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Environmental Research Centre
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Vytautas Magnus University

Lithuanian Culture Research Institute, Lithuania

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Strong gradients in forest sensitivity to climate change revealed by dynamics of forest fire cycles in the post Little Ice Age era

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The length of the fire cycle is a critical factor affecting the vegetation cover in boreal and temperate regions. However, its responses to climate change remain poorly understood. We re-analysed data from earlier studies of forest age structures at the landscape level, in order to map the evolution of regional fire cycles across Eastern North American boreal and temperate forests, following the termination of the Little Ice Age (LIA). We demonstrated a well-defined spatial pattern of post-LIA changes in the length of fire cycles towards lower fire activity during the 1800s and 1900s. The western section of Eastern North America (west of 77 °W) experienced a decline in fire activity as early as the first half of the 1800s. By contrast, the eastern section showed these declines as late as the early 1900s. During a regionally fire prone period of the 1910s–1920s, forests in the western section of Eastern boreal North America burned more than forests in the eastern section. The climate appeared to dominate over vegetation composition and human impacts in shaping the geographical pattern of the post-LIA change in fire activity. Changes in the atmospheric circulation patterns following the termination of the LIA, specifically changes in Arctic Oscillation and the strengthening of the Continental Polar Trough, were likely drivers of the regional fire dynamics.

Dendrochronological reconstruction of forest fire regime in *Pinus sylvestris*-dominated forest in Slītere National Park, Latvia

Māra Kitenberga[1], Igor Drobyshev[2, 3], Roberts Matisons[1], Andis Adamovičs[1], Juris Katrevičs[1], Mārtiņš Puriņš[1], Āris Jansons[1]

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The inter-dune peatland complex of Slītere National Park is one of the best-preserved natural areas of old natural *Pinus sylvestris* forest stands in Latvia due to a remote location and challenging terrain. The aim of this study was to describe the historical forest fire regime. In total, 490 deadwood samples were collected in the 2360-hectare large area, where 72% were occupied by wetlands and 27% by sandy dunes. In total, we were able to date 229 fire scars from 66 fire events. The earliest dated fire occurred in 1558 and the latest in 1992. The mean point-scale fire interval for the studied period (1558–1992) was 46 ± 33.5 years. The shortest point-tree fire interval was 6 years. Our results show that fire is an important disturbance agent in Slītere National Park. To the best of our knowledge, this is the first reconstruction of the historical forest fire regime in the Baltic countries.

ECHoES – Effects of tree Colonization on Hydrology and carbon sequestration in peatland EcoSystems

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Healthy peatlands are globally important long-term greenhouse gas (GHG) sinks contributing to vital carbon (C) sequestration, biodiversity, and fresh-water purification. However, climate change increased nitrogen deposition and anthropogenic activities (e.g. drainage and peat harvest) may cause water-table and vegetation changes, which rapidly transform the peatlands into GHG net emitters. Strongly reduced C sequestration is expected if drier conditions turn moss-dominated peatlands into tree-covered conditions. At present, there is a growing bulk of evidence for accelerating shrubification and tree colonization at Scandinavian and Baltic peatlands. However, despite the global importance of peatland ecosystems, we still lack a holistic and integrated understanding of the processes linking peatland tree colonization with hydrology and C sequestration. In the project ECHoES (*Effects of tree Colonization on Hydrology and carbon sequestration in peatland EcoSystems*), we, therefore, aim to study linkages between tree colonization – hydrology – C sequestration in peatlands by, (i) monitoring of peatland tree colonization, hydrology and GHG fluxes, (ii) ecosystem modelling, and (iii) comparisons between ongoing and past colonization events during the Holocene. To fulfil our research objectives, ongoing processes will be studied using dendrometers and state-of-the-art monitoring equipment for GHG fluxes (CO2 and CH4) and water-table changes. To enable comparisons with earlier tree colonization events, such as the tree establishment during the Holocene Thermal Maximum, subfossil peatland trees will be used. For these studies, more than 1000 subfossil trees from sites in Sweden and Lithuania have been collected and analysed. This material shows that trees have colonized Northern Hemisphere peatlands repeatedly during the last 10,000 years. The outcome of the ECHoES project will advance our knowledge about links between tree colonization, moisture variability, and carbon sequestration in peatlands, which in a wider context has a direct impact on the global carbon cycle. Such information, therefore, has high societal relevance as it provides valuable input to environmental governance, particularly as a basis for ecosystem services and strategies for carbon sequestration in the context of future climate change.

