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Climate influence on coniferous species radial growth in Moldovita River Basin

Nicolaie Plaiu

University Ştefan cel Mare Suceava, Forestry Faculty, Suceava, Romania. Corresponding author: N. Plaiu, nplaiu@yahoo.com

Abstract. The thoroughness of knowledge concerning the relation between climate and coniferous species forest ecosystems from Romania is a very present theme among the scientific community from environmental field, nationally and internationally. This study presents an incorporated dendroclimatological analysis regarding coniferous species response to climate variation from Moldovita River Basin. A network of dendrochronological series was accomplished, composed of 4 silver fir (*Abies alba*) series, 3 Norway spruce (*Picea abies*) series, 2 Scots pine (*Pinus sylvestris*) series and 2 European larch (*Larix decidua*) series. There have been taken 480 samples of radial growth from 240 trees. All individual radial growth series were standardized using the 67% spline function. Trees reaction to climate variation was analyzed through Pearson correlation coefficients. A certain period of time, when temperature significantly influences trees radial growth, corresponds to each coniferous species. Knowing in future the way temperature fluctuates has a major importance in ecological distribution of coniferous species from Moldovita River Basin.
Key Words: coniferous trees, tree rings, dendroclimatological response, correlation.

Rezumat. Aprofundarea cunoştinţelor privind raporturile dintre climă şi ecosistemele forestiere de răşinoase din România constituie o temă de certă actualitate în rândul comunităţii ştiinţifice din domeniul mediului pe plan naţional şi internaţional. În acest studiu se prezintă o analiză dendroclimatologică integrată privind răspunsul arborilor de răşinoase la variaţia climatului din zona bazinului râului Moldoviţa. A fost realizată o reţea de serii dendrocronologice constituită din 4 serii de brad, 3 serii de molid, 2 serii de pin silvestru şi 2 serii de larice. Au fost prelevate 480 probe de creştere radială de la un număr total de 240 de arbori. Toate seriile de creştere individuale au fost standardizate folosindu-se funcţia spline cu o frecvenţă de 67%. Reacţia arborilor la variaţia climatului a fost analizată prin intermediul coeficienţilor de corelaţie de tip Pearson. Fiecărei specii de răşinoase îi corespunde o anumită perioadă din an în care regimul termic influenţează semnificativ creşterea radială a arborilor. Cunoaşterea modului de variaţie a regimului termic în viitor are o importanţă deosebită în zonarea ecologică a speciilor de răşinoase din bazinul râului Moldoviţa.
Cuvinte cheie: specii de răşinoase, inele de creştere, analiză dendroclimatologică, corelaţie.

Introduction. In the context of last decades climatic changes and of their potential effects, there are multiple questions about forest vegetation response to annual temperature changes or to extreme temperature incidents (IPCC 2007).

The climatic signal is considered one of the main factors that control trees growth and a better understanding of climatic factors effects on trees growth offers a better understanding regarding long-lasting management strategies adaptation of forest ecosystems (Sidor 2011).

Knowing the way trees respond to climate variation represents an imperative condition in order to underlie both possible next evolution and strategies of long-lasting management and development of the forest district (Timiş 2010).

The need to extend dendrochronological researches in areas less studied and to achieve new networks of dendrochronological series, for the Carpathian area by choice, represents a necessity of Romanian researches in environmental science field (Timiş 2010).

An illustrative segment of Romanian Carpathians and of Eastern Carpathians in particulary, is formed by Bukovina slopes, the forests in this area filling about 75% of total area, being thus one of the most extended forest district of the country.

Therefore, this study has as purpose the analysis of the relationship between climate influence and coniferous species diameter increment (silver fir - *Abies alba*, Norway spruce - *Picea abies*, Scots pine - *Pinus sylvestris*, and European larch - *Larix decidua*) from Moldovita River Basin.

Material and Method. The study site is represented by forest ecosystems of silver fir, Norway spruce, Scots pine and European larch from Moldovita River Basin (Figure 1). In order to obtain a comparative analysis of the relationship between climate and radial growth of studied species, it was mainly aimed the identification of the oldest trees, as well as their spread according to altitude, being selected to be studied, 2 experimental plots for both Scots pine and European larch, 4 experimental plots for silver fir and 3 experimental plots for Norway spruce, spread relatively equally along Moldovita River Basin (Table 1 and Figure 1).

