LONG-TERM GROWTH DECLINE OF *QUERCUS ROBUR* L. FORESTS IN VLĂSIA PLAIN

ŞTEFAN NEAGU

University "Ştefan cel Mare" of Suceava, Str. Universităţii nr. 13, 720229 Suceava, Romania;
Forest Research and Management Institute (ICAS), Bd. Eroilor 128, 077190 Voluntari, Romania, biometrie@icas.ro.

Received November 22, 2010

The aim of this paper is to examine the long-term growth dynamics of English oak (*Quercus robur* L.) in the Vlăsia Plain region, in the changing environment of the last 200 years.
The assessment of radial increment in similar cambial age classes allowed the confirmation of size differences between succeeding periods. Four age classes have been considered: 1-50, 51-100, 101-150 and 151-200 years, respectively. Confidence limits for each period were estimated at p=0.01, based on the number of sampled trees. The radial increment series were also summarized for the four periods to estimate changes in long-term radial increment. The statistical significance of the differences between the age classes was tested by comparing the confidence limits for means estimated, based on the number of measured tree rings.
The analysis of growth series revealed a declining growth trend in the last 200 years, which was statistically confirmed by the analysis of variance at p=0,01. The relative radial increment losses are between 9 and 18%, according to the considered tree age classes and compared to historical data. The most plausible explanation of this trend is linked both to natural and anthropogenic driving forces.

Key words: forest growth, decline, *Quercus robur*, radial increment.

INTRODUCTION

The large number of oak species, spread all over the world, and the decline observed in recent decades, both in Europe and North America, has generated intense concerns in terms of deepening the knowledge upon the eco-physiological behaviour of these species in different environment conditions. The general trend of the oaks area, under permanent water stress associated with one of the major causes of decline, led to development of eco-physiological research in such circumstances, both in our country and abroad[1–8]. As a general conclusion, oak trees adopted tolerance or avoidance strategies to water stress by specific mechanisms, regulating leaf gas exchange and morphological and behavioural adaptations.

On international level, sudden oak death (SOD) was reported and investigated extensively in Croatia and Slovenia even since the year 1902[9], in Poland in the years 1939 and 1940[10], in the former Soviet Union countries since 1892, in Germany since 1918[11] and in the United States of America, from 1932[12].

In Romania, there is no indication of a specific date of the occurrence of SOD[5]. In SW Romania, there had been an intense SOD during 1910–1914 periods. In the subsequent period 1930–1932, we received reliable information about the intensity of this phenomenon. There have been identified three major periods of SOD[5]: 1937–1943 in Argeş region, from 1947 to 1949 as a result of prolonged drought and the contribution of *Ophiostoma valachium* and *O. roboris* fungi and *Erwinia valachica and E. quercicola* bacteria and the third period, from 1955 to 1961, when the phenomenon reached across the entire oak area. The main causes were mainly attributed to large areas deforestation, inappropriate management practices in terms of maintaining minimum habitat quality conditions, grazing activities and negative expression of a water regime for many years. In addition, repeated tree defoliation caused by insects and bacteria of the genus *Erwinia* and the action of fungi of the genus *Ophiostoma* had a negative impact.

From research conducted on this phenomenon has emerged the idea of convergent action of several types of biotic and abiotic factors. In terms of climate conditions, the essential feature in the SOD regions, a strong imbalance in the distribution of precipitation over the growing season, and over the years, as well. In addition, late frosts damaged the tree foliage, and as a consequence had an effect equivalent to one defoliation event. The analysis of geomorphological conditions, soil and water showed that SOD was observed in all terrain and soil conditions, but with greater intensity in situations with excess water and salt phenomenon, and failed to establish a link between the SOD intensity and the forest type. In particular, management system and practices in the past are the most important factors of SOD[5]. Recommended measures have put more emphasis on preventive and protective interventions against defoliators and maintaining and improving site conditions. Nevertheless, the oak stands of low productivity, where conditions allow, it recommended the plantation of pine, acacia, alder, birch etc.

