THE METHODOLOGY OF BUILDING DENDROCHRONOLOGICAL SERIES IN RODNA MOUNTAINS FOR SPRUCE

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Abstract

Dendrochronological series for spruce at altitude of 1200 m (PITJ). Experimental plot is located in a pure stand of spruce species found in ecological optimum (47° 36' N, 24°35' E) on the southwestern slope of the northern part of Pietrosul Rodnei in area called Izvorul Alb. Cores were sampled from a total of 22 trees, being removed from the processing one cores of tree number four, due to missing a part of the core. Average radial growth is 2.72 ± 0.73 mm·year^{-1} ranging from 1.43 mm·year^{-1} and 4.56 mm·year^{-1}. Mean first order autocorrelation for the growth series varies between 0.79 and 0.95, with an average of 0.83 ± 0.07, decreasing to 0.56 ± 0.14 for standard index series, being statistically insignificant for residual dendrochronological series (-0.02±0.07).

Key words: Spruce, sample, tree ring, radial growth, dendrochronological series, signal common population - EPS, the ratio of signal and noise – SNR.

INTRODUCTION

Dendrochronological series is defined as a time series of annual ring parameter (width, total width of earlywood and latewood density, etc.) measured and transformed by specific methods - standardization - in series of indices (Popa, 2004). Environmental signal stored in tree-ring parameters (tree-ring width, maximum density and chemical composition etc.) is the result of complex interactions between environmental input and tree physiological output (Speer, 2010). Radial growth and its associated parameters for a growing season integrate current and past environmental conditions, as modified by the genetic background of species (Fritts, 1976).

The growth ring varies from one year to another (in the case of annual variation of the climate) or from one vegetation period (season) to another (in the case when the seasonal variation of climate is longer or shorter than a year, as far as both its width and its structure and density of wood are concerned. The annual tree ring constituted an archive a real database, regarding the secular and multi-secular variation of the environment factors at both global and mezzo-and micro scale levels.

In order to emphasis the changes in dendroclimatological response relative with spatial position on the north part of the massif and the influence of altitude level have developed a number of 6 chronologies.

Spatial layout of experimental plot allows obtaining primary data for each main valley and mountain Pietrosu where three levels of altitude.

MATERIAL AND METHOD

Dendrochronological series is defined as a time series of annual ring parameter (width, total width of earlywood and latewood density, etc.) measured and transformed by specific methods - standardization - in series of indices (Popa, 2004).

Choosing specific sampling techniques and data processing was done in relation to restrictions imposed by the nature protection area, the available equipment and field conditions.

Sampling, sample processing and measurement of growth. The choice and location of the experimental plots considered two main aspects: maximizing climatic signal specific of the study area and evidence of climate response variability in relation to altitude (Fig. 1).

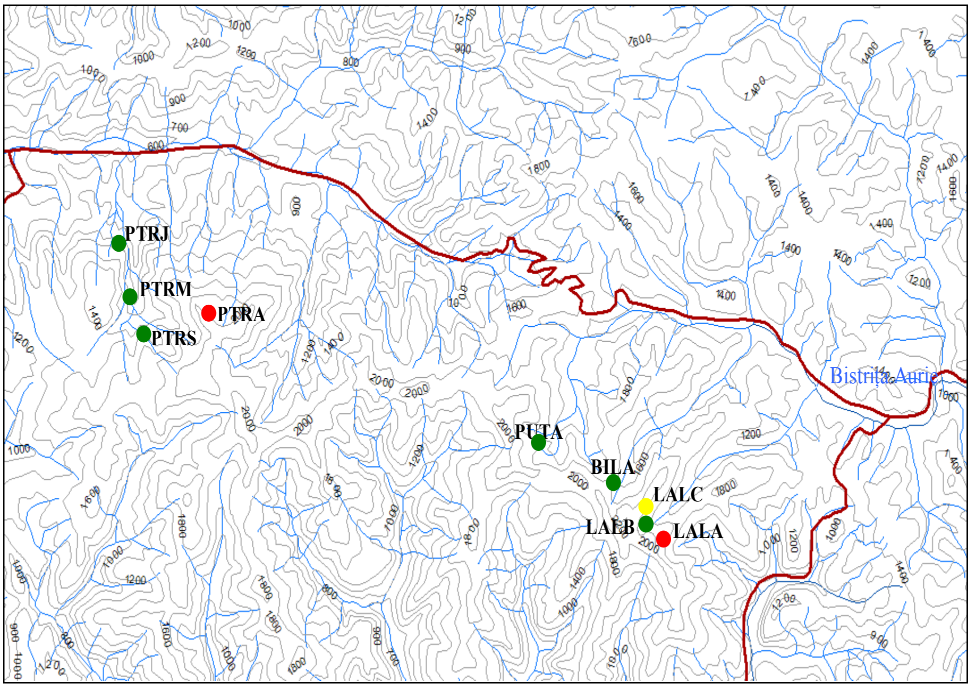

Fig. 1. Dendrochronological series elaborated in the Rodna Mountain

From each tree were extracted two cores at 1.30 m in height using a Pressler increment borer (Fig. 2).

