

Comparative analyses of the space exploring growth in natural forests (“Izvoarele Nerei” natural reserve) and in managed forests

Brad R.

Forest Research and Management Institute Timisoara

*Corresponding author. Email: brad_radu@yahoo.co.uk

Abstract This article presents some preliminary results concerning the study of crown architecture for two sets of beech seedlings (*Fagus sylvatica*) with different origins: one from old-growth forest and the other one from second-growth forest. The data obtained from the measurements and the observations which were done (total height of the tree, internodes lengths, number of growth cycles, number of second growth stems, geometrical parameters of the crown) were pairwise compared. The results show that there are significant differences between the crown architecture of two statistical populations of seedlings and the growth differences do not actually describe a certain architectural type.

Key words

beech crown architecture, internodes lengths, number of growth cycles

Study of tree architecture has been recognized as a promising way to improve the photosynthetic yield of fruits orchards [1, 2] or labor productivity when olives are to be harvested [3]. About forestry, tree architecture seems to be an important challenge for the multiple primary and secondary effects the tree crown architectures have had on the carbon sequestration capacity [4-6] competition among forest tree species [7, 8] or photosynthetic yield of mixed deciduous species combining a shade tolerant species with oak [9].

Within a shade tolerant species, like beech (*Fagus sylvatica*) the crown architecture is worth being studied due to the valuable information provided with respect to the expected differences between seedlings grown in old-growth forest and seedlings grown in second-growth forests, where group systems are being applied on a large scale. Comparing crowns of the two statistical populations of seedlings, one from old-growth forest and the latter from second-growth forests show significant differences of their crown architecture.

Growth process describing data

The increment of the main prevailing stem or of the offshoot prevailing stem is produced by the apical meristems. From the point of view of growth cycles, beech exhibits recurrent or poly-cyclical growths, as oak, walnut or chestnut do. These four species are typified by successive growths separated by shut breaks, brought about by many branches. The first

cycle is labeled as spring growth, followed by several summer growth cycles¹.

Therefore the measurements carried out in this research was made with appropriate precision, (tenth of centimeter), and the internodes lengths were divided by the total height of the tree, in order to obtain comparable data across two populations. Then, the growth data were pairwise compared. As shown in Figure 1, the larger the differences within each pair of internodes are, the greater is the growth lag between the two populations of seedlings.

It should be pinpointed that growth differences do not actually describe a certain architectural type, but they rather show the growth lag between the two populations, which is obviously suggested in Fig. 1.

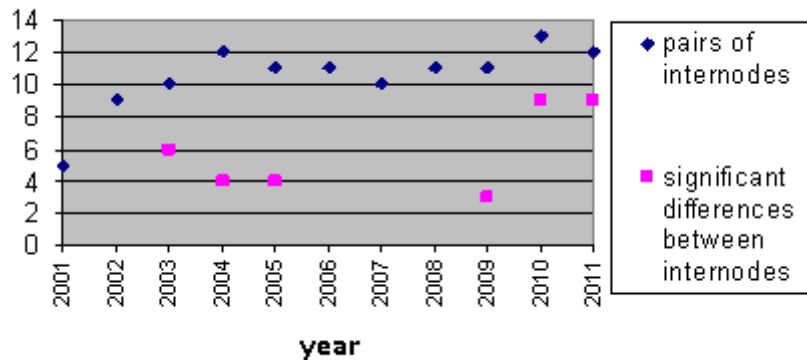


Fig. 1 Periods when the growth differences between the two populations were statistically significant

Fig. 2 provides a closer look to the differences between the two statistical populations, with respect to the relative lengths of the two pairs of internodes, one for the old-growth forest and one for the second-growth forest. Obviously for the growths corresponding to year 2011, on average, the seedlings

from the second-growth forest grew faster, reached an apex, which corresponds to the fifth internode, and decreased afterwards. In the same time, the internodes of the old-growth forest seedlings grew slower, reached an apex corresponding to the eighth internode, and decreased a little bit slower afterwards, comparing to the second-growth forest seedlings.

