ISSN 1821-1046

INSTITUTE OF FORESTY
BELGRADE

INSTITUT ZA ŠUMARSTVO
BEOGRAD

SUSTAINABLE FORESTRY

ODRŽIVO ŠUMARSTVO

COLLECTION
TOM 57 - 58

ZBORNIK RADOVA
TOM 57 - 58

BELGRADE BEOGRAD
2008.

ISSN 1821-1046
9 771821 104000

ISSN 1821-1046

INSTITUTE OF FORESTY
BELGRADE

INSTITUT ZA ŠUMARSTVO
BEOGRAD

SUSTAINABLE FORESTRY

ODRŽIVO ŠUMARSTVO

COLLECTION
TOM 57 - 58

ZBORNIK RADOVA
TOM 57 - 58

BELGRADE BEOGRAD
2008.

BELGRADE BEOGRAD
2008

INSTITUTE OF FORESTRY BELGRADE | **INSTITUT ZA ŠUMARSTVO BEOGRAD**

SUSTAINABLE FORESTRY | **ODRŽIVO ŠUMARSTVO**
COLLECTION | ZBORNIK RADOVA

Publisher | **Izdavač**
Institute of Forestry Belgrade, Serbia | Institut za šumarstvo Beograd, Srbija

For Publisher | **Za izdavača**
Ljubinko Rakonjac, Ph.D | Dr Ljubinko Rakonjac

Printed in | **Tiraž**
300 copies | 300 primeraka

Formatting and Printing | **Kompjuterski slog i štampa**
Standard 2 | Standard 2

Belgrade, December 2008

Beograd, Decembar 2008

Cover Page: Design and author of the photos Mara Tabakovic-Tosic, Ph.D
Naslovna strana: Autor dizajna i fotografije dr Mara Tabaković-Tošić

CIP – Каталогизација у публикацији
Народна библиотека Србије, Београд

630

SUSTAINABLE Forestry : collection = Održivo šumarstvo = zbornik radova / glavni i odgovorni urednik Mara Tabaković-Tošić. – 2008, T. 57/58- . – Beograd (Kneza Višeslava 3) : Institut za šumarstvo, 2008- (Beograd : Standard 2). – 24 cm

Godišnje. – Je nastavak: Zbornik radova – Institut za šumarstvo = ISSN 0354-1894
ISSN 1821-1046 = Sustainable Forestry
COBISS.SR-ID 157148172

CONTENTS - SADRŽAJ

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY COLLECTION 57-58, 2008
ODRŽIVO ŠUMARSTVO ZBORNIK RADOVA 57-58, 2008

UDK 630*524 : 582.632.2 Fagus = 111
Original scientific paper

DEPENDENCE OF HIGH BEECH STAND FORM FACTOR AND FORM HEIGHT ON SITE AND STAND FACTORS

Miloš Koprivica, Bratislav Matović[1]

Abstract: Dependence of the high uneven-aged beech stands form factor and form height on the site and stand factors was studied. The data collected by the simple systematic sample in seven representative beech stands were the basis study materials. One hundred and sixty sample plots, circle-shaped, 500 m² size, in which all the trees above 10 cm diameter were measured, were set. Several dendrometrics and statistics methods were applied for data procession. The regression models for the estimate of the high beech stand form factor and form height were obtained. The gross and net influences of the site and stand factors were studied, and the most important of them were singled out: stand mean height (Lorey's), stand quadratic mean diameter and site class (tariff series). It was determined that the obtained results can be easily applied in practice.

Key words: beech, stand, volume, form factor, form height

ZAVISNOST ZAPREMINSKOG KOEFICIJENA I OBLIKOVISINE VISOKIH SASTOJINA BUKVE OD STANIŠNIH I SASTOJINSKIH FAKTORA

Izvod: Istraživana je zavisnost zapreminskog koeficijenta i oblikovisine visokih raznodobnih sastojina bukve od stanišnih i sastojinskih faktora. Osnovni materijal istraživanja činili su podaci prikupljeni u sedam reprezentativnih sastojina bukve, pomoću jednostavnog sistematskog uzorka. Postavljeno je 160 probnih površina, oblika kruga i veličine 500 m², na kojima je izvršen potpun premer svih stabala prečnika iznad 10 cm. Za obradu podataka primenjeno je više dendrometrijskih i statističkih metoda. Dobijeni su regresioni modeli za procenu veličine zapreminskog koeficijenta i oblikovisine visokih sastojina bukve. Sagledan je bruto i neto uticaj stanišnihi i sastojinskihi faktora, i izdvojeni najznačajniji: srednja visina sastojine (Lorajeva), srednji prečnik sastoji-

[1] Miloš Koprivica, Ph.D, Bratislav Matović, M. Sc, Institute of Forestry, Belgrade, Serbia
Translation: Marija Stojanović

ne po temeljnici, i bonitet staništa (tarifni niz). Utvrđeno je da se dobijeni rezultati mogu primeniti u praksi.