Fig. 2. Pressler increment borer

Number of trees included in the survey range from 15 to 25 trees. Annual ring width measurement was performed using the system Lintab at Forest Research Station Câmpulung Moldovenesc (Fig. 3). Accuracy of tree ring width measurements was 0.001 mm (Rinntech, 2005). Values measured for each sample were recording in separate files for each experimental plot using the standard format TUCSON format (*.rwl).

Fig. 3. The system Lintab for measuring annual ring width

Statistical analysis and crossdating of individual growth series. Tree ring width, determined mostly by changes in environmental factors, is variable from year to year. Description of time series represented the temporal variation of tree ring width was achieved through a set of statistical indicators specific to time series (Popa, 2004). Primary data processing was done with ARSTAN software ver. 4.1 (Cook, Krusic, 2006).

Individual series were checked and crossdated using the software TSAPwin (Rinntech, 2005), graphically comparing individual chronologies with average growth curve. Robustness check of crossdating process was done by statistical methods, respectively by moving correlation analysis on 50-year subperiods using the computer routines of COFECHA program (Holmes, 1983; Grissino-Mayer, 1997, 2001).

Standardization and calculation of reference chronologies. Time series representing the variation of tree ring width is a combination of different signals. In this thesis has adopted a pragmatic approach to modeling the dynamics of radial growth, considering all the different signals of climate signal as noise. After testing different types of statistical models recommended in the literature to standardize growth series (Helama et al., 2004) was chosen to apply a cubic spline function with frequency equal to 67% of the length of each individual series (Cook, Peters, 1981; Cook, Kairiukstis, 1990). This feature allows preserving the medium and high frequency signal.

By standardization the growth series are transformed in indices with the average one and variance relatively constant over time. Dendrochronological series was achieved through robust biweight mean (Cook, Kairiukstis, 1990) which allows a reduction in the influence of outliers. Statistical calculation was done through the computer program routines ARSTAN ver. 4.1 (Cook, Krusic, 2006).

Assessment of statistical significance of the series developed dendrochronology was achieved through statistical indicators: average correlation coefficient between individual series and mean chronology; average correlation coefficient between individual growth series taken two by two - rbar; signal common population - EPS, the ratio of signal and noise - SNR, the variance explained by first principal component. These statistical indicators have allowed an objective assessment of the reliability of dendrochronological series compiled and provided the period with statistical feasibility.

For massive Pietrosul Rodnei we developed three independent chronologies corresponding to three altitude levels: 1650 m, 1400 m and 1200 m. The location of experimental plots were in the stands subjected to forest management for altitude levels of 1400 m and 1200 m, and in a relatively natural stands, with low accessibility to the upper range of the forest (1650 m).

RESULTS AND DISCUSSION

The length of individual growth series for this plot ranges between 58 and 141 years, with an average of 102 ± 23 years, covering the period 1867 to 2007. This relatively low average age compared with other dendrochronological series of spruce is explained by the forest management works, the ecosystem currently being included in the full protection area of Rodna Mountains National Park. A total of over 10 individual series are recorded only after 1887.

Average radial growth is 2.72 ± 0.73 mm·year^{-1} ranging from 1.43 mm·year^{-1} and 4.56 mm·year^{-1}. Mean first order autocorrelation for the growth series varies between 0.79 and 0.95, with an average of 0.83 ± 0.07, decreasing to 0.56 ± 0.14 for standard index series, being statistically insignificant for residual dendrochronological series (-0.02±0.07). Average sensitivity of individual series increases from raw data (0.20 ± 0.03) to residual index series (0.25±0.03). Mean standard deviation of individual series of residual growth indices range between 0.17 and 0.31, with an average of 0.23 ± 0.03.

Correlation between individual series and dendrochronological series is 0.54, the correlation between the index series (rbar) is 0.31 for residual chronology, and 0.23 for standard index. Mean EPS is 0.94 with values above the limit of statistical significance (0.85) after 1890. Variability explained by first principal component is 36.6% and the ratio between signal and noise for optimal joint period (1935-2007) equals 10.1. Mean tree ring width beginning at values of 5.5-6.0 mm·year^{-1} between delinquency stabilized at 1.0-1.2 mm·year^{-1} at the age of 100 years.

Annual variation of mean radial growth of spruce from the altitude range of 1200 meters of Pietrosul Rodnei presents a general trend downward, as higher average age, with decadal variations caused by changes in stand structure (Fig. 4).

These changes in stand structure with an impact on tree ring width is observed during the decade 1930-1940, when there is an accelerating process of bioaccumulation in the tree ring. Significantly increasing trend in tree ring width after 1990, evidenced also in dendrochronological series of other experimental plots, is present also in this case, up to 2001. Subsequently the growth rate is reduced to a level above 1990.