Table 1

Geographical characteristics of experimental plots

No	*Code series*	*Forest unit*	*Forestry district*	*Species*	*Altitude (m)-exposition*	*Latitude*	*Longitude*
1	SF1	17 c	Vama	CF	735-980	47°39'	25°33'
2	SF2	91 a	Vama	CF	980-1120	47°38'	25°29'
3	SF3	205 a	Moldoviţa	CF	990-1235	47°34'	25°34'
4	SF4	41 b	Vama	CF	880-1150	47°44'	25°20'
5	NS1	205 a	Moldoviţa	NS	990-1235	47°34'	25°34'
6	NS2	41 b	Vama	NS	880-1150	47°44'	25°20'
7	NS3	301 f	Moldoviţa	NS	875-1100	47°44'	25°34'
8	SP1	143 b	Moldoviţa	SP	1200-1350	47°41'	25°22'
9	SP2	401	Moldoviţa	SP	820-900	47°44'	25°36'
10	EL1	216 c	Moldoviţa	EL	1050-1180	47°46'	25°21'
11	EL2	41 b	Vama	EL	1000-1150	47°35'	25°30'

CF - Silver fir; NS - Norway spruce; SP – Scots pine; EL - European larch.

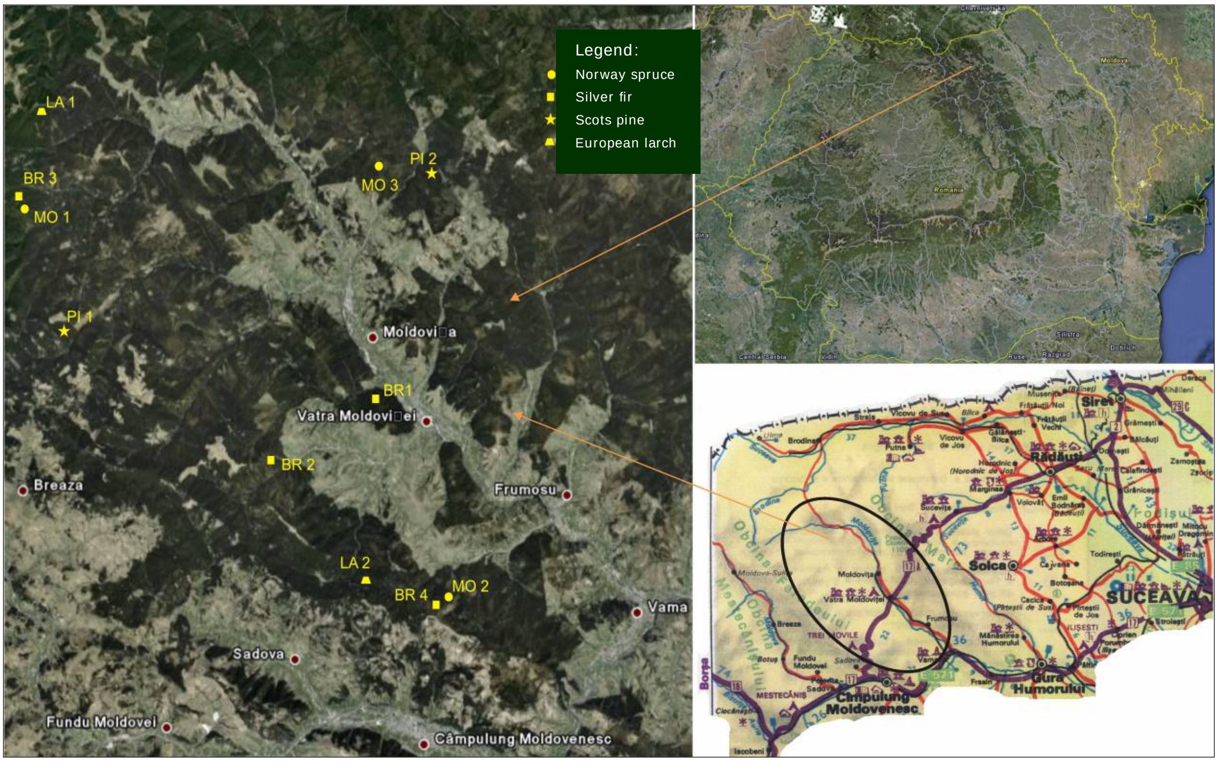

Figure 1. The study site (http://www.google.com/earth/).