Ključne reči: bukva, sastojina, zapremina, zapreminski koeficijent, oblikovisina.

1 INTRODUCTION

There are numerous methods for the determination of the stand volume which are based on the total or partial measurement of the trees above the taxation limit. All methods are characterised by a level of accuracy and economic, i. e. efficacy.

The basic formula for calculating stand volume is: V = G H F, in which V is the volume, G is the basal area, H is the mean height (Lorey's) and F is the form factor. The elements of volume G, H and F should be determined very accurately, with regard to the objective of the determination of stand volume.

Although it is usually considered that the complete measurement of the stand is the most accurate method of calculation of it is volume, it is not always true. There are several reasons for it, and we noted that this method also implies the calculation of the mean height and form factor according to tree sample (M i r k o v i ć and B a n k o v i ć, 1993).

Alongside the individual elements of stand of volume, their products HF or GF can also be determined. The first expression refers to so-called stand form height and is used more often that another expression. The direct application of the basic formula for determination of stand volume implies the knowledge of the elements of volume. The subject of this paper is the determination of the form factor and form height of the high uneven-aged beech stands in central Serbia. The problem had been partially studied before (P a n i c, 1971).

2 TASK AND AIM

Two tasks of this study were set:

- determine the dependence of the form factor and form height of the high beech stands (dependant variables) on the other most important taxation elements of the stand and site characteristics (independent variables) and

- analyze net influence of some taxation elements of the stand and site characteristics on the form factor and form height.

The aim is to define in theory the statistics dependence and achieve the results which can be implemented easily in practice, i.e. for fast and relatively cheap inventory of high beech stands.

3 MATERIAL AND METHOD

The numerous data collected on stands and their site within the project "*Method of estimate of quality and assortment structure of the high beech stands in Serbia*", which was implemented by Institute of Forestry from Belgrade (2005-2007), are used as material in this study. The choice of the stands used for study, the way of collection and procession of the data is presented in a great detail in the paper by K o p r i v i c a et al. (2005). In addition, in several papers the site and taxation characteristics of the study stands are described (Koprivica and Matović, 2006, 2007; Koprivica et al. 2006, 2007). It is important to note that the study was conducted on the base of several high uneven-aged beech stands, selected in three forest areas: Severno Kučajsko, Podrinjsko-Kolubarsko, and Jablaničko. In all stands the systematic sample of the sample plot, circle-shaped and 500 m^2 size, in the square arrangement, at 100 m distance, was set. The total 160 sample plots were measured. The relevant data for each sample plot were processed separately, as average or aggregate size, translated into hectares (Table 1).

In the further analysis the characteristics of the sample plots are conditionally treated as the characteristics of the hypothetical stands, i.e. the starting point was the hypothesis that they can be equalized in theory. In this case, the variability of the taxation elements in the sample of the sample plots is somewhat greater than the variability of the taxation elements in the stand samples. Therefore, the greater reliability of the obtained models is to be expected when they are applied on the concrete beech stands.

Table 1- Statistics for taxation elements of the high beech forests in central Serbia (n = 160)

Taks elem	Statistics indicators							
	X_{midle}.	$X_{min.}$.	$X_{max.}$.	S	CV%	m%	a_3	a_4
F	0.49296	0.34314	0.55034	0.0294	5.97	0.94	-1.60	7.97
H_LF	14.304	4.712	19.442	2.778	19.42	3.07	-0.32	2.88
V	387.72	68.21	972.84	166.59	42.97	6.79	0.92	3.97
G	26.89	7.23	51.83	9.31	34.61	5.47	0.31	2.50
N	278.13	60.0	1200.0	149.29	53.68	8.33	2.46	14.11
H_l	28.91	13.73	40.33	4.95	17.12	2.71	-0.08	2.70
H	24.33	11.70	39.40	5.37	22.09	3.49	0.24	2.68
D_g	36.97	18.66	61.26	8.42	22.78	3.60	0.24	2.71
D	33.71	17.50	56.30	8.53	25.31	4.00	0.39	2.74
SK	0.833	0.14	1.00	0.17	20.57	3.25	-1.51	5.18
TN	3.281	1.00	8.00	1.60	48.72	7.59	0.51	2.62
NV	788.78	406.0	1030.0	196.68	24.93	3.94	-0.65	2.01
NT	21.99	6.0	42.0	8.91	40.49	6.40	-0.05	2.02
EK	3.65	1.0	8.0	2.52	69.13	10.93	0.76	1.98