Radial-growth patterns and climate sensitivity of Norway spruce (*Picea abies* (L.) Karst.) infected by root rot

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Fungal root pathogens causing root rot and stem decay have become a serious threat to the vitality of Norway spruce (*Picea abies* (L.) Karst.) in northeastern Europe that bring substantial economic losses for forest managers. Fungal root pathogens act as stressors that do not kill the tree immediately, but by damaging root system and lower part of the stem may weaken tree anchoring and hamper nutrient uptake, which in turn may negatively affect tree growth. The aim of this study was to assess the occurrence of butt rot damage in mature Norway spruce stands growing on fertile forest site types. In addition, we assessed whether the radial growth patterns and climate sensitivity of trees infected by fungal root pathogens differ from healthy ones. We hypothesized that radial growth of trees infected by butt rot is lower compared to that of healthy trees and infected trees are more climate sensitive. This study is based on the analysis of the radial growth patterns, obtained from tree-ring measurements. Increment cores were collected from 40 to 80-years old Norway spruce stands growing in the south and southeastern Estonia.

Long-term growth dynamics of Scots pine in peatland sites of Estonia, Belarus and Sweden

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The growth rate of trees is determined by numerous various factors. In peatlands, suppressed tree growth can be a result of high groundwater level (GWL), since excessive moisture provides unfavourable soil aeration. Management of hydrological regime (artificial drainage) can change such site conditions and be followed by growth release of trees. Modification of peatland sites was previously one of the popular means to improve forest productivity, and nowadays, considerable amount of forest resources are located in such sites (e.g. in Fennoscandia and Baltics). Maintenance of ditch network is required in order to continue a sustainable forest management in drained sites; another option is to restore a peatland by rewetting. In order to consider both management options, it is important to have knowledge and understanding of related long-term processes in peatland ecosystems, which are often reflected in the growth dynamics of trees. One of the questions arises, if growth release events in peatland sites are mainly a result of the artificial lowering of GWL, may then the similar effect happen due to natural (climatic) reasons?

In order to address this issue, available tree-ring data (768 trees in total) from several sites located in peatlands of Estonia, Belarus and Sweden were used to analyse long-term radial growth trends of Scots pine trees. As a first approach, per cent growth change method (based on 10-year running means) was applied to reconstruct disturbance dynamics (during the 20th c.) of distant sites, which differ in productivity and management history (drained and undrained). Per cent growth-change series of individual trees and the number of trees responded with growth release were compared between selected study areas. Results suggest that growth trends of Scots pine from peatlands of Estonia and Belarus are quite synchronous: growth release events are almost simultaneous (particularly during 1910–1920 and 1930–1940 but is less obvious in 1963–1973) and visible in case of a large number of trees located in nearly all of the study areas. Whereas the synchronized drainage activities are highly unlikely, growth release events are assumed to be driven by climatic variability reflected in GWL fluctuations: a growth rate of peatland trees increased during periods of lower than usual GWL. Swedish sites seem to have different patterns in growth release events compared to Estonia and Belarus, which should indicate different trends in climatic drivers. Ditching has improved forest productivity affecting the mean-growth rate, but growth dynamics of trees in drained peatlands remain quite similar to those of trees from undrained sites.

