GROWTH VARIABILITY AND COMPETITION INFLUENCE ON TREE GROWTH IN ABIES BORISII-REGIS FORESTS FROM SOUTH-EAST ALBANIA

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Abstract

Competition is one of the main factors controlling growth of trees. This study investigated the growth variability and the potential influence of competition (exerted among individual trees) on tree growth of *Abies borisii-regis* forests growing in south-eastern part of Albania. Several growth variables such as diameter at breast height, height, distance to the nearest tree, crown radius, age and inter annual radial growth (earlywood, latewood and tree ring widths) were measured. Based on this data other growth variables (basal area, volume, mean annual increment and competition indices (Hegyi, Gerrard and Bella)) were calculated. Correlation analyses were carried out among growth variables to figure out any possible relationship among them. The growth variables generally showed high variability. However, higher growth variability was observed in the case of age, diameter at breast height and height as compared to earlywood, latewood and tree ring widths variables which showed somehow lower variability. Correlation analysis indicated high significant positive relationship between diameter at breast height and height, tree ring width and breast diameter, tree ring width and earlywood width, and tree ring width and latewood width whereas the tree ring width and age showed negative association. Positive correlation coefficient was also observed between earlywood width and latewood width but the relationship was weaker as compared to the above mentioned associations. The trees showed moderate competition among them which affected considerably their growth. The influence of neighbor trees was better evaluated by the Gerrard and Bella competition indices as their high values indicated low tree growth and vice versa. These competition indices take into consideration the overlapping growing space among neighbor trees which seems to be a better indicator of competition than diameter ratio which is used for calculation of the Hegyi index. We conclude that tree growth in *A. borisii-regis* stand is generally high but efforts should be made to control the competition among trees as it affects their growth.

Key words: tree growth, *Abies borisii-regis*, correlation analysis, competition.

Introduction

Recent investigations on the development dynamics in plant populations point out that the understanding of population development is enhanced significantly when the stand is broken down into a mosaic of individuals and interactions in a dynamic spatial–temporal system (Biging & Dobbertin, 1995). The division of the stand into a mosaic of individuals that interact as a dynamic spatial-temporal system allows advances in the analysis and more accurate evaluation and prediction of forest stand development (Pretzsch, 2005). Total stand development is derived from the interactions taking place between individual trees. Therefore, the relationships among growth variables at the individual tree level are of particular interest in forest science. Rates at which the individual trees grow have an important influence on tree diameter and therefore on quality (Rıo, Montero & Bravo, 2001). The growth of trees and production is affected among others by the competition which means the interaction between trees through spatial occupancy and resource exploitation such as carbon dioxide, water, nutrients and light as an energy source. Competition is the common phenomenon in forest ecosystem that shapes the plant morphology, has a profound impact on plant community structure and dynamics (Wen-Jun et al. 2010). The competition among trees is quantified by means of competition indices which characterize resource availability and the growing conditions of each individual tree. When resource availability in a stand is lower than required for optimal tree growth, the individual trees are in direct competition with one another. Competition indices make use of tree diameter, height, crown size and distance to neighbor trees to quantify the competitive situation of individual trees and the impact on growth. In particular, crown size is a good indicator of competition which directly affects the growth of trees as in high densities the individual trees have very little space to seize resources like light, water and nutrients (Pretzsch & Schutze, 2005).The objectives of this study were (i) to evaluate the basic tree growth parameters (diameter at breast height (dbh)), height, basal area, volume, crown size, distance to neighbor trees, inter annual radial growth variability (early wood, latewood, ring width)) in an *Abies borisii regis* stand located in south-east of Albania and (ii) to quantify the effect of competition on tree growth variables in this specie.

Study area

The *A. borisii-regis* pure stand considered in the study grows in south-east (40°11'59.78"N, 20°25'30.11"E) of Albania (Figure 1), on steep slopes (45%), east aspects and elevation about 300 m.a.s.l. The area is characterized by Mediterranean climate with mean annual temperature of 20.3˚C and total annual precipitation of 1870 mm. The soil type is grey brown, which is a shallow soil, with low water holding capacity and organic matter on the surface (FAO, 1998). The understory vegetation is composed mostly of shrubs such as *Phyllorea angustifolia, Erica arborea, Arbutus unedo,* ect.