Legend: F-stand form factor; H_lF – stand form height; V- stand volume per hectare; G- stand basal area per hectare; N- stand number of trees per hectare; H_L-mean stand height by Lorey; H- arithmetic mean stand height; D_g- stand quadratic mean diameter; D – arithmetic mean stand diameter; SK- stand canopy; TN- tariff series (site class); NV- stand altitude; NT- stand slope; EK- stand aspect

For the definition of the statistics relations between stand form factor (F) and stand form height (H_LF) as dependent variables and selected taxation elements of the stand (G, N, H_L, H, D_g, D, SK) and site characteristics (TN, NV, NT, EK) as the independent variables, the *method of simple and multiple regression* was applied. The *method of stepwise multiple regression* was applied for the selection of the "best" regression equation (model), and for the alleviating the consequences of co-linearity and multicolinearity between the independent variables the *method of ridge regression* was applied (Hadživuković et al. 1982; Hadživuković, 1991). Ezekiel's method was applied for analytical and graphical definition of net values (Ezekiel, 1953).

4 RESULTS

4.1 Form factor of beech high stands

Several regression models were obtained, which due to simplicity in the discussion will be marked as: *Model 0* – simple regression, *Model 1*- multiple regression as the best theoretic solution, *Model 2* – multiple regression as the best practical solution and *Model 3* – multiple ridge regression.

4.1.1 Model of simple regression

Upon the analysis of the matrix of the simple and partial coefficients of the linear correlation, it was concluded that stand form factor mostly depends on: mean stand height by Lorey, tariff series–site class and stand quadratic mean diameter.

Regression equations are:

$$F = 0.137425 + 0.0231704H_L - 0.000365438H_L^2 \quad (1)$$

$S_e = 0.02496$ $R^2 = 28.89\%$

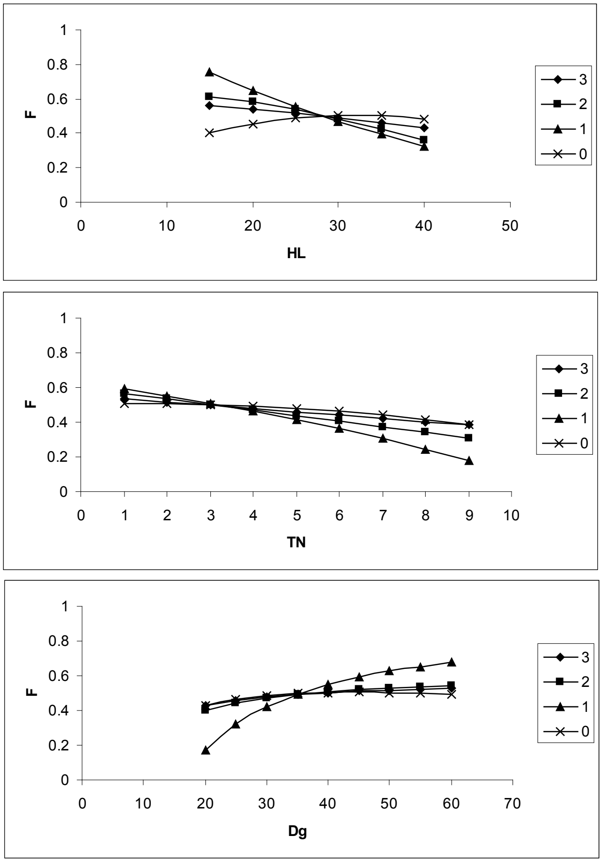
$$F = 0.502251 + 0.0054493TN - 0.00204198TN^2 \quad (2)$$

$S_{e=}$ 0.02451 $R^2 = 31.42\%$

$$F = 0.735117 - 0.0026203D_g - 5.08537 / D_g \quad (3)$$

$S_e = 0.02480$ $R^2 = 29.77\%$

The equations (1-3) are presented in Graph 1, as *Model 0*. By the increase of the mean value by Lorey and of the stand quadratic mean diameter, the form factor also increases, and it decreases by the increase of the tariff series (by decrease of site class). This dependence is logical to the professionals, but in all cases only around 30% of the total variability of the stand form factor is explained, and the standard error is high. In addition, there is an important linear correlation between all three independent variability, which is significant during the analysis of the net influence of some independent variables on dependent variable in the model of a multiple regression.



