PROPOSAL FOR A NEW INDEX DESCRIBING THE LINK BETWEEN TREE AGE AND PRODUCTIVITY CLASS

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Abstract: the correct affiliation of the tree stands to productivity class, particularly the young, between 30-40 years old stands is hindered by difficulties due to highly variable height growth dynamics which is dependent upon a multitude of factors such as stand characteristics and site conditions. the determination of productivity class according to the average stand height in old growth managed stands was performed with certain amount of approximation causing the affiliation of the same stand to different productivity classes during its lifetime. hence, stands of 30-40 years are affiliated with approximation to productivity classes due to multiple causes, all circumscribed to the accuracy of tree heights measurement. the combined influence of factors determining height growth leads to misclassifications within productivity class system. there are situations when stands, during their life cycle transit to different productivity classes, an inexplicable situation from the perspective of the growth dynamics under long-term more or less stable site conditions. therefore, the present paper proposes indices based on the ratio between average tree height and basal area which enable the correct determination of the productivity class. the ratios were calculated for same tree age separately for the five consecrated productivity classes and regression equations were obtained for the corresponding productivity class for spruce (picea abies) and fir (abies alba). the paper aims to establish an index covering the link between growth and site conditions for several important and valuable tree species from the forestry fund. data from tree and stand biometry tables were employed for heights and basal areas ratios which were calculated in accordance to productivity classes and age. that is why there are some inconvenient to establish very rigorous the productivity classes in the old system. the approach presented in the paper can be used as a starting point for a new and reliable system permitting the determination of the productivity classes.

Key words: *Average tree height, basal area, productivity class, regression equations*

INTRODUCTION

Until the present time, the determination of productivity class according to the average stand height in old growth managed stands was performed with certain amount of approximation causing the affiliation of the same stand to different productivity classes during its lifetime (LEAHU I., 2001). Hence, stands of 30-40 years are affiliated with approximation to productivity classes due to multiple causes, all circumscribed to the accuracy of tree heights measurement (LEAHU I., 1994).

In fact, the transition of the same stand to different productivity classes during its ontogeny is not possible because site conditions do not vary significantly during short periods of time. The aim of the present paper is to establish the link between site conditions and height growth. This variable is a more sensitive indicator of site conditions comapared to other biometric variables (BAILEY N.T.J., 1995, CHIȚEA GH., 2001).

The tight correlation between average tree height and stand basal area is incorporated in the index which quantifies the link between stand productivity and site conditions (CHANGHUI PENG., 2000). According to aforementioned observations, the goal of the present paper is to establish a correlation between average tree height and the corresponding basal area in order to facilitate the affiliation to the corresponding productivity class of the stand.

MATERIAL AND METHODS

The paper aims to establish an index covering the link between growth and site conditions for several important and valuable tree species from the forestry fund. Data from tree and stand biometry tables were employed for heights and basal areas ratios which were calculated in accordance to productivity classes and age (KEVIN O.L., 1998).

The ratio h/g can be expressed through two equations: the first equation expresses the ratio as function of age and the second equation expresses the ratio as function of the average stand diameter (DOROG S., 2004, 2005). The equations are presented below:

$$h/g = a_0 + a_1 t + a_2 t^2 + \ldots + a_5 t^5$$

$$h/g = a_0 + a_1 D + a_2 D^2 + \ldots + a_5 D^5$$ where:

- t stands for the average stand age
- D stands for the average stand diameter

Data processing is presented below.

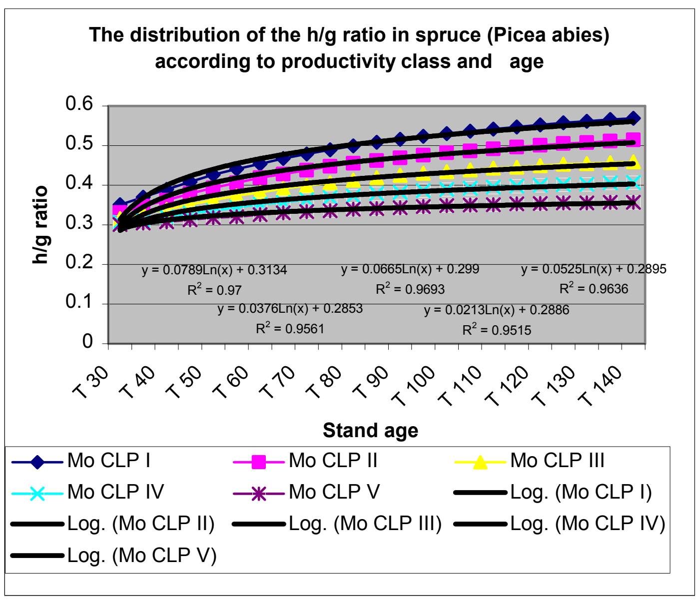

Figure 1 The distribution of the h/g ratio in spruce (*Picea abies*) according to productivity class and age (Legend: Spruce-productivity class I, Spruce-productivity class II, Spruce-productivity class III, spruce-productivity class IV, Spruce-productivity class V, log (spruce-productivity class I). Log(spruce-productivity class II),). Log(spruce-productivity class III),). Log(spruce-productivity class IV),). Log(spruce-productivity class V))