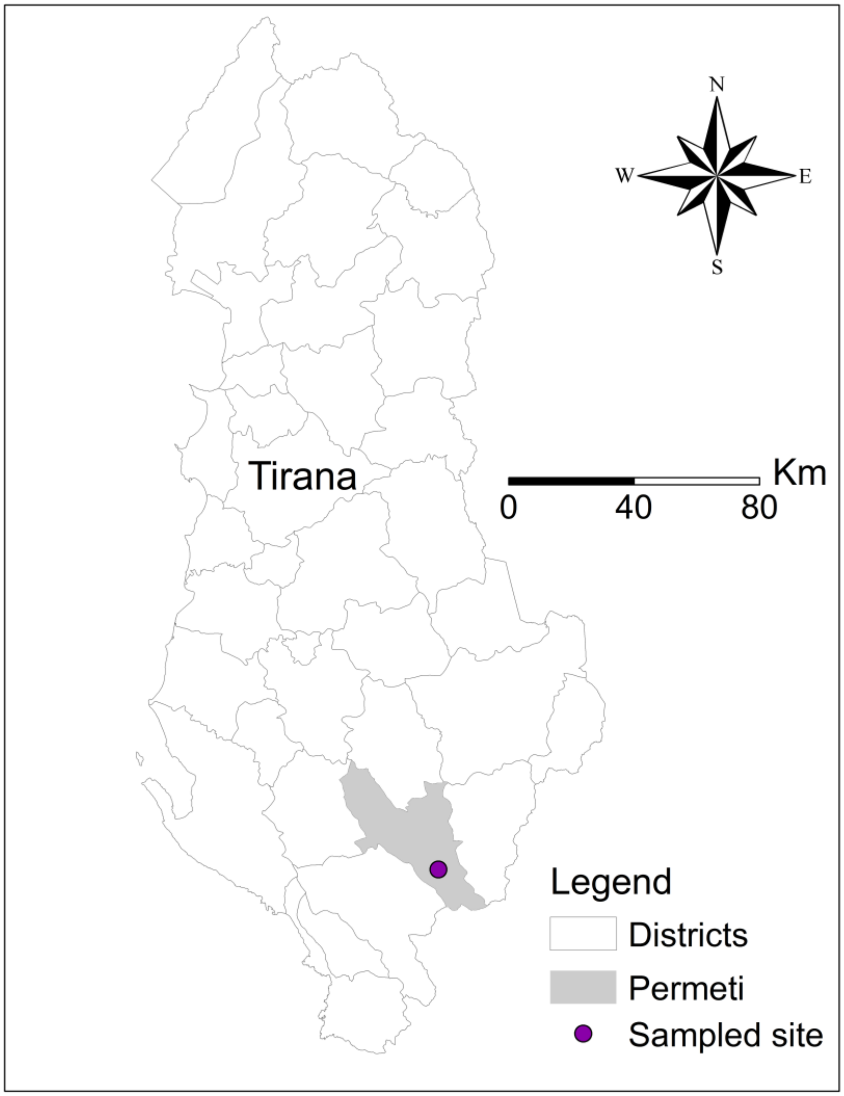

Figure 1. Location of the study site in Përmeti region (south-east of Albania).

Methods

Dendrochronological methods

Dendrochronological methods were used to evaluate the radial growth variability in the sampled trees. In particular, at the site, 17 dominant trees separated by at least 10 m were randomly selected, their diameter at 1.3 m (dbh) was measured and they were sampled (Figure 1). Two radial cores per tree were extracted at 1.3 m height using a Pressler increment borer. The cores were prepared following standard dendrochronological methods (Fritts, 2001). They were dried, mounted and sanded with sandpapers until tree-rings were clearly visible with a binocular microscope. All samples were visually cross-dated and the ring width was measured using a LINTAB measuring device (Rinntech, Heidelberg, Germany). Cross-dating was evaluated using the COFECHA program (Holmes 1983).