Graph 1- Dependence of beech stand for factor on other factors

4.1.2 Model of multiple regression as the best theoretic solution

This model was obtained by the method of a multiple regression. Stand form factor (dependent variable), numerous taxation elements of the stand and site characteristics (independent variables) were used as the initial variables. The original independent variables were also taken in the transformed form, as the square and reciprocal values.

The best solution is the following equation of a multiple regression,

$$F = 1.28079 - 0.027273H_L + 0.000184692H_L^2 + 0.00429302D - 0.0000330709D^2 + 9.79367/D - 0.0326681TN - 0.00185462TN^2 - 0.00000001854N^2 - 0.0000103734H - 15.1607/D_g \quad (4)$$

$S_e = 0.00322$ $R^2 = 98.88\%$

In the equation (4) it is seen that as the independent variables, the influence of which on dependent variable is significant by 99% probability, the following values are included: mean value by Lorey, arithmetic mean diameter, tariff series, a number of trees per hectare, arithmetic mean height and the stand quadratic mean diameter.

From this equation the equations of net regression, presented in Graph 1 as *Model 1*, are obtained. The influence of the mean height by Lorey on stand form factor seemed illogical, which can be explained as the consequence of the multicolinearity between the selected independent variables. Although *Model 1* is the best theoretic (statistics) solution, it can not be easily applied in the practice, since it requires the previous determination of six independent variables. Owning to it, the best solution which could be used in practice was searched.

4.1.3 Model of multiple regression as the best practical solution

The best equation of a multiple regression which can be applied is,

$$F = 1.21667 - 0.0141291 H_L - 2.44963 / H_L - 0.0319587 TN - 4.30151 / D_g \qquad (5)$$

$S_e = 0.01302 \qquad R^2 = 80.89\%$

In the equation (5) the following values are included as independent variables: stand mean height by Lorey, tariff series and stand quadratic mean diameter. It is possible to determine these independent variables in the concrete stand in a rather simple way, which will be elaborated on later.

Three equations of a net regression, which are presented in Graph 1 as *Model 2*, are obtained from the equation (5). Some net influences are illogical, due to the presence of multicolinearity. By increase of the mean stand height by Lorey, unchanged tariff series and stand quadratic mean diameter the stand form factor decreases, and it would be logical to increases. By increase of tariff series (decrease of site class) and unchanged influence of the mean height per Lorey and stand quadratic mean diameter, stand form factor decreases, which is logical. Increase of the stand quadratic mean diameter, and unchanged influence of the stand height by Lorey and tariff series, the stand form factor increases.

In the equation (5) there is a statistically important linear correlation between the independent variables. The correlation coefficient between H_L and TN is -0.87, between H_L and D_g is 0.64, and between TN and D_g is -0.36. During the analysis of the structure of the model the colinearity of the variables with the higher correlation coefficient is of a particular importance (Koprivica, 1982). In this there is the colinearity between mean height by Lorey and tariff series, which resulted in the change of the matematical sign of the regression coefficient of the stand mean height in the equation of net regression in the comparison with the equation of the simple regression. In order to alleviate the problem of multicolinearity, the *method of ridge regression* was applied.

4.1.4 Model of the multiple ridge regression

The model was obtained by adding the coefficient $k = 0.05$, with the same independent variables as the *Model 2*. The *method of ridge regression* was applied in order to obtain the equation of a multiple regression with the stable coefficients (Hadzivukovic, 1991).

The following equation of a multiple regression was obtained,

$$F = 0.841378 - 0.00633599H_L - 0.580752/H_L - 0.0190806TN - 2.86657/D_g \quad (6)$$

$S_e = 0.01664$ $R^2 = 55.31\%$

By the comparison of the equations (5) and (6) it can be seen that there was a significant change of the coefficient regression, but that the mathematic sign of the parameters in front of the independent variables remained the same. The greatest change is in the value of the standard regression error, i.e. of the coefficient of the multiple regression. Thus, the equation (5) is better for the estimate of the stand form factor, and the equation (6) for the analysis of the net influence of the independent variables on the dependent variable. Three equations of net regression were also obtained and presented in Graph 1 as *Model 3*. It is seen that there is no important difference between the equation of net regression marked as *Model 2* and *Model 3.* Therefore, the problem of multicolinearity is only partially alleviated.

