conditions.

The effects of historic land use on the growth dynamics of pedunculate oak (*Quercus robur*)

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Keywords: Pedunculate oak, *Quercus robur*, historic land use

Historic land use is a major driver of tree morphology and stand development, with its effects often persisting for centuries. Pedunculate oak *(Quercus robur*) established in former agricultural or other open landscapes typically develops shorter, thicker stems, broader and more expansive crowns, and lower branching heights. In contrast, oaks in forests generally exhibit taller, more slender stems, narrower crowns, and higher branching heights as a result of competition for light. Despite these well-documented differences, quantitative comparisons of growth dynamics across contrasting land-use histories remain limited.

This study aimed to evaluate differences in the growth dynamics of pedunculate oak growing in forest- and agricultural-origin stands. Field sampling is planned in 14 oak stands, comprising six stands of agricultural origin and eight stands of forest origin, with 10 trees sampled per stand. For each tree, total height, diameter at breast height (DBH), height of the first major branch, crown height, crown projection area, number of primary branches, branch angle relative to the stem, and crown asymmetry will be recorded. These measurements will be analysed alongside tree-ring and vessel lumen area data collected as part of a previous study to investigate the influence of historic land use on oak radial growth dynamics.

It is hypothesised that trees growing in forest-origin stands would exhibit narrower annual growth rings, together with taller, more slender stems and more uniform, symmetrical crowns. Conversely, trees in agricultural-origin stands are expected to display wider growth rings, larger stem diameters, broader and more asymmetric crowns, lower branching heights, and wider branch angles, reflecting the high morphological plasticity and sensitivity of pedunculate oak to growing conditions during stand establishment. The findings will contribute to a better understanding of the long-term legacy of historic land use on the structure and development of pedunculate oak and provide valuable information for the management of veteran oak populations.

Using the Cell And Ring RecOgnition Tool (CARROT) to evaluate hydraulic responses of pedunculate oak to selective stand thinning

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Keywords: *Quercus robur* L., oak release, conservation management, vessel lumen area, tree ring width

Selective removal of Norway spruce from oak-dominated stands is employed to improve habitat conditions for light-demanding biodiversity associated with mature oaks, although its consequences for the long-term vitality and hydraulic functioning of retained trees remain uncertain. Quantitative wood anatomy has the potential to improve understanding of such responses, and recent developments in automated image analysis have increased the feasibility of incorporating anatomical traits into ecological studies. Nevertheless, the performance of these approaches under forest management scenarios remains insufficiently tested. This study examined the suitability of the Cell And Ring RecOgnition Tool (CARROT) for automated assessment of wood anatomical characteristics while investigating the long-term responses of hemiboreal pedunculate oak to selective spruce removal. Tree-ring width (TRW) and vessel lumen area (VLA) of mature oaks from two stands in western Latvia were quantified using CARROT, with TRW additionally measured using LINTAB for validation purposes. Comparisons between methods were performed for TRW, whereas TRW and VLA chronologies were further analysed using principal component analysis, correlation analyses, and linear mixed-effects models to evaluate management and climatic effects. Despite small discrepancies at the individual ring level, CARROT generated TRW chronologies comparable to those obtained using LINTAB. Approximately a decade after thinning, radial growth and vessel dimensions showed only minor changes, while climate sensitivity and growth synchrony were substantially altered and differed between stands, indicating that the effects of spruce removal were strongly mediated by local stand conditions. Vessel anatomical traits displayed stronger climatic responses than radial growth. The results support the use of automated quantitative wood anatomy as a complementary approach for evaluating tree responses to forest management interventions.

Rooting for answers: annual growth ring variability in the taproot and rhizome of *Viscaria vulgaris*

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Keywords: herb-chronology, root collar, *Viscaria vulgaris*, secondary growth, xylem anatomy

The analysis of growth rings in perennial herbaceous plants – herb-chronology – has emerged as a powerful tool for estimating plant age, population dynamics, and past environmental conditions in non-forested ecosystems. Similar to dendrochronology in trees, this approach relies on the presence of visible secondary growth rings in persistent underground structures. Standard herb-chronological protocols commonly target the root collar as the primary sampling location for growth ring analysis. However, despite its central role in age determination, the root collar is rarely defined anatomically in ecological studies and is frequently treated as a fixed, uniform sampling point. In reality, the root collar represents a transition zone between root and shoot tissue rather than a discrete anatomical boundary, raising fundamental uncertainties regarding where rings should be sampled and how reliable count estimates are across this transition.

