The influence of early wood and late wood to emergence of pointer years in oak trees

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Abstract Axial variation of early wood and late wood widths of thirty oak trees (Quercus petraea (Matt.) Liebl) was analyzed. The influence of sampling trees was found to be weak for both, earlywood and latewood widths, that meaning results don’t varied a lot of if the number of tree is larger. The observed trends with expanding number of samples show distinctively that EW (earlywood), don’t have influence on appearance or maximized the value of pointer years. The phenomenon is due to the fact that early wood reacts only at the interference of two factors: precipitation and average temperatures of April. Unlike the earlywood, the latewood and total wood shows a high sensibility at the cumulated precipitation and the temperature of September (the previous year of the formation of the growth ring) respectively Mars, April, May, June and July (the year of the formation of the annual ring). Related to the oak’s dendrochronological series different reaction at the climate variation there were identified different results for the 3 analyzed series. There are even event years that cannot be found than in the latewood or total wood series, but most care be found in both categories. The percentage of showing in individual series varies at the event years founded in both total wood series and in the analyzed early wood series.

Response function and correlation analyses are established to understand the complex influence of climate on tree growth [1; 2]. This type of analyses provides information about relationship between ring widths in general, earlywood (EW) and latewood (LW), in particular, and climate variation. But not always climate represent the limiting factor, which can be pollution, ecological site condition, etc. The pointer year’s frequency and strength might be controlled by species specific differences [3].

Dendroclimatic research has highlighted event years, like 2003, which through the measurements made, represents the extreme year for all the period of the measured instrumental data [4]. Long time periods of lacks (absence) of atmospheric moisture gathered with high temperatures which induces complex evapotranspiration processes and contribute at the decreases of the cumulated wood, sometimes the rings disappear becoming black or absent rings [5]. That phenomenon can’t be interpreted as if this year doesn’t produce biomass accumulation in the trees trunk, but most likely as a complex process whereby the tree as a living entity has the capacity to forward and to supplement the radicle volume for taking more water from the ground.

The last decades are being analyzed in a climatic point of view advancing lots of questions as a result of increasingly level of pollution which according to specialists causes evident climatic changes [6]. The most heated discussions about the climatic analysis in the last century consist in the time stability fluctuation of the denticlomatic answer of the trees. In this study we check what influence has EW and LW in frequency and strength of pointer years. This study can’t be important for understanding first of all what climatically condition is limiting in what period of bioaccumulation process.

Material and Method

Thirty sessile oak trees were sampled (tow samples for each tree) in Bistrita region (47°4’22”N, 24°25’15”E, 372 m HAE) with a time span of master series of 237 years from 1773 to 2009. Samples of oak wood fulfilling the requirements of the dendrochronological method were subjected to suitable preparation. For each sample measurements were made with TSAP-win [7] program for determination of earlywood and latewood widths with 0,001 mm accuracy. Correlation and averaging of the growth sequences produced were made with the TSAP-win and COFECHA [8] programs. Transformation into the standardized ones of individual series was obtained with ARSTAN [9] program. We used a cubic spline with the window of length equal to 67% of average length of growth sequences of the length of the series. The residual chro-
nology obtained after standardization was used in study.

Meteorological data used for comparison with the pointer years came from meteorological grid box data CRU_TS3 [10], for the period 1901 – 2009. Precipitations are defined by a 650 mm multiannual average value. The minimal monthly value for the analyzed period has been calculated for February (305 mm/month) and the highest in June (95.2 mm/month). The lowest temperature monthly media was recorded in January and it goes from 0.1 °C (t max) to 8.8 °C (t. min) and the highest oscillates between 25.4 °C (t. max) and 12.7 °C (t. min).


Pointer year analysis is a method of showing annual growth reactions at the forced changes in environmental conditions [11, 12]. To establish the pointer years it was used the statistic analyse of the normalised values into the mobile window [13]. The pointer years were determined by the separation of the 1.75 meaning limit, value which shows that the ring breadth in t year is higher or smaller with 1.75 standard deviations than the local average. The pointer years were considered only those with a 75% larger representation from the total number of individual series. We have calculated pointer years and pointer interval with the WEISER [14] program.

Results

The radial growing is thorough between 0.17 mm a year\(^{-1}\) and 3.56 mm-year\(^{-1}\) with average of 1.49 mm-a year\(^{-1}\) for the total wood series. The growing average for the radial series of earlywood is thorough between 0.11 mm- year\(^{-1}\) and 0.84 mm- year\(^{-1}\), and the average is 0.60 mm- year\(^{-1}\). The latewood series average has values thorough between a 0.05 mm- year\(^{-1}\) minimum and a 2.74 mm- year\(^{-1}\) maximum (Figure 1). The maximum length of the individuals’ series is 237 years, and the minimum is 103 years with an average equal to 175 ± 45 years. The period with a largest than 10 series cover is between 1830 and 2009; the total covered by the dendrochronological series is between 1773 and 2009.