4.2 Form heigh of beech high stands

Form height of beech high stands was analyzed in the same way as the stand form factor.

4.2.1 Model of a simple regression

Upon the analysis of the matrix of the simple and partial linear correlation coefficients, it was concluded that in beech stand, form height mainly depends on the same factors as the stand form factor.

Regression equations are:

$$H_L F = -6.88831 + 0.94011H_L - 0.00695937H_L^2 \quad (7)$$

$S_e = 0.7207$ m $R^2 = 93.35\%$

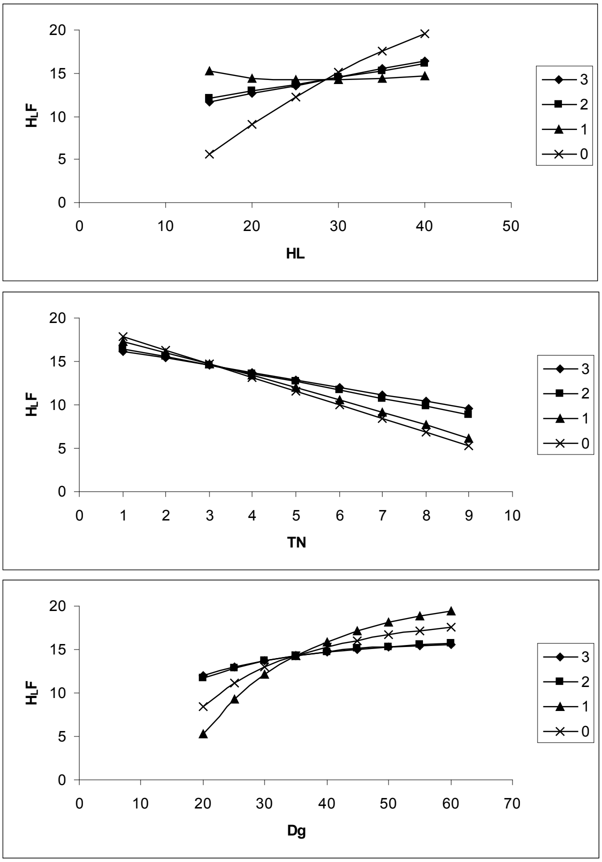
$$H_L F = 19.4819 - 1.57797TN \quad (8)$$

$S_{e=}$ 1.1661 m $R^2 = 82.48\%$

$$H_L F = 22.1302 - 273.925/D_g \quad (9)$$

$S_e = 2.0082$ m $R^2 = 48.06\%$

The equations (7-9) are presented in the Graph 2 as *Model 0.* By increase of the stand mean height by Lorey and stand quadratic mean diameter the stand form height also increases, whereas by the increase of the tariff series (by decrease of site class) it decreases. All these dependences are profesional logical. However, regardless of the statistically important determination coefficient, regression standard error is high, and there is an important linear correlation between all three independently variables.



Graph 2- Dependence of beech stand form height on other factors

4.2.2 Model of the multiple regression as the best theoretic solution

As the best theoretic solution the following multiple regression equation was obtained:

$$H_LF = 9.13555 + 0.111663H_L + 0.177968D_g - 0.00141294D_g^2 - 384.427/D_g + 0.0345579D + 252.821/D - 1.22148TN - 0.0167313TN^2 - 0.000580911H^2 - 0.000000114024NV \quad (10)$$

$S_e = 0.1015$ m $\qquad R^2 = 99.88\%$

In the equation (10) it is seen that the following values, the influence of which on the dependent variable is important by 99% probability, were included as the independent variables: mean height by Lorey, quadratic mean diameter, arithmetic mean diameter, tariff series, arithmetic mean height and altitude. From this equations the net regression equations, presented in Graph 2 as *Model 1* were derived. The influence of the mean height by Lorey on stand form height seemed illogical, which is the consequence of multicolinearity between the selected independent variables. Although *Model 1* is the best theoretic (statistical) solution, it can not be easily applied in practice, since it requires the previous determination of six independent variables.

4.2.3 Model of a multiple regression as the best practical solution

The best multiple regression equation which can be applied is

$$H_L F = 16.2749 + 0.159373 H_L - 0.946515 TN - 121.538 / D_g \quad (11)$$

$S_e = 0.3828$ m $R^2 = 98.14\%$

In the equation (11) stand mean height by Lorey, tariff series and stand quadratic mean diameter were included. Therefore, the same variables were included as for the determination of stand form factor in a regression equation (5). It is possible to determine these independent variables in a rather simple way in a concrete stand. From the equation (11) three net regression equations were derived and presented in Graph 2, as *Model 2.*

Although the multicolinearity is present, all net influences are logical. By increase of the stand mean height by Lorey, and unchanged tariff series and stand quadratic mean diameter, stand form height increases. By increase of tariff series (decrease of site class), and unchanged influence of mean height by Lorey and stand quadratic mean diameter, stand form height decreases. By increase of stand quadratic mean diameter and unchanged influence of stand mean height by Lorey and tariff series, stand form height increases.