Impact of the urban "island of heat" on the tree-ring dynamics of Scots pine

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Cities change the local climate faster than it happens on the surrounding territories. Researches of the Belarusian Institute of Nature Management have showed that daytime summer temperatures in Maryina Gorka (a small town near Minsk) became higher in comparison with Minsk, especially in the last decades. At the same time (since 1977), night temperatures in Minsk remain higher than in rural areas, i.e. the city forms the so-called "island of heat" (Loginov, 2008). As a result, duration of the growing season increases, a period with a stable snow covers decreases and a regime of early and late frosts changes. Such differences, even minor ones, should stimulate the growth of trees located in the city.

The purpose of our research was to determine the differences in the tree-ring dynamics of trees growing in the city (but far from direct pollution sources) and on the surrounding territories. The object of the research – Scots pine trees growing in the forest park Slepyanka (Minsk) and in the Pukhovichi district (50 km from Minsk). Forest type is the same (*Pinetum pteridiosum*) and the age of trees is 120–140 years in both sites. In each site, 35 trees were cored.

Comparison of the growth indices of the urban and control stands has showed an increase in radial increment (and, therefore, productivity) in the urban forest, starting from the late 1980s. The difference in growth is up to 19%. At the same time, during the years with extreme climate conditions (especially with summer droughts), the differences between urban stands and control stands disappear (1991–1992, 1999, 2002–2003 and 2013–2014).

The first results of dendro-dating in Latvia of the oak panels of paintings by Dutch and Flemish old masters

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In Riga, in the second half of 2018, the results of the "Baltic Oaks" project will gradually be made available to the Latvian public. The project tasks include an exhibition and research conference, as well as several academic publications. The central event to be held in the frame of the project is an exhibition featuring Flemish and Dutch panel paintings of the 16th and 17th centuries from the collections of the Riga Bourse Art Museum.

In the northern part of central and Western Europe, artists of the Renaissance period generally have painted on panels made from oak boards imported from countries of the Baltic Sea basin (known as *wainscots*). A combination of dendroprovenancing and DNA comparison of wood has been used in Latvia for the first time in the frame of this project in order to determine the source region of the oaks whose trunk wood was used for the boards of the panels of several of the paintings in the exhibition.

Dendrochronology has been used to date the boards of the oak panels of a total of six paintings. The ring-width data was obtained from digital macro photographs of the annual rings, using the *OSM4* program [1].

The results confirmed that the panels of five paintings were made from Baltic oak, while the sixth was most probably made from oak grown in Germany. The ring-width series of two Baltic oak panels have showed the most significant similarity with the *Baltic1* oak chronology, one series was most similar to *Baltic2*, and the last two were most similar to *Baltic3*. This indicates that in the 16th and 17th centuries, the Baltic oak used for painting panels was not homogeneous in terms of the source area, but rather was sourced in various countries around the Baltic Sea. The source areas have so far not been identified more definitely or precisely. It is concluded that establishing more precisely the areas corresponding to the Baltic oak tree-ring chronologies created in Western Europe for previous centuries has now become an urgent task, which should be undertaken in the near future. Because historical wood of local origin is gradually disappearing in the countries around the Baltic Sea, this task becomes increasingly difficult as the years pass.

[1] [Knibbe, B.], 2014. OSM4 Manual & Reference. [Vienna]: SCIEM, 91 pp.

Mystery of the miraculous painting of the Mother of God at Krekenava Basilica of the Assumption: science confirms the legend

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Marian devotions are very important among Catholics in Lithuania and there are several highly venerated icons of the Virgin that are believed to be miraculous. One of such images is the miraculous painting of Our Mother with the Child or Our Lady of Snows in Krekenava Basilica of the Assumption (Panevėžys district). The prototype of the painting is the venerated icon of the Blessed Virgin Mary titled *Salus Populi Romani* from the Santa Maria Maggiore Basilica in Rome of the old iconography type Hodegetria.

Two main legends are related to this painting. One states that the icon dates back to the 15th c. and was brought to Krekenava by the missionary Albert from Krakow. The other refers to the miraculous salvation of the painting from the huge fire, which destroyed the church in the first half of the 18th c. This also gave the fame of the rescuer from fires to the painting.

