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FORM FACTOR FOR CLONE VM 58 (*E. urophylla X E. Camaldulensis*) AND HYBRID SEEDS (*E. urophylla X E. grandis*)

Maria Cristina Bueno Coelho
Universidade Federal do Tocantins
Forest Engineering Course
Gurupi Tocantins
https://orcid.org/0000-0003-0409-0624

Max Vinicios Reis de Sousa
Universidade Federal do Tocantins
Forest Engineering Course
Gurupi Tocantins
https://orcid.org/0000-0002-3509-6394

Thiêssa Tamilla de Carvalho Santana
SEMAS /PARÁ
Environmental management technician
https://orcid.org/0000-0002-6658-0138

Mauro Luiz Erpen
Instituto Federal do Tocantins
Civil Engineering Course
Gurupi Tocantins
https://orcid.org/0000-0002-5144-6665

Maurilio Antonio Varavallo
Universidade Federal do Tocantins
Forest Engineering Course
Gurupi Tocantins
https://orcid.org/0000-0002-9113-296X

Juliana Barilli
Universidade Federal do Tocantins
Forest Engineering Course
Gurupi Tocantins
https://orcid.org/0000-0002-2724-4254

Yasmin Andrade Ramos
SEMAS /PARÁ
Environmental management technician
https://orcid.org/0000-0002-5157-7550

Marcos Giongo
Universidade Federal do Tocantins
Forest Engineering Course
Gurupi Tocantins
https://orcid.org/0000-0003-1613-6167

Mathaus Messias Coimbra Limeira
Universidade Federal do Tocantins
Forest Engineering Course
Gurupi Tocantins
https://orcid.org/0000-0002-3061-6004

Walberisa Magalhães Gregório
Universidade Federal do Tocantins
Forest Engineering Course
Gurupi Tocantins
http://lattes.cnpq.br/0149734248490627

Marcos Vinicius Cardoso Silva
Senior Analyst
Ecology & Environment do Brasil
https://orcid.org/0000-0003-4507-0961

Yandro Santa Brigida Ataide
Universidade Federal do Tocantins
Forest Engineering Course
Gurupi Tocantins
https://orcid.org/0000-0002-7593-353X

Abstract: In forest inventory systems, it is essential to search for fast and accurate information about the volume of wood to be obtained. Aiming at this, this work aims to model an artificial form factor in a forest stand with clone VM 58 (*E. urophylla* x *E. camaldulensis*) and hybrid seeds (*E. urophylla* x *E. grandis*) at seven and a half years of age, in the southern region of the state of Tocantins. The database was obtained from a systematic and stratified forest inventory of VM 58 clone and hybrid seeds from fixed plots of 27.5 x28 m (770 m^2) totaling 42 plots (2.9% sampling intensity). Thirty-two trees were cubed (16 for VM 58 and 16 for seeds) by Smalian and seven models and Stepwise were tested. The Stepwise model was the one that had the best performance for the clone ofVM 58, com R^2aj. of 0,69, Syx(%) of 4,87 and CV(%) of 8,85 with these features: $ff = 2{,}520 + (-0{,}04275 * d_{0,1}) + (-0{,}0260 * d_{0,5}) + (-0{,}697 * \frac{h}{dap}) + (11{,}41 * \frac{d_{0,3}}{d^2}) + (-35{,}08 * \frac{1}{h})$. and for hybrid seeds (*E. urophylla x E. grandis*) with R^2aj. of 0,875, Syx(%) of 7,46 e CV(%)of 18,307 from the model: $ff = (-1{,}333) + (-0{,}02289 * H) + (-0{,}0684 * d_{0,5}) + (2{,}967 * \log d)$. The artificial form factor tables ranged from 0,4066 e 0,5385 for the clone VM 58 (*E. urophylla* x *E. camaldulensis*) and from 0.4223 to 0.7780 hybrid seeds (*E. urophylla*) x *E. grandis*). The use of the selected models must be restricted to stands with similar characteristics to the one studied and under similar soil and climate conditions and driving regimes.
Keywords: Modeling, Rigorous cubing, Volume.

INTRODUCTION

In 2018, Brazil reached an area of 9,895,560 ha of planting, the genus *Eucalyptus* is the most present population in the Brazilian territory, corresponding to 76.23% of the total planted area, in second place is the Pinus population with 20, 05% and the other cultures 3.7%. The state of Tocantins has a plant area of 152,138 ha, of which 95.1% is for *Eucalyptus*, other species with 4.7% and Pinus with only 0.04% of planted area. (SNIF, 2020).

Eucalyptus belongs to the group of exotic forest species most adapted in Brazil, as a result of efficient and advanced silviculture (SEREGHETTI, 2012), which results in a significant planting area that aims to meet the demands of Brazilian forest-based industries, with a strong tendency expansion plan to serve domestic and foreign markets (SETTE JR et al., 2012).

The incessant search for alternatives that allow optimizing forest production involves the improvement of biometrics, inventory and forest management techniques (THOMAS et al., 2006). Among the ways to quantify forest production, the use of the tree form factor and regression modeling stands out.