4.2.4 Model of a multiple ridge regression

In this case the model was also determined by adding coefficient $k = 0.05$, with the same independent variable as in *Model 2.*

Multiple regression equation is,

$$H_L F = 14.6631 + 0.19166 H_L - 0.834544 TN - 110.656 / D_g \quad (12)$$

$S_e = 0.3924$ m $R^2 = 95.91\%$

By the comparison of the equations (11) and (12) it can be seen that there was no significant change of the regression coefficients and that mathematics signs in front of independent variables remained the same. Also, there was no important change of the regression standard error and multiple determination coefficients. Therefore, the regression equations are equally good for the calculation of stand form height, as well as for analyzing of the net influence of independent variables on dependent variable. The obtained equations of a net regression are presented in Graph 2, as *Model 3.*

5 APPLICATION OF RESULTS

The regression equations (5) and (11) are intended for practical use. In a concrete beech stand it is necessary to determine: tariff series (site class), mean height by Lorey and quadratic mean diameter. The problem can be solved by the application of *relascopy method*.

The work method will be decribed briefly: The stand structure (according to the tree thickness and their arrangement by stand area) should be determined first, and then the factor of tree counting should be selected, so that the average number of the trees by a sample plot would be 15-20 (Van Laar and Akca, 2007). The sample plots should be located in the stand by professional estimation, so that they represent the stand in regard to the volume of it. The number of sample plots should be 3-5. In each sample plot the trees which should be measured are to be marked (diamater at breast height is wider than the width of the measurement scale). Then, diameter at breast height and the height of all the selected trees should be measured. By these data, stand height curve can be drawn and tariff series (TN), i.e. site class can be determined. By the classification of trees per diameter class, the stand basal area per diameter class and total per hectare, i.e. G_1 , G_2 ... G_k and G will be obtained. Mean height of the trees per diameter class h_1 , h_2, ... h_k should be read from height curve and stand mean height by Lorey (H_L). In order to determine the stand quadratic mean diameter (D_g), the number of trees in the stands per hectare should be also determined. It should be done separately for each diameter classl (dividing the number of the counted trees in diameter class, i.e. class basal area lper hectare $G_{i,}$ by the basal area of mean tree in diameter class g_i), and then add. After that, the stand mean basal area from the relation G/N is determined, i.e. mean diameter D_g. By this method all the elements of stand necessary for the determination of stand form factor (F) or stand form height (H_LF) are determined.

Since the stand basal area G is known, the stand volume can be determined as well. It is clear that the stand volume determined in this way will not be accurate enough. If we want to increase the accuracy of the stand volume, the additional sample plots can be set. In them only the basal area per hectare, without the measurement of diameter and tree height can be determined. This type of the sample is two-phase, since in the first phase the stand basal area is determined in a great sample, and in the second the stand form factor or stand form height are determined in a small sample (Kangas and Maltamo, 2006). In theory, it is justifiable, because in the sample of plots, basal area is the most variable (CV = 34.61%), then stand form height (CV = 19.42%) and mean height per Lorey (CV = 17.12%), and the least variable stand form factor (CV = 5.97%). Coefficient of volume variability is 42.97%.

Example: In one beech high stand by the described method the following elements were determined: tariff series 5 (site class III), G = 30 m^2/ha, H_L = 25 m and D_g = 35 cm. By a regression equation (5) F = 0.48276, and by equation (11) H_LF = 12.054 m. Therefore, stand volume is V = 30 x 25 x 0.48276 = 362 m^3/ha, i.e. V = 30 x 12.054 = 362 m^3/ha. By the classic measurement, by sample of 5% intensity, it was determined that the volume of this stand is 380 m^3/ha, with the double relative error +/- 11,0%. The real average volume of this stand ranges between 338 and 422 m^3/ha, by 95% probability. The average stand volume determined by the described method is also within these limits.

6 CONCLUSION

By the method of simple, multiple and net regression the dependence of high beech stand form factor and form height on the most important taxation elements of the stand and site factors was defined. The obtained models are significant in both theory and practice.