For the chronologies formatted was calculated the average correlation between all series (rbar), which express the strength of climatic signal. The parameter was calculated in a 50 years moving window [15, 2]. The value is higher for the LW series (0.41), and minimum for the EW series (0.13). ESP value (Expressed Population Signal) was calculated in order to check the credibility of the chronology (Cook et al. 2002). This parameter varied between 0.97 to latewood series and 0.89 to early wood series.

The average sensibility of growing RW series is between 0.21 and 0.36 with a 0.28 average for the radial growing values. The values decrease at the residual series of index by arriving at a 0.12 value in earlywood. The average percentage modification of the annual ring breadth related to the precedent and the next annual ring is maximal at the RAW growing series for earlywood (0.46). This high value indicates a high sensibility of the annual ring at the limitative ecological facts.

The proportion between the signal and the noise defined by SNR parameter varies at the total wood series between 2.05 for the radial growing values and 2.55 for the residual index series. Latewood presents a highest value at the RW dendrochronological series, 2.30, and smaller than the RW dendrochronological of residual index (2.42). The value of the variation explained by the first engine vector built-in is highest in RW and LW series. The highest value is recorded at the residual index of RW series (49.53) and the smallest belongs to earlywood RAW series (18.96). The relative low values of the average radial growing in earlywood involves a low variation, between 1800 and 2009, being almost linear, with small variations which follows only in part the trend of the other two RW and LW series. Unlike those, the summer wood is well defined inducing the inter-annual and inter-decade difference.
The high sensibility of the trees at the action of limitative environment factors is proven even by the values of the correlation between the climatic parameters represented by the medium precipitation, respectively the monthly maximum, medium and minimum temperatures. By the action of remaining correlation we can notice even influences of the climatic conditions from the previous year of the radial growing ring creation. Earlywood is positively influenced by the precipitation in December, April and June which generated correlations values with values of 0.31, 0.43, respectively 0.29. RW series had a significant correlations with the precipitation in September (0.22), December (0.30), March (0.22), April (0.34), May (0.24) and June (0.32). Different from the previous mentioned months, for the total wood series, the latewood presents a significant correlation in July (0.23) (Figure 2).

The analyses between the medium temperatures and the index series highlighted April through the significant values -0.28 (RW), -0.24 (EW) and -0.25 (LW). Earlywood related with the medium temperature of July, resulting a 0.20 correlation value. The response functions generated significant values. The minimal temperature didn’t relate in a significant way with the index series and also the response functions.

From the calculation of the pointer years for the total wood dendrochronological series resulted a 53 number of years through 29 are negative and 24 positive. The analyzed period is between 2008 and 1793 (Figure 3). The negative pointer years are 1801, 1802,

By analyze of the pointer years for earlywood shows only one positive year, 1980 (Figure 4). The negative pointer years are six: 1836, 1874, 1918, 1925, 1972 and 1981. An apparition percentage in individuals series superior to 80% were calculated only the negative pointer years 1918 (83.61 %) and 1972 (81.97 %).
For latewood series were calculated 62 pointer years from which 34 are negative and 28 are positive (Figure 5). The negative pointer years: 1794, 1801, 1802, 1812, 1821, 1824, 1827, 1833, 1836, 1842, 1848, 1854, 1855, 1863, 1869, 1872, 1875, 1878, 1893, 1896, 1899, 1904, 1908, 1915, 1918, 1925, 1950, 1953, 1954, 1964, 1972, 1981, 1990 and 1995. The positive pointer years are the following: 1798, 1805, 1810, 1817, 1825, 1829, 1837, 1838, 1853, 1861, 1865, 1871, 1891, 1903, 1912, 1920, 1922, 1926, 1933, 1938, 1945, 1951, 1955, 1969, 1979, 1988, 1997 and 2006. Eight negative pointer years can be found in over 95 % from the individuals’ series, from this I can tell: 1801 (95.83 %), 1827 (97.17 %), 1848 (97.14 %), 1863 (97.14 %), 1904 (96.66 %), 1908 and 1918 (95.08 %), respectively 1972 (98.36 %). The positive pointer year unanimous calculated for all the individuals series analyzed are 1838 (100 %).