Competition indices calculation

The tree-level competition was evaluated by using three competition indices (Hegyi, Gerrard and Bella). The Hegyi index (Hegyi, 1974) includes information on tree to tree distance and their dbh ratio, and is calculated as it follows:

$$H_g CI_j = \frac{\sum_{i=1}^{n} \frac{d_i}{d_j}}{dist_{ij}}$$

CI_H= Hegyi competition index
d_i = dbh of the competitor tree i
d_j = dbh of the central tree j
$dist_{ij}$ = distance between the competitor i and the central tree j
n = number of competitors

The Gerrard competition index (Gerrard, 1969) considers the ratio of the overlapping crown projection area between the central tree and the competitors, and the crown projection area of the central tree.

$$KI_j = \frac{\sum_{i=1}^{n} O_{ij}}{CS_j}$$

CL_G= Gerrard index of competition
O_{ij} = overlapping crown projection area between the central tree j and the competitor i
CS_j= crown projection area of the central tree j
n = number of competitors

The index from Bella (Bella, 1971) considers both the overlapping crown projection area and the distance between the central tree and the competitors.

$$B_j = \sum_{\substack{i=1 \\ i \neq j}}^{n} \frac{o_{ij}}{CS_j} * \frac{d_i}{d_j}$$

CI_B= Bella competitor index
O_{ij} = overlapping crown projection area between the central tree j and the competitor i
d_i = dbh of the competitor tree i
d_j = dbh of the central tree j

Correlation analysis

The Pearson correlation coefficient was calculated among the measured growth variables (diameter at breast height, height, distance to the nearest tree, crown radius), calculated growth variables (basal area, volume, mean increment) age and inter annual radial growth (earlywood, latewood and tree ring widths) to investigate any relationship among them.

Results and discussion

Tree growth variability

The age and growth variables generally showed high variability. Considering growth variables, higher growth variability was observed in the case of diameter at breast height, height and basal area as compared to earlywood, latewood and tree ring widths variables which showed somehow lower variability. The age of trees also varied considerably among sampled individuals.