The answer to the question how the high beech stand form factor and form height change by the use of their tariff series, mean height by Lorey, and quadratic mean diameter, was obtained by the models of a net regression:

- if the other factors are unchanged, by the increase of tariff series (decrease of site class) the stand form factor and stand form height decrease,
- if the other factors are unchanged, by the increase of the mean height by Lorey, the stand form factor decreases, and the stand form height increases, and
- if the other factors are unchanged, by the increase of the stand quadratic mean diameter, the stand form faktor increases slowly, and stand form height increases at a fast pace.

The regression equations (5) and (11), by which according to three factors (stand mean height by Lorey, tariff series and stand quadratic mean diameter) we can accurately estimate the stend form factor and stand form height, as the basic elements for the determination of the volume of it, are most significant in practice. Given the reliability of the model, it is better to use equation for stand form height (11).

The decribed method of the application of results is aimed at the fast estimate of the high beech stand volume, as well as for the possible rough monitoring of the determined stands volume by some classical method. In all cases, the accuracy of stand volume depends upon the accuracy of its elements. During the analysis of the decribed method, one should bear in mind that neither by the use of the classic method, with the economically justified sample size, the estimate of the beech stand volume, aimed at the creation of the reliable management plans, most usually cannot be achieved. (Koprivica, 2006).

LITERATURE

Ezekiel, M. (1953): Methods of Correlation Analysis. John Wiley and Sons Inc., New York.

Hadživuković, S. (1991): Statistical methods. The Faculty of Agriculture, Novi Sad. *(Original- Statistički metodi. Poljoprivredni fakultet, Novi Sad)*

Hadživuković, S., Zegnal, R., Čobanović, K. (1982): Regressional analysis, Economic Review, Belgrade. *(Original- Regresiona analiza. Privredni pregled , Beograd)*

Kangas, A., Maltamo, M. (2006): Forest Inventory - Methodology and Applications. Springer. Dordrecht, The Netherlands.

Koprivica, M. (1982): Contribution to the knowledge of problems and limits in the application of methods of regressional and correlative analysis in forestry research. Forestry and wood procession, XXXVI, notebooks 10-12, Sarajevo. *(Original- Prilog poznavanju problema i ograničenja u primjeni metoda regresione i korelacione analize u šumarskim istraživanjima. Šumarstvo i predada drveta , XXXVI, sv. 10-12, Sarajevo)*

Koprivica, M., Miletić, Z., Tabaković-Tošić, M. (2005): Methodology of collection and procession of field data for analysis of quality and assortment structure of beech high stands in Serbia. Manuscript, Institute of Forestry, Belgrade. *(Original- Metodika prikupljanja i obrade terenskih podataka za proučavanje kvaliteta i sortimentne strukture visokih sastojina bukve u Srbiji. Rukopis. Institut za šumarstvo, Beograd)*

Koprivica, M., Matović, B. (2006): Regressional equations of volume and volume increment of beech trees in high forests in Serbia. The Collection of Papers, volumes 52-53, Institute of Forestry, Belgrade. *(Original- Regresione jednačine zapremine i zapreminskog prirasta stabala bukve u visokim šumama na području Srbije. Zbornik radova, tom 52-53. Institut za šumarstvo, Beograd)*

Koprivica, M., Matović, B. (2007): Variability and accuracy of estimation of taxation elements of trees by diameter classes in beech high stands. Forestry, 1-2, pp. 1-11. Belgrade. *(Original- Varijabilitet i preciznost procene taksacionih elemenata stabla po debljinskim klasama u visokim sastojinama bukve. Šumarstvo, 1-2, str. 1-11. Beograd)*

Koprivica, M. (2006): Reliability of results of beech height stand inventory by sample method. International Scientific Conference „ Sustainable use of Forest Ecosystems - The Challenge of the 21st Century". Donji Milanovac, Srbija. Proceedings, Institute of Forestry, Belgrade

Koprivica, M., Čokeša, V., Matović, B. (2006): Quality and assortment structure of the volume of beech height stands in Jabaničko forest area. International Scientific Conference „ Sustainable use of Forest Ecosystems - The Challenge of the 21st Century". Donji Milanovac, Serbia Proceedings, Institute of Forestry, Belgrade

Koprivica, M., Čokeša, V., Matović, B. (2007): Quality and assortment structure of the volume of beech height stands in Kolubarsko-Podrinjsko forest area. International Symposium . Ohrid, Macedonia.