Concerning the graph from fig.1, the trend of the curves corresponding to h/g ratio is similar to the graphs describing the establishment of productivity classes.. These curves are more stable as compared to the graphs presented in biometry books and offer better conditions for the establishment of productivity classes (GIURGIU V., 1979, GIURGIU V., DRĂGHICIU D., 2004). Regression curves are of logarithmic type with high values of the determination coefficient R^2 (between 0.95-0.97) which suggests that for more than 95% of the encountered situations the proposed determination curves (of the productivity class) can be employed successfully.

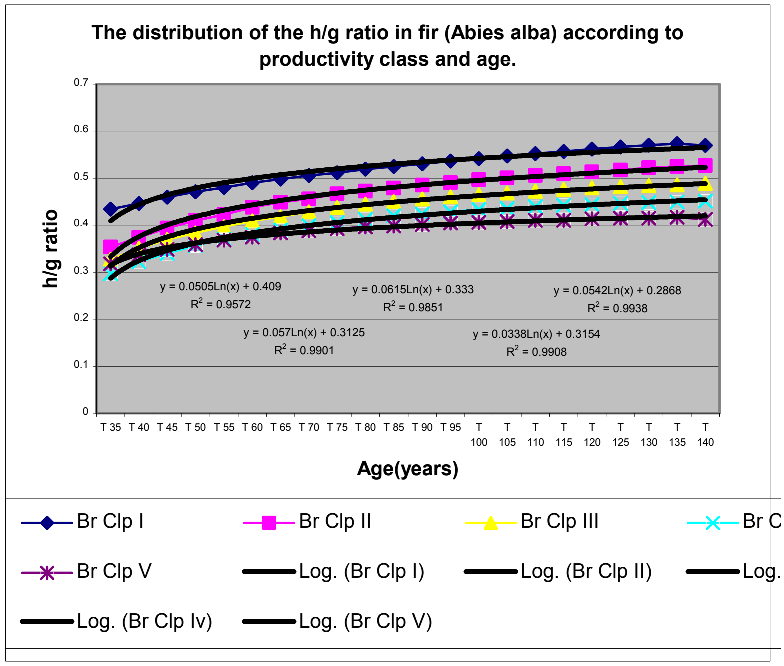

Figure 2. The distribution of the h/g ratio in fir (*Abies alba*) according to productivity class and age.Legend:fir-productivity class I, fir-productivity class II, fir-productivity class III, fir-productivity class IV, fir-productivity class V, log(fir-productivity class I), log(fir-productivity class II), log(fir-productivity class III), log(fir-productivity class IV), log(fir-productivity class V).

RESULTS AND DISSCUTIONS

The distribution of the h/g ratios for spruce according to productivity classes and age (table 1) display the increment of the index with age, more accentuated at the beginning between two successive stages (0.1) and decreasing at higher stages. From the perspective of the productivity classes the situation is quite similar, the ratios decrease swiftly in the case of the superior productivity classes and the differences increase at the level of the inferior productivity classes. Below, the table 2 presents the values of h/g ratios and their distribution according to productivity classes of the corresponding age.

The analysis of the obtained curves can be considered as starting point for the classification of the stands using h/g index which takes into consideration site conditions and stand structure. This classification system if is further developed can give better results for mixed stands as compared to the system under use designed exclusively for pure and even aged stands (GIURGIU V., DRĂGHICIU D., 2003); the approximations using a simple arithmetic algorithm leads to false results due to the fact that the pure stands display different behavior as compared to mixed forests which are assembled by the same species under same site conditions.

The examination of the data presented in table 2 shows that the differences are not significant between neighboring classes at same age at a significance level of 0.05. however, the differences increase as age increases, the highest values corresponding to the differences between upper level productivity classes. the other differences the increase is swifter due to the fact that site conditions get worse. from the third column of the table 2 (differences according to age) it is obvious that the decreasing differences correspond to a decreasing trend from upper level productivity classes toward to lower level productivity classes.