Stylistic of the painting contradicts the 15th c. dating, and this legend is now used for popularisation only. Earliest existing documents, which mention the painting as an import from Italy, are from the 17th c. Nevertheless, there was a controversy among scientists about the origin and dating of the existing painting. Art critics who investigated its stylistic in the 1960' dated it to the first half of the 17th c. However, other scientists have believed that the salvation of the icon from a fire in the 18th c. was a pure legend and the existing painting was much younger.

The painting has been under restoration at the P. Gudynas Restoration Centre in Vilnius for last four years and this makes possible to investigate its panel. Wood identification has revealed the panel is made of Scots pine boards. This quite uncommon panel material has rejected the Italian origin but held forth a hope to apply the dendrochronological analysis.

The analysis has demonstrated that three of the four-panel boards were made from the same tree. The last existing ring was dated to 1611 against local pine chronologies. The fourth board was made from older pine and its last ring was dated to 1593.

P. Gjerdrums' (2003) rule was used to estimate the missing sapwood rings and possible felling dates. The coinciding interval of most possible felling dates of the trees is 1642–1645.

Thus, the scientific investigation has proved the legend of the salvation of the painting from the 18th c. fire and unravelled its local origin at the first half of the 17th c.

Dating of icons in the Institute of Art History, Ethnography and Folklore

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Dendrochronological dating of cultural heritage (icons, paintings, household items, etc.) allows specialists to take a fresh look at the history of their origin. In Belarus, dendrochronological dating is being carried out since 2010.

In 2017–2018, researchers at the Institute of Experimental Botany started the dating of the exhibits in the Museum of Ancient Belarusian Culture at the Institute of Art History, Ethnography and Folklore of the National Academy of Sciences of Belarus.

Initially, 220 wooden items were selected for the analysis: 185 icons, 30 wooden sculptures and 5 royal doors. At first, the edges of the boards had been partly polished, then tree species and the number of annual rings have been determined. In the result, the number of objects suitable for dating has been reduced to 83 icons and 2 sculptures. At present, 63 icons and 2 sculptures have already been processed.

Most of the icons have been collected by the staff of the museum during the Soviet period in the southern part of Belarus: 65 in Brest region, 3 in Gomel region, 7 in Grodno region, 6 in Minsk region and 2 in Vitebsk region.

All objects had been painted on pine panels. Objects made from birch and lime were excluded from analysis. Their dating is currently not possible due to the lack of tree-ring chronologies. There were no icons painted on the oak boards in the collection.

The average number of annual rings is 86, the lowest – 31 and the highest – 184. We have used Belarusian chronologies BY02, BY03, NVG01, YUR, VLK01 and chronologies provided by colleagues from Poland (KUJAWPOM), Lithuania (LITPINUS 1) and Latvia (DSN-1739) for dating.

Currently, 31 icons and one sculpture have been dated. The best chronologies for dating are BY02, LITPINUS 1 and KUJAWPOM. Some were not dated despite a large number of annual rings (more than 100). This may be because the icons do not originate from the region under investigation.

The last year rings of the objects are from 1604 to 1820. Some objects turned out to be much younger than they were supposed to be. The new data allowed the museum to re-evaluate the age of the icons, which previously had been estimated only basing on the analysis of iconography, techniques of icon painting and spectral analysis of a pigment.

Dendrochronological dating of churches in the Kaunas County

Adomas Vitas
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In 2018, dendrochronological dating was performed in five churches located in the Diocese of Kaunas: St. Anna church in Skaruliai, St. George the Martyr church in Kaunas, St. Jacob church in Jonava, Bishop Martin church in Šimkaičiai and St. George church in Kėdainiai. Missing sapwood rings in oak were estimated assuming that the number of sapwood in the Baltic countries ranges from 6 to 18 rings (Sohar et al. 2012). Missing sapwood rings in pine were estimated using the compiled pine sapwood database.