There were chosen in each experimental plot, according to dendrochronological criteria (Fritts 1976; Cook & Kairiukstis 1990; Popa 2004), 20-25 trees and from each of them two increment samples at 1.30 meters were taken, on perpendicular directions on the line of the highest gradient. The increment cores were taken using Pressler drill. These cores were carried and preserved in special paper tubes, so that they would dry slowly. After drying, increment samples were fixed on special wood holders.

The measuring of annual rings width was done with CooRecorder 7.4 software. The increment series were interdated using TsapWin software and COFECHA software (Holmes 1983; Cook et al 1997).

All individual radial growth series were standardized to eliminate non-climatic influence and to obtain the maximum of climatic information from dendrochronological series. For that, 67% spline function was used, because this one is maximizing the climatic response in the strongest way (Sidor 2011). ARSTANwin software was used (Cook & Krusic 2006). The residual dendrochronological series were utilized due to the fact that autocorrelation is cut out from the obtained index series.

In order to use an unitary set of climatic data for the entire study site, it appealed to climatic database with resolution of 0.5°x0.5° CRU T.S. 3.0. (Mitchell & Jones 2005).

Trees reaction to climate variation was analyzed through Pearson correlation coefficients (Fritts 1976; Cook & Kairiukstis 1990). To this purpose, it was utilized DENDROCLIM 2002 software (Biondi & Waikul 2004). Pearson correlation coefficients were calculated through bootstrap method.

Regarding the analyzed period, there were studied the month between previous July and current July (for every studied year) between 1901-2011.

Results and Discussion. In order to analyze the relationship between climate and the coniferous species from Moldovita River Basin, among species, growth regional curves have been elaborated for all the 4 studied species (silver fir, Norway spruce, Scots pine, European larch). They have been studied according to dendroclimatological response to climate variation, dendroclimatological comparative analysis between the 4 species at regional level being, thus, possible (Figure 2). The obtained results highlight the fact that, on the whole, in the case of species, temperature has a more significant importance in biomass storage on coniferous trees stem from Moldovita River Basin, by comparison to pluviometric regime.

In general, temperature’s influence is a positive one, except for temperature’s influence from the end of the previous vegetation season (July, August, September). The temperature from this period, even though it negatively influences the radial growth of all species, has a very high influence just on Norway spruce. For most coniferous species, photosynthesis benefit from the previous vegetation season has a major impact on radial growth from current year (Kozlowski & Pallardy 1997).

In the area from the vegetation’s altitudinal borderline, for Norway spruce from the Alps alpine area, temperature is a factor with dominant part in radial growth, significant influence having the temperature from the autumn previous to annual ring forming (Eckstein & Aniol 1981). Likewise, for the French Alps, it has come to the conclusion that temperatures from the previous vegetation season cause a negative reaction (Desplanque et al 1998). The resembling dendroclimatological patterns for Norway spruce radial growth have been identified in Romania in the areas Întorsura Buzăului, Comăneşti, Gârda, Lăpuşna, Oţelul Roşu (Sidor 2011).

The negative influence of the temperatures from previous October and November, highlighted at all species, is higher for Scots pine. The positive influence of the temperatures from the cold season (previous December - current March) was also pointed out for all species, the highest influence being on silver fir. The positive reaction of silver fir radial growth to temperature from the cold season was identified in the Alps (Frank 2005), in Slovenia (Schichler et al 1997), in the centre of Italy (Manetti & Cutini 2006). In Romania, this type of dendroclimatical response for silver fir was relieved in Vrancea Mountains’ area (Sidor & Popa 2007), Sinaia area (Popa & Cheval 2007), Întorsura Buzăului area, Gârda, Lăpuşna (Sidor 2011).