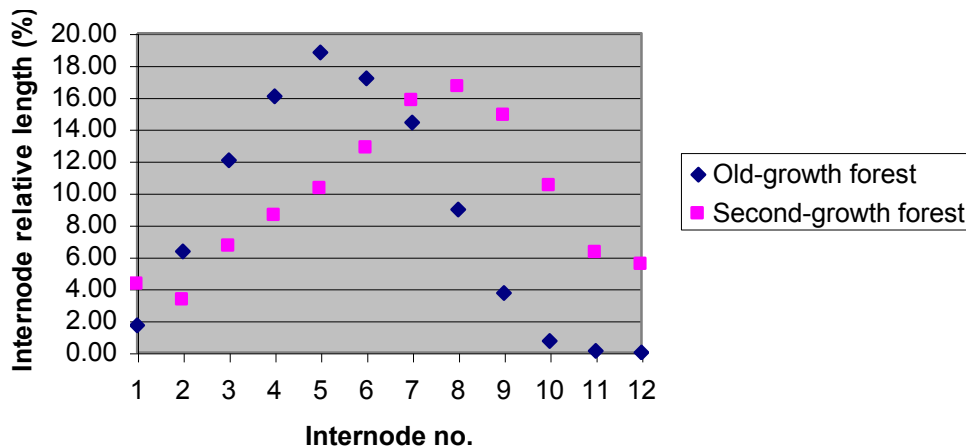


Fig. 2 Elongations of the 12 pairs of internodes where statistical significance of differences between average growths was tested, for the year 2011.

Another important question worth being answered is the number of second-growth stems of the two populations of seedlings. The answers can be found in

Table 1, which shows that, out of the 75 seedlings randomly collected from the old-growth forest, 46 had no dominant, re-branched stems, while quite the same number of seedlings, coming from the second-growth forest, had more than one and less than four re-branched stems (branches that undertook the height growth of the main stem).

For crown architecture another methodological approach compares, on the one hand,

the average crown volumes of the two samples, finds out which geometrical rotation body better fits crowns shapes. On the other hand, the average crown lateral areas of the two samples, finds out which lateral area of geometrical rotation body better fits crowns areas. In order to compute the volume of any rotation body wherein each crown is enveloped, the first step was to measure some basic parameters needed to mold the crown.

Table 1

Number of seedlings with different second-growth stems along the main prevailing stem

Number of seedlings with ... second-growth stems along the main prevailing stem	Old-growth forest		Second-growth forest	
	Count	%	Count	%
0	46	61,3	24	28,2
1	16	21,3	25	29,4
2	10	13,3	18	21,2
3	3	4,0	12	14,1
4	0		4	4,7
5	0		1	1,2
6	0		0	
7	0		1	1,2
Total	75	100,0	85	100,0

These parameters are as follows: Ht – total height (cm); Ph - pruned length (the distance between the soil and the first-order branch); Ch – crown height (the distance between the insertion point of the first-order branch and the top of the crown; Cw – crown width (largest width of the crown), L1 – distance between the top of the crown and the point where the crown width was measured and L2 – distance between

Table 2. As expected, the variation coefficients for the saplings from the old-growth forest

the insertion point of the first-order branch and the point where the largest width was measured. The following checking formulae apply: $Ht=Ph+Ch$, $Ch=L1+L2$.

These measurements were made on the virtual 3D images produced by Photomodeler® software. The main statistics necessary to reshape the crowns are presented

in a little bit higher than those reported for second-growth forest.

Table 2

Main measurements needed for reshaping the crown volume (in cm)

Statistics	Ph	Ch	L1	L2	Cw
	Old-growth forest				
Average	216,78	78,78	138,00	66,92	71,08
Stand.dev.	17,59	19,75	21,17	15,04	15,46
Variation coeff.	8,11	25,07	15,34	22,47	21,76
Val. min.	167,00	27,71	63,21	28,82	34,39
Val. max.	254,00	125,79	192,29	122,13	102,91
	Second-growth forest				
Average	211,93	71,91	140,03	64,67	74,69
Stand.dev.	12,48	22,52	23,86	17,51	18,10
Variation coeff.	5,89	31,32	17,04	27,07	24,23
Lowest val.	187,00	20,69	83,55	33,16	37,87
Highest val.	245,00	143,68	193,31	137,76	124,04

Having the data reported in

Table 2, the enveloping volumes of the crowns, the volumes of three rotation bodies based on the three dimensions above referred were computed, to

Table 3. The data reported on this table suggest the ellipsoidal paraboloid fits the best onto crown shape, considering both the crown volume and

be further compared with the volumes estimated on the 3D virtual image, averaged in the last column of

the crown areas, whose statistics are presented in Table 4.