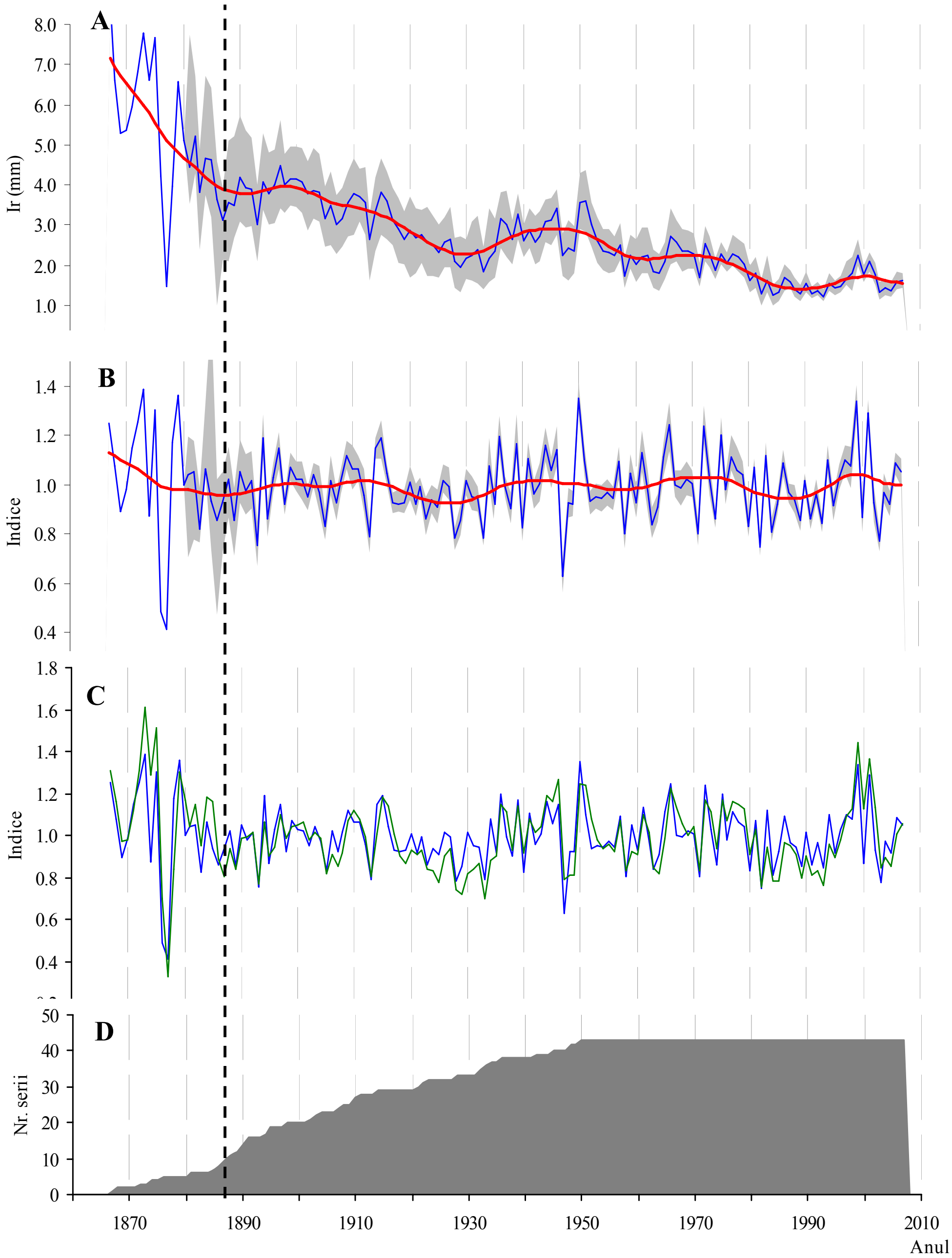

Fig. 4. Dendrochronological series for spruce from Izvorul Alb (PITJ): (A – mean growth series: blue – annual values, red – 20 years spline values, grey – confidence interval; B – dendrochronological series: blue – annual index values, red – 20 years spline values, grey – confidence interval; C – comparison of mean index chronologies: bleu – residual index series, green – standard index series; D – distribution in time of individual series; black dotted line – significance limit of dendrochronological series)

CONCLUSIONS

The annual tree ring constituted an archive a real database, regarding the secular and multi-secular variation of the environment factors at both global and mezzo-and micro scale levels.

The Romanian forest ecosystems have a very high dendrochronological potential, the building of dendrochronological series for the main forest, by ecological areas, being a premise of a better knowledge on the dynamics of environment factors and implicitly of the complex biological system, the forests.

At timberline the dominant factor in radial growth is temperature. An important influences upon the tree-ring haves the previous autumn temperature and the may-august period in the same year.

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