Mirković, D., Banković, S. (1993): Forest Mensuration. The Institute for Textbooks and Teaching Devices. Belgrade. *(Original - Dendrometrija. Zavod za udžbenike i nastavna sredstva Srbije. Beograd)*

Panić, Đ. (1971): Results of the researches of beech stands in Serbia. The Collection of Papers, book X. The Institute of Forestry and Wood Industry, Belgrade. *(Original- Rezultati istraživanja bukovih sastojina na području Srbije. Zbornik, knj. X. Institut za šumarstvo i drvnu industriju, Beograd)*

Van Laar, A., Akca, A. (2007): Forest Measurement Springer. Dordrecht, The Netherlands.

DEPENDENCE OF HIGH BEECH STAND FORM FACTOR AND FORM HEIGHT ON SITE AND STAND FACTORS

Miloš Koprivica, Bratislav Matović

Summary

The dependence of the high uneven-aged beech stand form factor (F) and form height (H_LF) on the site and stand factors is analyzed is this paper. The data collected by the sample method in seven representative beech stands in central Serbia were the basis study materials. The systematic sample with the sample plots, circle-shaped, 500 m^2 size, set in the square arrangement, at 100 m distance, was applied. A total of 160 samples plots, in which all the trees were measured, were set. After the dendrometrics data procession, the method of a regression and correlation analysis was applied (simple, multiple, net and ridge regression). In the conducted analysis the sample plot was conditionally equalized with the stand. Several regression models by which the gross and net influence of the site and stand factors on the value and direction of the stand form factor and form height was analyzed. It was determined that the stand form factor and form height mainly depend on three factors: mean height (Lorey), quadratic mean diameter and tariff series (site class). The regression equations (5) and (11) are aimed for practical use. Given the reliability of the model, it is better to use the equation for stand form height (11). The beech stand form factor in the sample ranges between 0.34314 and 0.55034, the average value of it is 0.49296, and variation coefficient 5.97%. Beech stand form height ranges between 4.712 and 19.442 m, the mean value of it is 14.304, and variation coefficient 19.42%. The distribution of the form factors deviates greatly from the normal distribution, and the distribution of form heights is similar to the normal distribution. The method of the practical use of the results of the research, i.e of the quick estimate of beech stand volume, was also elaborated.

ZAVISNOST ZAPREMINSKOG KOEFICIJENA I OBLIKOVISINE VISOKIH SASTOJINA BUKVE OD STANIŠNIH I SASTOJINSKIH FAKTORA

Miloš Koprivica, Bratislav Matović

Rezime

U radu je analizirana zavisnost zapreminskog koeficijenta (F) i oblikovisine (H_LF) visokih raznodobnih sastojina bukve od stanišnih i sastojinskih faktora. Osnovni materijal za ovo istraživanje prikupljen je primenom metoda uzorka u sedam reprezentativnih sastojina bukve na području centralne Srbije. Primenjen je sistematski uzorak sa probnim površinama, oblika kruga i veličine 500 m^2, postavljenim u kvadratnom rasporedu na rastojanju 100 m. Postavljeno je ukupno 160 probnih površina na kojima je izvršen potpun premer svih stabala. Posle dendrometrijske obrade podataka primenjen je metod regresione i korelacione analize (jednostavna, višestruka, neto i ridž regresija). U provedenim analizama probna površina je "uslovno" izjednačena sa sastojinom. Dobijeno je više regresionih modela na bazi kojih je sagledan bruto i "neto" uticaj stanišnih i sastojinskih faktora na veličinu i tok zapreminskog koeficijenta i oblikovisine sastojine.

Utvrđeno je da zapreminski koeficijent i oblikovisina sastojine najviše zavise od tri faktora: srednja visina (Lorajeva), srednji prečnik po temeljnici, i tarifni niz (bonitet staništa). Za primenu u praksi namenjene su regresione jednačine (5) i (11). S obzirom na pouzdanost modela, bolje je koristiti jednačinu za oblikovisinu sastojine (11). Zapreminski koeficijent sastojina bukve u uzorku varira od 0,34314 do 0,55034, sa sednjom veličinom 0,49296 i koeficijentom varijacije 5,97%. Oblikovisina sastojina bukve varira od 4,712 do 19,442 m, sa srednjom veličinom 14,304 m, i koeficijentom varijacije 19,42%. Distribucija zapreminskih koeficijenata značajno odstupa od normalne distribzcije, a distribucija oblikovisina je slična noramalnoj distribuciji. Izložen je i postupak pratične primene rezultata istraživanja, odnosno brze procene zapremine sastojina bukve.