It is supposed that St. Anna church in Skaruliai was built in 1620–1622. The date is based on the fact that a benefaction for the church was given at that time. 26 pine samples from subfloor, attic and roof constructions have been sampled trying to determine dates of the building and main renovations. The first (lowest) floor has been dated to 1630s–1640s. The upper floor was installed in the 19th c. (between 1810 and 1863). Four oldest beams in the attic were dated to 1571–1574. The identified renovations in the attic took place in 1600, 1670–1671, 1715, and 1817. Rafters were replaced in 1676 and 1731.

In St. George church in Kaunas, 12 samples of disassembled side altar, parts of Baroque-style pews and choir gallery have been dated. Dating has revealed that the side altar was made in the 1760s. Pews were made from pine and lime. The parts made from pine do not have a waney edge. Therefore, the sapwood estimate has indicated a range between 1777 and 1832, which means that pews could be remade according to the old style after the war of 1812. The dating of pine beam from the choir gallery has indicated that it was built in the second half of the 19th c. (1852–1899).

St. Jacob church in Jonava was built in 1791–1793. Pine beams in the attic were dated to 1791, which corresponds to the building date of the church. Beams in the belfry were dated to the second half of the 19th c. (sample without waney edge) and 1900–1901 indicating the later repairs in the tower.

In the church of Šimkaičiai, three pine samples and one oak timber were dated. All samples have a waney edge. A rafter is dated to 1932, which coincides with the building time (1931–1932) of the church. Two beam supports (oak and pine) were dated to 1873–1874, and one pine beam, which was withdrawn from the constructions and left in the attic, was dated to 1841. This indicates that the older timbers were reused from the former cemetery chapel in Girkalnis. The building date of the chapel is unknown and the aforementioned dates represent the chapel reconstructions because archival sources confirm that the chapel was already standing in 1806.

Eleven oak samples were taken in the belfry of St. George church in Kėdainiai. Nine samples were crossdated with each other and a chronology spanning for 82 years was constructed. One sample containing 93 rings do not show similarity to other samples. The dating attempts with available regional oak chronologies from Poland and Latvia so far were not successful.

From microscope to geography

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The first attempt to use dendrochronology for dating in Estonia was made by architect K. Aluve on construction wood in the 1970s. Later biologist A. Läänelaid compiled tree-ring chronologies for pine and spruce based on his samples from old buildings and living trees. In the recent decades Läänelaid's students, geographers K. Sohar and S. Toomik have switched into the dating of historical artefacts.

With the increasing dendrochronological database and improving dating skills, also the geographical scope of dated objects widened. In this presentation, we review a selection of dendrochronologically dated items accentuating the geographical connections in Europe. It is widely known that the Baltic region *sensu lato* has served as a timber source for Western Europe during the Middle Age and even later. Nevertheless, some wood has moved also in the opposite direction, e.g. violins in Estonia made of spruce grown in the Alps or Western Carpathians. Even a longer journey can be followed in the case of painting panels of the Dutch and Flemish masters when the origin of the panel wood (oak) has been determined as Baltic, the painting has been created in the Netherlands, and the artefact is restored and maintained in Estonia. A good example is a story of 'Still life with a lobster' by Hans van Essen. Dating results of oak panels of some altar paintings from Tallinn also refer to wood commerce between Western Europe and the Baltics. The international investigation (together with A. Daly) of three paintings on the same theme 'Christ expels moneylenders from the temple', attributed to either Bosch or Bruegel (or their workshops), reversed the age sequence of the versions.

Dendrochronological dating of shipwrecks may be complicated by technical problems such as obtaining and preserving subaquatic wood, rot and absence of a waney edge. In addition, the geographical origin of ship timber is often not known. Nevertheless, we recently succeeded to date several shipwrecks found on the coasts of Saaremaa Island and Tallinn.

To conclude, the old art items in Estonia are often related to other countries either by their origin or timber trade in the past centuries. Exploring these relations helps to explain the historical connections between the countries and broadens our understanding of the trade geography. At present, an international Project called TIMBER is going on, funded by the European Research Council.