The aim of this paper is to examine the long-term growth dynamics of English oak (*Quercus robur* L.) in the Vlăsia Plain region, in the changing environment of the last 200 years, using instruments and means of dendrochronology analysis by reconstructing the radial increment of dominant trees and use it as an indicator of changes in productivity.

MATERIALS AND METHODS

Under the influence of various disturbing factors, biological systems react distinctly depending on the time taken into account, so that changes in short-term growth of a forest can become long-term changes in the productivity of entire stands[14].

From the methodological point of view, comparing the height increment would be the most appropriate approach to identify possible changes in forest productivity, as the dominant tree height and average age of a stand are the most important indicators and less dependent on stand composition and competitive relations between individuals[13]. The disadvantage of this approach lies in the difficulty and the significant effort required to undertake the analysis of a sufficient number of trees and also is a destructive method. For this reason, the analysis of radial increment was considered as an alternative.

The method consists in analyzing the actual radial increment of dominant trees of the oak stands representative for the study area, trees located in similar site conditions, but of different generations in order to reveal any differences between the generations of trees in terms of the same cambial age[14]. Such an approach requires stratification in radial growth series of age classes so that one can compare the statistical parameters of the respective series and achieve relevant conclusions. Data on annual ring width were processed for each individual year, and stratified in four major age classes, i.e., between 1 and 50 years, 51 to 100 years, 101 to 150 years, and between 151 and 200 years. Confidence intervals were determined and analyzed for the significance ($p=1\%$) of differences between the means. Direct comparison of mean increment of trees belonging to different generations has the advantage of not requiring standardization to eliminate the influence of age from tree-ring series and mathematical modelling, and may be considered an indicator of site productivity variation over time.

Only complete core samples (including the pith) were analysed, allowing precise determination of cambial age (over 450 samples). Selected trees are dominant in the forest stand and of different diameters categories, free from noticeable injuries, with symmetrical crown architecture. In terms of radial increment, the selected trees are representative for respective forest site, and it can be assumed that the same trends have been recorded in the trees' ring width under the influence of exogenous factors.

RESULTS AND DISCUSSION

In order to avoid the disadvantages of ring width series standardization, one can use a simpler method based on comparing the differences between biometric characteristics of tree ring width for different generations, grouped into 50 years classes and comparable cambial age, whose size is also 50 years. Essentially, there were analyzed the radial increment of elderly, adult and young trees, compared to the same cambial age of annual rings. Possible errors of this method are dependent on the size of the periods analyzed, age structure and bio-ecological characteristics of analysed oak trees.

Effects consist in a longer growing season and the potential effect of fertilization because of increased concentration of carbon dioxide (CO_2)[14].

As expected, considering the ecological and climatic recent modifications, we started from the assumption of a positive trend in terms of oak growth for the analyzed region, due to climate warming in the plain area[15]. Consequently, the last 200 years, as confirmed by analysis of variance of the average tree rings width of the samples analyzed, which are statically significant ($p<0.1\%$) (Fig. 1, Fig. 2 and Table 1).

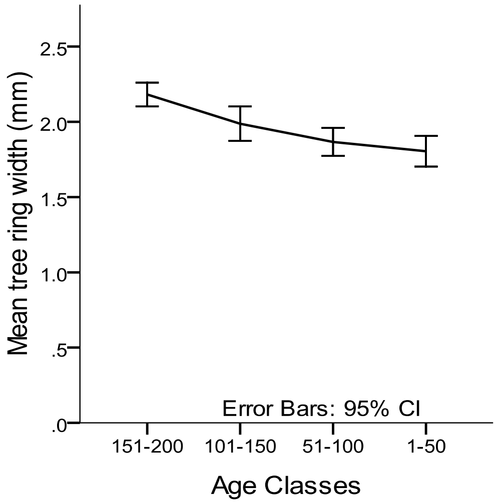

Fig. 1. Negative trend of average ring width for oak trees of 1-50 years of cambial age, in Vlăsia Plain.