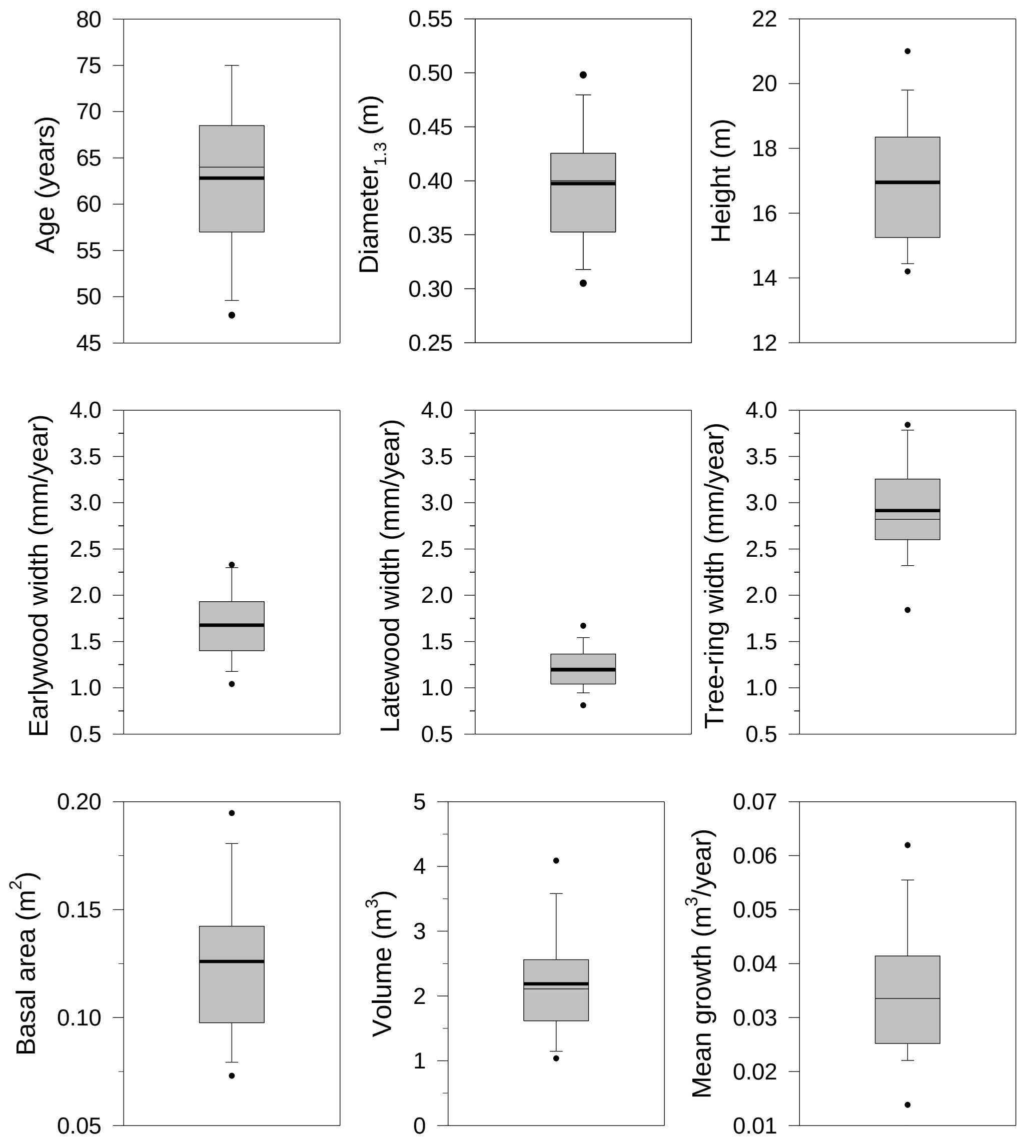

Figure 2. Variability of age and growth variables in the sampled trees

Growth variables relationship

Correlation analysis indicated several significant relationships among the growth variables. High significant positive relationships were observed between diameter at breast height and height, tree ring width and breast diameter, tree ring width and earlywood width, and tree ring width and latewood width whereas the tree ring width and age showed negative association. Positive correlation coefficient was also observed between earlywood width and latewood width but the relationship was weaker as compared to the above mentioned associations.

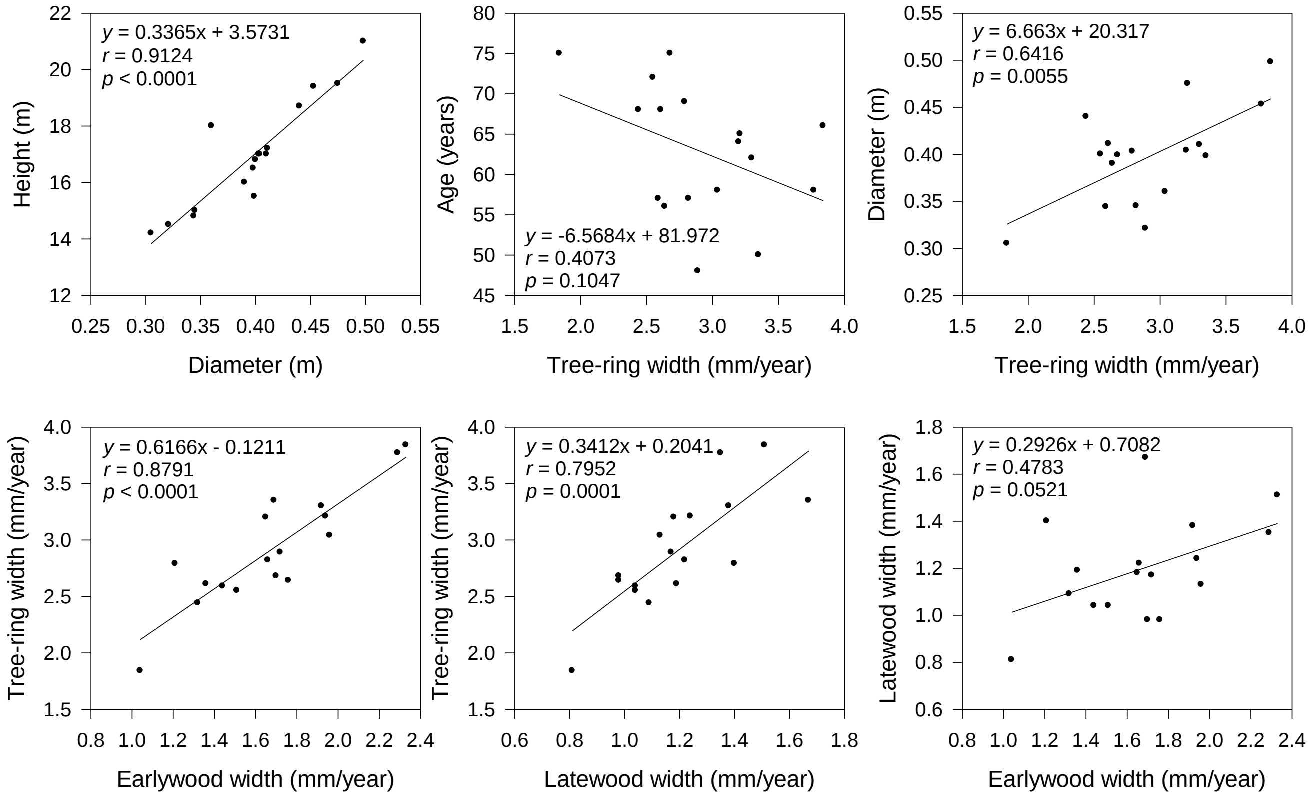

Figure 3. Relationships among the studied growth variables.