Table 1

The distribution of the h/g ratios for spruce according to productivity classes and age

Spruce	**Productivity classes**				
Age (years)	**I**	**II**	**III**	**IV**	**V**
	Values of h/g				
T 15	0.304813	-	-	-	-
T 20	0.315068	0.306122	0.302083	-	-
T 25	0.330667	0.315951	0.304833	0.299020	-
T 30	0.350797	0.330769	0.316265	0.306818	0.301075
T 35	0.369610	0.346939	0.328982	0.312102	0.304721
T 40	0.389313	0.362500	0.338824	0.320225	0.307692
T 45	0.408680	0.378906	0.351528	0.329923	0.312704
T 50	0.426343	0.392924	0.362140	0.335714	0.318452
T 55	0.440536	0.406082	0.373281	0.343820	0.320442
T 60	0.453659	0.419130	0.381853	0.351931	0.325521
T 65	0.467409	0.428331	0.391941	0.356701	0.330025
T 70	0.479005	0.438221	0.399287	0.363273	0.333333
T 75	0.489297	0.447496	0.405923	0.368932	0.335632
T 80	0.499248	0.455556	0.412969	0.373106	0.339286
T 85	0.508148	0.462500	0.418760	0.378479	0.340564
T 90	0.516082	0.469231	0.425041	0.381818	0.343220
T 95	0.523121	0.475684	0.430195	0.386404	0.346473
T 100	0.530000	0.481982	0.434295	0.389085	0.348269
T 105	0.536068	0.486647	0.438291	0.392361	0.350000
T 110	0.542017	0.491924	0.442879	0.395548	0.350394
T 115	0.547222	0.496361	0.445820	0.397631	0.352713
T 120	0.552342	0.500722	0.449387	0.399666	0.353728
T 125	0.557377	0.505007	0.452888	0.401653	0.355388
T 130	0.561737	0.507801	0.454819	0.402619	0.355140
T 135	0.566038	0.511268	0.456716	0.405844	0.356747
T 140	0.568942	0.514685	0.459259	0.406752	0.356490

Table 2

The significance of the differences among h/g ratios for the same stage and same productivity class.

t-Table	Differences productivity class I and II, differences productivity class III-IV, differences productivity class IV-V. (Studentized Range Distribution)							
	Differences CLP I-II		Differences CLP II-III		Differences CLP III-IV		Differences CLP IV-V	
Differences CLP I-II	-	-	-0.39327	N.S. (P>0.05)	-1.18499	N.S. (P>0.05)	-2.41367	N.S. (P>0.05)
Differences CLP II-III	0.979247	-		-	-0.79172	N.S. (P>0.05)	-2.02039	N.S. (P>0.05)
Differences CLP III-IV	0.637829	-	0.858041	-	-	-	-1.22867	N.S. (P>0.05)
Differences CLP IV-V	0.081579	-	0.18803	-	0.610355	-	-	-

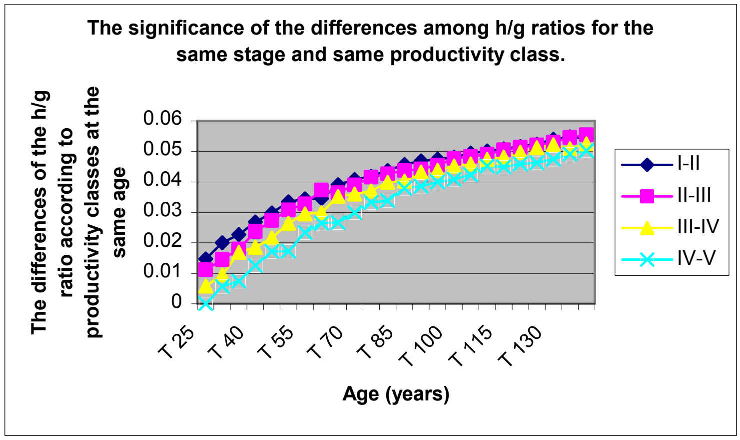

Figure 3 The significance of the differences among h/g ratios for the same stage and same productivity class.

Table 3

Average differences between productivity classes in accordance to the distribution of h/g ratios

Age (year)	Average differences between productivity classes, age (years) Productivity class I-II (%), Productivity class III-IV (%), Productivity class IV-V (%)			
	CLP I-II (%)	CLP II-III (%)	CLP III-IV (%)	CLP IV-V (%)
25-50	2.65	2.29	1.86	1.20
55-75	3.81	3.74	3.35	2.79
80-100	4.63	4.47	4.25	3.82
105-125	5.09	5.03	4.85	4.49
130-140	5.43	5.43	5.19	4.89

CONCLUSIONS

The variation of the h/g index according to the productivity class presents a decreasing trend within same age as site conditions get worse. Considering different productivity classes within same age, the differences are not significant.

Considering tree diameter, the index increases as site conditions get better.

The value of h/g ratio have an increasing, hyperbolic trend considering the age and the curves corresponding to different productivity class are nearly parallel, a fact which is not reported in the case of stand classification in productivity classes using the average height.

In highly productive sites the basal area dominates the h/g index while in unfavorable sites height increment becomes more important.

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