Wood rays in tree-rings of Scots pine

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Quantitative wood anatomy is emerging as a new and perspective discipline of dendro-sciences, extending beyond the width components of tree-rings thus aiming for a deeper understanding of xylogenesis and ecophysiological responses of trees. At present, conductive and cell-wall properties of tracheids and vessels have been among the most studied proxies; however, relatively little attention has been paid to storage tissues, e.g., wood rays. Considering weather-related fluctuation in assimilation, inter- and intra-annual variation in the quantity of wood rays has been observed; yet due to weather-related specifics in carbon allocation, the variation pattern can differ from that in wood increment. Present studies have assessed quantity of wood rays based on the cross-section cuts of a stem, which only partially reveal the variation of the proxy. Nevertheless, frequency dependent signals have been highlighted both in earlywood and in latewood.

The aim of this study was to assess the variation in the quantity of wood rays in the xylem of middle-aged Scots pine of different social (canopy) status in a commercial stand. We assumed that trees of different social status show diverse patterns in the variation of wood rays due to specific carbon allocation patterns. Tangential thin sections of early- and latewood from increment cores were prepared by a hand sliding microtome. Samples were stained in safranin and astrablue and microscopic images were acquired. The number and size of wood rays were measured using WinCELL software. The measured time series of wood ray proxies were rather short (< 50 years), as parenchyma in older wood rays had lignified and was not disguisable. Earlywood and latewood differed by size and quantity of wood rays; wood rays were more numerous in latewood. The quantity of wood rays displayed high-, and well as medium-frequency variation.

Influence of climatic factors on the radial increment of Norway spruce from different origin regions of Latvia in the same growing conditions

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In the context of the global climate change, it is important to determine the adaptability of forest trees to the changing climate. Comparison of the tree growth in various regions with different temperature and precipitation can provide information on the future impact of climate change on forests. The aim of this study is to compare the influence of climatic factors on the radial increment of Norway spruce from different origin regions of Latvia in the same growing conditions.

Two provenience trials are used in this study from Latvian Western and Central origin region of spruce. In each sample plot, samples were collected from trees of each region of origin. The influence of climatic factors is compared between sample plots and regions of origin within each plot.

Climatic factors associated with tree-ring width of Norway spruce of different origin regions in the same growing conditions are similar. The key factors are air temperature and moisture content in the summer — June and July. In general, 31.0–51.3% of the variance of tree-ring width can be explained with climatic factors.

Impact of climatic factors on the radial increment of English oak of different haplotypes

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In the last ten years, geneticists have analyzed more than two thousand populations of English oak across Europe. Studies made it possible to determine the ways of oak spreading during the Holocene period. In Belarus, specialists from the Forest Institute have identified 14 different haplotypes of the oak. The oak trees of *haplotype #1* comprise to 50% of all analyzed trees found throughout the country and *haplotype #2* is characteristic of 12% of trees and is distributed only in certain regions.

The main goal of our research was to identify the changes in radial increment of oak trees of *haplotypes #1* and *#2* in respect to climatic factors.

The wood samples have been taken at the same site (Rechitski district, Gomel region) from oak trees (21) of *haplotype #1* (RCH01o) and from oak trees (17) of *haplotype #2* (RCH02o). Tree-ring chronologies for a period of 170 years have been developed.

The study has showed that the radial growth of oak trees of both haplotypes demonstrates the same pointer years in 1875, 1893, 1940, 1984, 2003 and 2015. The results of the correlation analysis between the tree-ring chronologies RCH01o and RCH02o showed that they have a high correlation coefficient (0.90), which indicates that external environmental factors almost equally affect the growth of trees of both haplotypes.