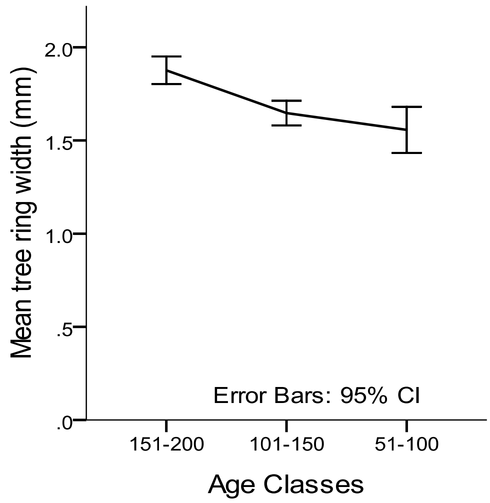

Fig. 2. Negative trend of average ring width for oak trees of 51-100 years of cambial age, in Vlăsia Plain.

Table 1

One-way analysis of tree ring width for oak trees in Vlăsia Plain

Variable		Sum of Squares	df	Mean Square	F	Sig.
Mean tree ring width for oak trees of 1-50 years of cambial age (mm)	Between Groups	8.103	3	2.701	11.440	<0.001
	Within Groups	91.138	386	.236		
	Total	99.241	389			
Mean tree ring width for oak trees of 51-100 years of cambial age (mm)	Between Groups	4.167	2	2.083	15.601	<0.001
	Within Groups	32.184	241	.134		
	Total	36.351	243			

Considering the statistical significance, it was found at least the existence of significant differences between age classes analyzed, except in the case of trees younger than 100 years, which could indicate an attenuation of the negative trend of tree rings width in the last century (Table 2).

Table 2

Pos-hoc tests ANOVA (LSD-Fisher's least significant difference)

(I) Age Classes (yrs)	(J) Age Classes (yrs)	Mean Difference (mm) (I-J)	Std. Error	Sig.	99% Confidence Interval	
					Lower Bound	Upper Bound
151-200	101–150	.19384*	.06872	.005	.0160	.3717
	51–100	.31509*	.06962	.000	.1349	.4953
	1–50	.37685*	.06962	.000	.1966	.5571
101-150	151–200	-.19384*	.06872	.005	-.3717	-.0160
	51–100	.12125	.06962	.082	-.0590	.3015
	1–50	.18301*	.06962	.009	.0028	.3632
51-100	151–200	-.31509*	.06962	.000	-.4953	-.1349
	101–150	-.12125	.06962	.082	-.3015	.0590
	1–50	.06176	.07050	.382	-.1207	.2443
1-50	151–200	-.37685*	.06962	.000	-.5571	-.1966
	101–150	-.18301*	.06962	.009	-.3632	-.0028
	51–100	-.06176	.07050	.382	-.2443	.1207

* The mean difference is significant at the 0.01 level.

Table 3

Differences between averages of tree ring widths related to age classes

Variable/Age classes (yrs)	151–200	101–150	51–100	1–50
Mean tree ring width for oak trees of 1–50 years of cambial age (%)	100	91	86	83
Mean tree ring width for oak trees of 51–100 years of cambial age (%)	100	88	83	–

These results show evidence of growth trend for oak trees on the studied region, in a very long time (about 200 years). It is not a real indicator of the total biomass production of forest ecosystems, and it does not take into account possible changes in wood density, that would compensate for changes in other biometric characteristics of the tree rings. In this perspective, the gradual reduction of the width of tree rings is up to 9% and 17% respectively, over the last 150 years. This is only a proof of oak trees adaptation response to changes in the environmental conditions, regardless of the initiating causes (Table 3).

The explanations of the decline phenomenon may be due to ecological and anthropogenic factors, but primarily to smaller quantity of rainfall and slight increase in average temperatures[15], which amplifies water stress during the growing season and induce reduction of growth as an adaptation response. Anthropogenic factors have had a negative impact on growth, but are rather impossible to separate them from the natural factors. It is also evident the coincidence with the application of an inappropriate silvicultural system, extensive grazing, insects outbreaks etc.[16–18].

CONCLUSIONS

The main objective of this paper was to highlight the long-term auxological trend of the oak forests compared to previous period, using instruments and means of dendrochronology analysis by reconstructing the radial growth of trees as an indicator of changes in productivity of the forest sites.