In this study, we tested the assumption that the root collar provides a consistent and reliable location for ring counting by examining spatial growth ring variability in a perennial grassland plant, *Viscaria vulgaris*. We first identified the location morphologically designated as the root collar across collected individuals. Cross-sections were then prepared immediately above and below this morphological transition. From these section pairs, we directly compared total ring counts and evaluated how easily growth ring boundaries could be identified.

The results were contrasting: while rhizomes usually exhibited distinct fiber bands that helped with ring counting overall, roots produced more distinct ring boundaries defined by large earlywood and small latewood vessels. Given the variable, complex morphology of these underground structures and these distinct tissue-specific traits, we recommend collecting two cross-sections per individual – one above and one below the root collar to maximize the chance of capturing the oldest tissue and resolve counting ambiguities. Ultimately, our results highlight a critical methodological issue in herb-chronology, emphasizing that sampling position relative to the root-shoot transition directly influences age estimates and demonstrating the need for standardized sampling protocols, explicit anatomical definitions, and transparent reporting of uncertainty in growth-ring research.

Mysterious Jurassic forests: 165-million-year-old conifer trees discovered in Lithuania

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Keywords: Middle Jurassic, Callovian, fossil wood, conifers, wood anatomy, *Protocedroxylon,* Lithuania

Jurassic deposits in Lithuania have traditionally been investigated mainly for their rich marine fossil assemblages, whereas terrestrial vegetation has remained poorly documented. In 2025, numerous fossil wood fragments were discovered in the Karpėnai limestone quarry (northwestern Lithuania), providing a rare opportunity to investigate the composition of Middle Jurassic forests in the eastern Baltic region. The wood originates from the Lower Callovian Papilė Formation (~ 165 Ma), deposited in a deltaic to marginal-marine environment.

The fossil wood was examined using reflected-light microscopy, transmitted-light microscopy, and scanning electron microscopy (SEM). Although preservation is generally poor due to extensive bacterial degradation and compression during diagenesis, several diagnostically important anatomical features remain preserved, particularly in pyritized regions. These include annual rings, bordered pits on radial tracheid walls, ray cell characteristics, and cross-field pitting, allowing preliminary taxonomic assessment.

Microscopic observations distinguish at least three morphoanatomical groups of conifer wood (*Pinopsida*). More than half of the specimens exhibit pitted ray cell walls, *Abietineentüpfelung* cross-fields, and mixed radial intertracheal pitting, suggesting affinity with the morphogenus *Protocedroxylon* Gothan / *Araucariopitys* Jeffrey. Additional specimens show anatomical features comparable to *Protophyllocladoxylon* Kräusel and *Protaxodioxylon* Bamford et Philippe. The presence of distinct annual rings indicates pronounced seasonal growth and climatic periodicity during the Middle Jurassic.

These newly discovered fossil woods represent the first comprehensive anatomical investigation of Jurassic conifers from Lithuania and provide new insights into the diversity and composition of Middle Jurassic forests in the eastern Baltic region. Ongoing studies, including further SEM analyses and comparison with European Jurassic fossil wood, are expected to refine the taxonomic interpretation.

“Linearized” tree rings: dating the Kernavė Chapel using the longitudinal semi-radial aspect of *Pinus sylvestris* logs

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Keywords: wooden heritage, digital imaging, the 18th century, Lithuania

Dendrochronology is based on the analysis of annual tree “rings”, with the annual growth layers of wood, visible as rings in cross section, constituting the primary subject of this field. However, the cross-section view is not always accessible in constructions. The annual growth layers of coniferous trees with their simple tracheid structure can also be discerned in a longitudinal radial section. Dendrochronologists do not value this section because from the side you can only see the thickness of the tracheids, but not the dimensions of their walls and lumina, therefore any intra-annual growth irregularities can mask the ring boundaries. Moreover, the wood rays also cover a considerable area in the radial section, hindering the analysis. Despite these disadvantages here we demonstrate a successful use of longitudinal radial aspect of Scots pine (*Pinus sylvestris* L.) logs for tree-ring dating.

In the paper we present a dendrochronological study of the wooden chapel of unknown age in Kernavė, Lithuania (54.88432 N, 24.85230 E). The chapel is octagonal in shape, built of extensively hewn Scots pine (*Pinus sylvestris* L.) logs, and the exterior is clad in planks. Such a construction poses significant challenges for conventional dendrochronological analysis, as standard sampling techniques, like coring or cross-section analysis, cannot be used.