Analysis of the correlation coefficients of standardized tree-ring chronologies RCH01o and RCH02o with meteorological parameters has showed a significant positive effect of precipitation in December of the previous year and in June of the current year for both haplotypes. The tree-ring chronology RCH01o has a significant positive correlation coefficient with precipitation in August of the previous year (0.23) and with the temperature of October of the previous year (0.22). In the tree-ring chronology RCH02o, a significant positive correlation coefficient with the temperature is observed in December of the previous year (0.23). In the trees of haplotype #2, the correlation with the precipitation in July is more significant, and in the trees of haplotype #1 – with the precipitation of September and November of the previous year. The response function explains 47.4% of the variation of tree-ring width in chronology RCH01o and 40.8% in RCH02o.

The radial increment of trees of *haplotype #2* is mainly associated with the climatic conditions of the current year, while the radial increment of trees of *haplotype #1* is associated with the conditions of current and the previous year. Perhaps, this is the reason for the higher growth rate of trees of *haplotype #2*, which adapts more rapidly to the changing conditions.

Pointer years in tree rings of different provenances of Scots pine in Latvia

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Climate and, particularly, weather extremes are shaping distribution of species and affecting their growth. Under the changing climate in Northern Europe, the effect of weather extremes on forests and their growth is predicted to intensify due to shifts in growth phenology and alterations in precipitation regime, thus causing economic consequences. Scots pine, which is a stress tolerant species, has been also predicted to decrease productivity; accordingly, numerous efforts are being made to withstand any negative effects of climatic changes. Considering the extensive distribution area of Scots pine, selection of provenances best suitable for future climates has been advised as one of the most effective measures to cope with the changing climate. For an educated selection of the best suitable provenance, detailed information about their growth response to weather fluctuation and its extremes is necessary. The aim of this study was to assess the occurrence of pointer years in tree-ring width of Scots pine provenances differing by productivity in Latvia. We analyzed two top- and two bottom-performing provenances, which originated in Poland and Northern Germany, as well as one local provenance, which showed the above-average performance.

The occurrence of pointer years differed by provenances, indicating differing sensitivity. The sensitivity to weather fluctuations also largely explained the performance of provenances. The top-performing provenances were less sensitive to temperature drops during the dormant period, yet were able to benefit from moist summers. The bottom-performing provenances were sensitive to winter temperature regime and water deficit, yet showed a weaker response to moist summers. The foreign provenances showed the linkage between weather conditions, nutrient reserves, and increment; while, the current weather had a stronger effect on xylogenesis of the local provenance. Considering observed sensitivity to weather conditions, the top-performing provenances are expected to maintain growth superiority also under the changing climate.

Impacts of hydrometeorological conditions in raised bogs on daily and seasonal radial stem dynamics in Scots pine (*Pinus sylvestris* L.)

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Several studies have shown that pine trees growing in peatlands represent an exclusive object for decadal to multi-millennial (hydro)climatic reconstructions. The availability of subfossil material in peatlands allows the construction of very long chronologies, making peatland trees a very interesting study object in the field of dendrochronology.

To determine relationships between hydrometeorological indices and tree growth we analysed radial stem changes (RSCH) using six automatic high-resolution band dendrometers DRL 26, installed at undisturbed parts of four raised bogs in different parts of Lithuania: Rėkyva, Kerėplis, Aukštumala and Čepkeliai. Simultaneously, we conducted the hydrological-dendrochronological monitoring. Next to the pine trees with the dendrometers measuring their girth changes, wells were installed, equipped with automatic groundwater level, temperature and atmospheric pressure gauges. To determine relationships between meteorological indices and tree growth, we used hourly data from the meteorological stations nearest to the study sites.

The seasonal radial stem growth of pines was found to begin when the mean 24-hour temperature exceeded +7 °C. When the temperature drops consistently below 7 °C, the dormant season begins and the amplitude of the stem changes decreases. Groundwater level rather than temperature regulates the radial growth throughout the vegetation period. A great impact on tree increment is exerted by the climate conditions of the pre-vegetation period. In assessing the diurnal cycles, we found that at low temperatures, the expansion of pine stems is more prominent at low water levels. At high temperatures, when transpiration activates, high groundwater level becomes more favourable. Differences between the daily cycles of investigated pines could be due to individual tree features (age, root system, etc.) and different habitat conditions.

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Notes