In the current April, the temperature has the strongest influence on Norway spruce radial growth, while the temperatures from current May have a determinate part on European larch radial growth. During the vegetation season (current June-July), temperature has a statistically significant part, positive determinant just for Scots pine (Figure 3).

The pluviometric condition doesn't represent, in general, a significant influence statistically, the months with statistically significant influence, in some cases being, in general, as a result of autocorrelation with temperature.

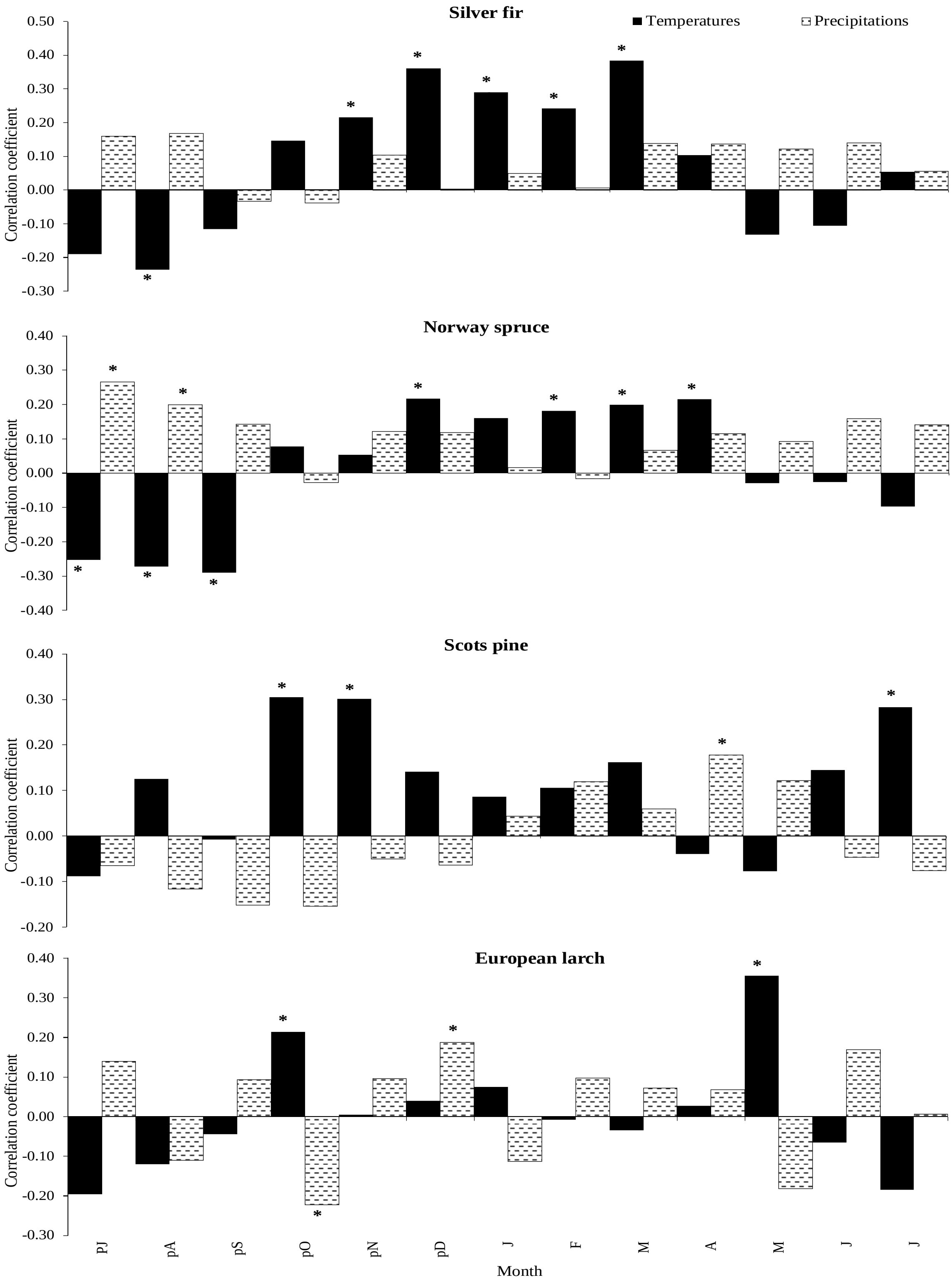

Figure 2. Coniferous trees response to the influence of climatic factors.