Fortunately, the insides of the logs, hewn almost to the pith in places, are not covered with planks or paint. Over the decades, transparent coatings have soaked in, highlighting the tree ring texture. This allowed us to apply a non-destructive methodological approach using the longitudinal aspect of annual rings. The inner surfaces of selected logs, which exposed radial – semi-radial aspects of wood, were photo-fixed using high-resolution digital photography. Seven representative timbers were selected based on their accessibility and ring amount. Overlapping images were digitally merged and analysed using the software CooRecorder. The resulting ring-width series were then processed following established dendrochronological procedures. Cross-dating was performed against regional master chronologies for Scots pine from Lithuania, Latvia, and Belarus.

A site chronology spanning 141 years was constructed and dated to 1578–1718. The outermost preserved ring dates to 1718 and is interpreted as a near-bark or bark-adjacent ring. Sapwood estimates of timbers, derived using Gjerdrum’s (2003) heartwood–sapwood rule, indicate that the trees were felled between autumn 1718 and spring 1721, thus verifying the felling date.

The study corroborates the applicability of longitudinal image-based ring measurements for dendrochronological dating in cases where traditional sampling is not possible and provides important new evidence for dating the construction of the Kernavė chapel highlighting the potential of dendrochronological analysis in heritage research.

Dendrochronological dating of historical wooden buildings in the open-air museum: advantages and disadvantages

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Keywords: dendrochronological dating, historical wood heritage, quality of wood samples

The number of historical wooden buildings has decreased rapidly in recent times. At the same time, the amount of old timber, with tree-rings containing important historical dendrochronological information, has also decreased significantly. The old wooden buildings and structures exhibited, and thus preserved, in open-air museums constitute one of the most valuable sources where this information can still be obtained in a relatively larger amount.

In the major open-air museums, the historical buildings that have been moved from a specific cultural or geographical region of the country are usually located more or less together. This makes it easier to identify and compare the construction traditions characteristic of each region, revealing their differences and changes over time. Dendrochronologists, in their turn, have the opportunity to obtain the necessary wood samples for research at one location, i.e., in the museum area, from timber that was used over a long period of time in one specific region and across the whole country.

However, the work of dendro-dating buildings exhibited in an open-air museum often presents several problems. These can be combined in the following four groups:

1. the absence or insufficient number of original wooden building elements used for the buildings exhibited in the museum;
2. lack or insufficiency of high-quality wood samples from original wooden building elements;
3. the heterogeneity of the timber used in the exhibited buildings;
4. dendro-dating does not indicate the year of completion of the building.

It has been found that work to refine the dating of historical wooden buildings exhibited in open-air museums is more successfully accomplished if a specific plan of dendrochronological dating work is developed and applied in advance.

Bell frame and bell yokes of St. Mary's Cathedral, Tallinn – Dendrochronological dating and provenance

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Keywords: dendrochronological dating, bell frame, bell yoke, timber provenance, St. Mary's Cathedral, Tallinn

Numerous historical buildings and timber structures in Tallinn Old Town have been dated using dendrochronological methods. This study focuses on the bell frame and four bell yokes preserved in the tower of St. Mary's Cathedral (in Estonian 'Toomkirik'), one of the oldest churches in Estonia. Founded in the 13th century, the cathedral has been rebuilt several times, including the construction of the present Baroque spire completed in 1779 after the great fire of 1684. Although the architectural history of the cathedral has been well documented, the age and origin of the timber structures in the bell tower have remained uncertain.

To clarify their construction history and possible timber provenance, wood samples were collected from the pine and spruce bell frame and from all four oak bell yokes. Tree-ring widths were measured and compared with reference chronologies from Estonia and the Baltic region. In addition, strontium isotope analysis was used to investigate the possible origin of the oak timber.

The analyses aimed to determine whether the current bell frame is contemporary with the bells (1685), dates to the construction phase of the Baroque spire (1779), or represents a later rebuilding stage. They also examined whether the bell yokes were manufactured together with the bells or were replaced at a later date. The dendrochronological analysis showed that most of the pine and spruce timber used in the bell frame was local and felled during the winter of 1777/78, indicating that the main structure belongs to the construction phase of the present Baroque spire, while several elements represent 19th-century repairs. No reliable absolute dating was obtained for the oak bell yokes. However, their tree-ring patterns showed strong similarities, suggesting that at least some of the timber originated from the same tree or from trees growing under very similar environmental conditions. Strontium isotope analysis indicated a possible provenance in central Sweden, southern Estonia, northern Latvia, or western Russia. These results provide new insights into the construction history of the cathedral bell tower and the provenance of timber used in its bell structures.