This study started from the assumption of a positive trend of oak growth, due to climate warming in the plain area, resulting in a longer growing season, and because of the potential effect of increased fertilization effect of CO_2 level. However, the general trend of growth was downwards. It was determined that, over the last 150-200 years, the negative trend was up to 9-18%, depending on the age of the trees, and that the causes were both natural and anthropogenic. These findings are important to forest management planning. Growth declining of oak forests, due to climate change should be taken into consideration for the long-term planning, in order to maintain an optimum stability and productivity.

REFERENCES

1. Alexe, A., *Complexe de măsuri privind prevenirea şi combaterea fenomenului de uscare a stejarului*, Rev. păd. 2, 1984, pp. 35–47.
2. Alexe, A., *Analiza sistemică a fenomenului de uscare a cvercineelor şi cauzele acestuia*, Rev. păd. 1, 3, 1985, pp. 56–69.
3. Alexe, A., *Analiza sistemică a fenomenului de uscare a cvercineelor şi cauzele acestuia*, Rev. păd. 1, 2, 3, 1986, pp. 5–15.
4. Catrina, I., Popa, A., Antonescu, V., Costea, A., Parascan, D., Stănescu, V., Tîrziu, D., Danciu, M., Postelnicu, A., Chiriescu, C., Afrenie, F., Damian, M., Man, G., Budu, E., Bujka, M., Cenuşă, R., DIRNESCU, I., Munteanu, S., *Concepţii şi metode noi în silvicultură, privind conversia energiei solare şi creşterea randamentului fotosintezei*, vol., Bucureşti, 1987, 58 p.
5. Marcu, G., *Studiul cauzelor şi al metodelor de prevenire şi combatere a uscării stejarului*, vol., Centrul de documentare tehnică pentru economia forestieră, Bucureşti, 1966, 582 p.
6. Breda, N., Garnier, A., Barataud, F., Moyne, C., *Effects of thinning on soil water balance and tree water relations, transpiration and growth in an oak forest (Quercus petraea)*, Tree physiology 15, 1995, pp. 295–306.
7. Luisi, N., Lerario, P., Vannini, A. (Editors), *Recent advances in studies on Oak decline*, Dipartamento di Patologia vegetale, Universtià degli Stud, Selva di Fasano, 1993.
8. Tyree, M.T., Cochard, H., *Summer and winter embolism in oak, impact on water relations*, Ann. Sci. For. Nr 53, 1996, pp. 173–180.
9. Langhoffer, A., *Schwammsoinnen und das Eingher unserer Eichenwalder*, vol., Zagreb, 1926.
10. Eliescu, G., *Asupra uscării în masă a stejarului*, Revista pădurilor, nr. 11–12, 1943, pp. 453–459.
11. Stratanovici, I.A., Zaborovschi, P.E., *Prisciní usîhanaia Sipova lesa Gosudartvennoe vsesoiuznoe obiedinenie lesnoi promişlenosti i lesnovo hoziastva*, vol., S.S.S.R. V.N.I.I.L.N. I L.F., Leningradskii filial, Leningrad, 1931, 3–87 pp.

12. Henry, B.W., *Chalara quercina n. sp. The cause of oak wilt*, Phytopathology, vol. 34, 1944, pp. 631–635.
13. Giurgiu, V., *Dendrometrics and forest auxology (in Romanian)*, vol., Editura Ceres, Bucharest, 1979, 692 p.
14. Becker, M., Nieminen, T.M., Geremia, F., *Short-term variation and long-term changes in oak productivity in northeastern France, the role of climate and atmospheric CO_2*, annales de Sciences Forestieres 51, 1994, pp. 477–492.
15. Busuioc, A., Caian, M., Cheval, S., Bojariu, R., *Variabilitatea şi schimbarea climei*, vol., Bucureşti, 2010, 226 p.
16. Giurgiu, V., *Conservarea pădurilor*, vol., Editura Ceres, Bucureşti, 1978, 307 p.
17. Giurgiu, V. (Editor), *Pădurea şi modificările de mediu*, Editura Academiei române, Bucureşti, 2005, 238 p.
18. Giurgiu, V., *Pădurile și schimbările climatice*, Rev. păd. nr 3, 2010, pp. 5–14.