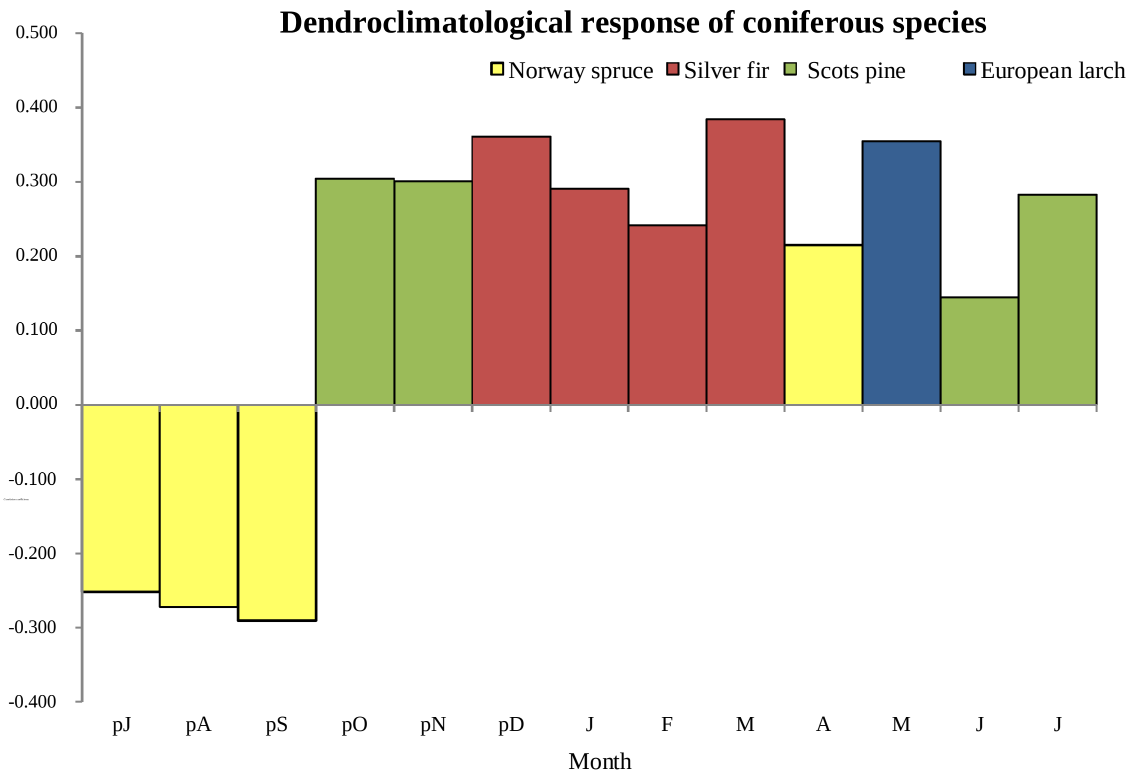

Figure 3. The significant dendroclimatical pattern for coniferous species from Moldovita River Basin.

Conclusions. The management strategies adaptation of coniferous species, in the context of possible climatic changes, will be possible only through a more detailed knowledge of the way coniferous species from this area are influenced by the variation of meteorologic factors. A certain period of time, when temperature significantly influences trees radial growth, corresponds to each coniferous species, the way temperature fluctuates in the future, having a major importance in ecological distribution of coniferous species from Moldovita River Basin.

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Author:
Nicolaie Plaiu, University Ştefan cel Mare Suceava, Forestry Faculty, 13 University St., Suceava, Romania, e-mail: nplaiu@yahoo.com

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