Table 3

Volumes (in dm³) for different rotation bodies enveloping the crowns and the real volume estimated on the 3D virtual image of the crown (last column)

Statistics	Cone	Ellipsoidal Paraboloid	Semi- ellipsoid	Real volume
	Old-growth forest			
Average	19,16	28,74	38,32	32,09
Stand.dev.	16,39	24,59	32,78	18,84
Variation coeff.	85,54	85,54	85,54	58,73
Val. min.	2,73	4,10	5,47	4,91
Val. max.	122,54	183,81	245,08	108,45
Second-growth forest				
Average	12,83	19,25	25,67	22,53
Stand.dev.	7,02	10,53	14,04	11,98
Variation coeff.	54,70	54,70	54,70	53,16
Lowest val.	1,96	2,94	3,92	7,05
Highest val.	36,40	54,60	72,80	62,33

Table 4

Crowns area (in dm²) for different rotation bodies enveloping the crowns and the real volume estimated on the 3D virtual image of the crown (last column)

Statistics	Cone	Ellipsoidal paraboloid	Semi- ellipsoid	Real area
	Old-growth forest			
Average	28,98	64,16	75,33	82,65
Stand.dev.	15,34	27,11	32,00	27,22
Variation coeff.	52,95	42,26	42,47	32,93
Val. min.	8,23	17,26	20,30	22,80
Val. max.	118,02	183,63	217,38	181,02
Second-growth forest				
Average	22,89	53,98	63,28	67,35
Stand.dev.	7,98	18,17	21,32	22,59
Variation coeff.	34,84	33,65	33,69	33,55
Lowest val.	8,36	21,88	25,54	27,96
Highest val.	46,20	101,56	119,30	138,59

Results and Discussions

Considering the growth data concerning the internodes lengths, the larger the differences within each pair of internodes are, the greater is the growth lag between the two populations of seedlings. They also show that the seedlings from the second-growth forest grew faster, reached an apex, which corresponding to the fifth internode, and decreased afterwards. The internodes of the old-growth forest seedlings grew slower, reached an apex corresponding to the eighth internode, and decreased a little bit slower

afterwards, comparing to the second-growth forest seedlings.

Accounting the number of second-growth stems of the two populations of seedlings, there was found that 61.3 % from the number of seedlings randomly collected from the old-growth forest, had no dominant, re-branched stems, while quite the same number of seedlings, coming from the second-growth forest, had more than one and less than four re-branched stems (branches that undertook the height growth of the main stem). Only 28.2 % from the number of seedlings collected from the second-growth forest had no dominant, re-branched stems.

The data regarding the average crown volumes and areas of two samples of seedlings were compared with the same geometrical parameters of three geometrical bodies which envelope the real crowns (cone, ellipsoidal paraboloid, semiellipsoid). This comparison shows that the ellipsoidal paraboloid fits the best onto crown shape, considering both the crown volume and area.

Conclusions

1. Comparing crowns of the statistical populations of seedlings from old-growth forest and from second-growth forests shows significant differences of their crown architecture.
2. The growth differences between these two statistical populations do not actually describe a certain architectural type, but they rather show the growth lag between the two populations.

References

1. Gagnard, M., F. Baret, and D. Simon, A 3D peach canopy model used to evaluate the effect of tree architecture and density on photosynthesis at a range of scales. *Ecological Modelling*, 2000. **128**(2-3): p. 197-209.
2. Honda, C., et al., Transformation of kiwifruit using the *ipt* gene alters tree architecture. *Plant Cell, Tissue and Organ Culture (PCTOC)*, 2011. **107**(1): p. 45-53.
3. Schneider, D., et al., Does alteration of *Koroneiki*™ olive tree architecture by uniconazole affect productivity? *Scientia Horticulturae*, 2012. **139**(0): p. 79-85.
4. Iida, Y., et al., Tree architecture and life-history strategies across 200 co-occurring tropical tree species. *Functional Ecology*, 2011. **25**(6): p. 1260-1268.
5. Ishii, H. and S. Asano, The role of crown architecture, leaf phenology and photosynthetic activity in promoting complementary use of light among coexisting species in temperate forests. *Ecological Research*, 2010. **25**(4): p. 715-722.
6. Percy, R., et al., A functional analysis of the crown architecture of tropical forest *Psychotria* species: do species vary in light capture efficiency and consequently in carbon gain and growth? *Oecologia*, 2004. **139**(2): p. 163-177.
7. Lintunen, A. and P. Kaitaniemi, Responses of crown architecture in *Betula pendula* to competition are dependent on the species of neighbouring trees. *Trees - Structure and Function*, 2010. **24**(3): p. 411-424.
8. Lang, A.C., et al., Tree morphology responds to neighbourhood competition and slope in species-rich forests of subtropical China. *Forest Ecology and Management*, 2010. **260**(10): p. 1708-1715.
9. Osada, N., et al., Changes in crown architecture with tree height in two deciduous tree species: developmental constraints or plastic response to the competition for light? *Forest Ecology and Management*, 2004. **188**(1-3): p. 337-347.