**Discussions**

The radial growing of wood has been differently measured in the annual ring in formation categories like earlywood (EW), latwood (LW) and total wood (RW). The highest values of growing have been measured in total wood as a result of the accumulation of the measuring of the earlywood with latewood. The statistic cover of the series with more than 10 individuals’ dendrochronological series was made after 1830, until 2009. The average sensibility has high values at the total and latewood. The relation between the signal and the noise is maximal at the residual index series. The maximum value has been calculated for the total wood series, followed nearly by the latewood series. For the early wood was obtained a low value of this parameter. The first engine vector explains a high value from the signal respectively 49.53 % at RW series. By analyze of earlywood indicates a weak answer to the action of the principal disturbing factor, value explained by the first engine vector being of 18.96 %.

The growing series doesn’t present a high variability, the trend is almost linear, and that means the trees didn’t suffered severe perturbations, capable to induce a prior ecological growing signal. Through this we can consider the answer at the climatic influence of the trees is high. The high sensibility of the trees at the limitative action of the environmental factors was observed through the calculation of the correlation between the average precipitation, the average temperature and the growing residual index. The highest values of the correlation have been established reported to the average temperatures. The month wherein were calculated the value due to the residual RW, EW and LW series is April. Earlywood is the strongest, positively conditioned of this predictor (0.42) in May, June and July, significant values in latwood series of index. Unlike the precipitation, the April’s average temperatures influence in a negative way the axiological process, the maximum value of correlation being calculated for the RW series.

By analyze of the pointer years for the growing series of the total, early, and latewood relieves remarkable differences between the three series. So, for the analyzed period, were calculated 53 years for the RW series, from which 29 negatives and 24 positives. For EW series were obtained 7 event years from which only one is positive. Using the same options for the calculation of the pointer year at the latewood series were obtained the highest number of years, 62, from which 34 negatives and 28 positives.

The negative pointer years which appear at the LW series in plus from the RW series are: 1995, 1816, 1893, 1875, 1872, 1854, 1833 and 1794. There are 3 pointer years which appears only at RW series and not at LW series: 2002, 1835 and 1828. We have to notice the fact that the apparition percentage in individuals’ series of the pointer years for the two series varies, so
we can find 3 patterns. For the first one the values are bigger for the RW series (100%) unlike LW (97%) in 1827. The second case describes the opposite relation, namely the percentage of apparition in individuals’ series is superior at LW series (93%) relative to RW (81%), percentage calculated for the 1950 pointer year. Finally, were noticed some situations when the calculated values are identical for both types of wood, 78%, in 1972.

For the positive pointed years we can find 1980 only in earlywood series. The positive pointer years founded only in latewood series are 1988, 1920, 1891, 1853 and 1798. Unlike this, only one positive pointer year has been calculated for the RW series, respectively 1846. In 1838 the apparition percentage in individuals’ series is of 100% both in RW and LW series.

By relating the obtain results to the years with an precipitation excess or deficit calculated by Topor, 1963 and Dragotă, 2006 we notice that there are some years that correspond but even years that can’t be found in the residual growing series. By making a parallel between the result and the obtained climatic data from data base CRU we can notice that the negative pointed years are influenced by the quantity of precipitation and even by the values of the temperatures. A level of precipitation inferior to 615 mm/year inducted the creation of growing rings with reduced breadth. For the positive years these precipitation values arrive at 880 mm/year, value observed for the positive pointed year 1912.

Conclusions

The dendrochronological oak series from Bistrița is sensible to the action of the climatic factors. The size of the series with more of 10 dendrochronological individual series is 179 years, between 1830 and 2009. The statistic parameters indicate high values of average sensibility, rbar and variability explained by the first engine vector. The separation of radial growing ring in independent series of early-, late- and total wood let us observe the variation mode of the statistic parameters and of the correlation values in the growing annual ring.

Latewood series has a stronger answer than the others at the favorable action of precipitation in April. Earlywood series is only limited to the relation with April. Significant relations were calculated even related to December and June, but these values have no biological support. Total wood is the most receptive at the temperatures oscillations in this month, this climatic parameter being a limitative one. The answer of latewood is significant even in the precedent year’s September and from Mars to July of present year. The value of the relation superior to the significacion limit for total wood sum up at Mars, April, May and June.

The negative pointed years are more than the positives ones. There are years found in all individual growing series. For late wood were calculated the most pointed years relative to the early- and total wood. The earlywood series has determined the calculation of a minimal number of pointed years, namely seven. It was noted that the participation percentage of individual series to the nominalization of the pointed years varies from case to case for the RW and LW series. There are also years existing only in total or latewood series. It was highlighted the period between 1878 and 1899 for whom weren’t calculated pointed years with an apparition frequency more than 75% from the individual series. The apparition of the pointer years varies depending of the each series answer to the limitative or propitious factors. Different answers at climatic action of total, late- end earlywood individual series is obvious by the number and apparition percentage of the calculated pointer years.

References