Growth parameters and tree level competition

The following table (table 1) provides data on the growth characteristics of each sampled tree and the level of competition exerted on them. The differences in growth observed among trees are likely related to differences in resource availability between large trees and suppressed smaller trees in the stands. There were found greater proportions of growth in the largest trees under low competition pressure and the opposite in the smallest trees. It is clear that the competition affected considerably the growth of trees. The three competition indices showed a variable competition level on each tree, with highest values obtained by the Hegyi index. However, the level of competition was better evaluated by the Gerrard and Bella competition indices as their high values indicated low tree growth and vice versa. These competition indices take into consideration the overlapping growing space among neighbor trees which seems to be a better indicator of competition than diameter ratio which is used for calculation of the Hegyi index. The influence of competition was clearly observed on the dbh and the basal area of trees which showed the opposite trend with the competition indices. This is consistent with the idea that increased inter tree competition causes a decline in individual tree vigor due to the low levels of resource available (Assmann, 1970).

Table 1. Growth characteristics and the competition indices of the sampled trees.

Nr.	Age (yr)	$D_{1.3}$ (cm)	H (m)	Radial growth (mm/yr) RW	EW	LW	G (m^2)	V (m^3)	Im (m^3/yr)	Comp. indices Hg	KI	Bj
1	68	41.1	17.2	2.61	1.36	1.19	0.13	2.28	0.03	0.01	0.00	0.00
2	72	40.0	16.8	2.55	1.51	1.04	0.13	2.11	0.03	0.23	0.30	0.28
3	66	49.8	21.0	3.84	2.33	1.51	0.19	4.09	0.06	0.18	0.25	0.21
4	62	41.0	17.0	3.30	1.92	1.38	0.13	2.24	0.04	0.26	0.15	0.18
5	75	39.9	15.5	2.68	1.70	0.98	0.12	1.94	0.03	0.14	0.05	0.04
6	68	44.0	18.7	2.44	1.32	1.09	0.15	2.84	0.04	0.17	0.10	0.09
7	64	40.4	17.0	3.20	1.65	1.18	0.13	2.18	0.03	0.21	0.08	0.09
8	69	40.3	17.0	2.79	1.21	1.40	0.13	2.17	0.03	0.10	0.00	0.00
9	56	39.0	16.0	2.64	1.76	0.98	0.12	1.91	0.03	0.15	0.00	0.00
10	50	39.8	16.5	3.35	1.69	1.67	0.12	2.05	0.04	0.15	0.05	0.05
11	57	34.4	14.8	2.59	1.44	1.04	0.09	1.37	0.02	0.16	0.03	0.03
12	75	30.5	14.2	1.84	1.04	0.81	0.07	1.04	0.01	0.20	0.01	0.01
13	48	32.1	14.5	2.89	1.72	1.17	0.08	1.17	0.02	0.22	0.05	0.05
14	57	34.5	15.0	2.82	1.66	1.22	0.09	1.40	0.02	0.33	0.30	0.31
15	58	36.0	18.0	3.04	1.96	1.13	0.10	1.83	0.03	0.27	0.40	0.38
16	58	45.3	19.4	3.77	2.29	1.35	0.16	3.13	0.05	0.10	0.05	0.04
17	65	47.5	19.5	3.21	1.94	1.24	0.18	3.45	0.05	0.25	0.40	0.36

Conclusions and recommendation

The growth of *A. borisii-regis* trees showed high variability, particularly the dbh and the tree height which could be related to variable age and growing space among individual trees. The inter annual variability of radial growth series appeared to be lower as compared to the other growth variables but they showed higher correlation within the tree ring features. Such relationship was also observed considering tree-ring width and dbh as higher tree-ring width leads to diameter increament. Competition indeces proved the influence of competition on tree growth parameters as the tree growth reduced with increasing competition. Therefore we conclude that efforts should be made to control the competition among trees as it affects tree growth.

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