The form factor is a parameter obtained by the ratio of the real volume of the tree, through rigorous cubing, and the volume of a cylinder. This factor reduces the volume of the cylinder formed by the basal area and the height to the true volume represented by the solid of revolution, which can be calculated by numerous methods (FINGER, 1992). From these data, mathematical regression models can be used to reliably stipulate the artificial form factor for the other individuals in the stand.

Regression models - linear, non-linear or *Stepwise* are used to describe the behavior of a random variable and thus define a parameter, Tadano et al (2009). Stepwise Regression is the fusion of two other methods: standard regression plus hierarchical regression. This type of analysis aims to identify the independent variables that are associated with each other and identify those that can provide the greatest contribution to the prediction of the dependent variable, eliminating the variables that significantly contribute to the regression in order to improve the future analysis (TARRÉ, 2009).

Among the ways to quantify forest production, the use of the form factor of the real tree of the tree, through rigorous sizing, and the volume of a cylinder, stands out. Drescher et al. (2001) state that the determination of the artificial form factor constitutes an important practice, when it is intended to estimate individual volume of trees. Figueiredo et al. (2005) recommends carrying out the calculation of the form factor by species, due to the large oscillation of this factor between species, and Batista et al. (2014) state that the form factor is variable even in homogeneous planted forests. The hypothesis tested here is whether or not regression exists. Thus, according to Valente et al. (2011), when the value of the Fcalculated test is greater than the Ftabulated, the hypothesis of no regression (nullity hypothesis) is rejected, that is, the model is significant at a certain level of significance, and it is concluded that at least least one independent variable is related to the value of the dependent variable.

Given the above, this study aims to select mathematical models to describe the artificial form factor for clone VM 58 (*E. urophylla x E. camaldulensis*) and hybrid seeds (*E. urophylla x E. grandis*) in the city of Aliança (TO), as well as creating a form factor table for the region under study.

MATERIAL AND METHODS

CHARACTERIZATION OF THE STUDY AREA

The present study was carried out in a plantation of *Eucalyptus*, belonging to the company Projecto Ltd, located at an altitude of 280m with the geographical coordinates 11°21'43" South, and longitude 49°03'37" west, in the municipality of Aliança do Tocantins, southern region of the state of Tocantins, with a distance 167 km from the capital Palmas. The planting area corresponds to 109 hectares divided into plots which are subdivided into two clones: VM 58 (*E. urophylla x E. camaldulensis*) and hybrid seeds (E.*urophylla x E. grandis*).

The climate, according to *Thornathwaite* e *Mather* consists of C2wA´a´´, humid sub-humid climate with moderate water deficit in winter, average annual potential evapotranspiration of 1,500 mm, distributed in summer around 420 mm over the three consecutive months with higher temperature. The average annual temperature is between 25ºC and 26ºC.

The chemical analysis of the soil carried out at 7.5 years of age indicates the classification of Red Yellow LATOSOL and medium texture with a predominance of the sand fraction. According to the Soil Chemistry and Fertility Commission – RS/SC (2004), the content of organic matter in the soil is low (≤ 2.5); pH is acidic, available P are too low (≤ 5,0; ≤ 3,0 mg dm^{-3}, respectively); exchangeable K is low (40 - 120 mg dm^{-3}); exchangeable Ca and Mg are low (≤ 2,0 e ≤ 0,5 $cmol_c$ dm^{-3}, respectively); Al saturation is high (> 20%) and base saturation is low to medium (≤ 20 < 45%). Thus, in general, the soil of the experimental area is of low fertility.

As for the management of the area, an incorporated base fertilization was carried out three months before planting with a subsoiler, applying natural phosphate at the bottom of the furrow. Afterwards, two topdressing fertilizations were carried out: the first cover was carried out at 90 days after planting and the second was carried out nine months after planting. After this period, a maintenance fertilization was carried out 25 months after planting. Cultural practices were carried out in the settlement, such as mechanized cleaning, ant and termite combat. A replanting was carried out in a period of 30 days after the first planting.

DATA COLLECTION

A systematic and stratified forest inventory by species was carried out. Measuring the total heights through the hypsometer of *haglof* and DBH (diameter at breast height) with a tape measure, from fixed plots of 27.5x28 m (770 m^2) totaling 42 plots, each plot with 77 individuals and a total of 3,234 surveyed in the inventory. Then, determining the diameter distribution with an amplitude of 2 cm. The selection of sample trees for cubage was carried out with the class amplitude set at 2 cm. The number of trees cubed per diameter class corresponded to the frequency distribution of the stand.

The selection of trees for cubage was performed based on the diametric frequency distribution. The selection and rigorous scaling of sample trees felled with DBH ≥ 12 cm was carried out in order to cover the entire diameter distribution. The number of trees to be cubed was defined using the formula described by Mello (2004):

$$n = \frac{t^2.(CV\%)^2}{E^2\%}$$

Where: t = tabulated value (*Student*) according to the "n" and the required precision level of 95% confidence probability; CV% = coefficient of variation in percentage and E = pre-established error, in this case 10% is used, n = number of trees to be accurately cubed.

It was necessary to establish a pilot sample to define how many trees must be rigorously cubed. This sample resulted in the cube of 32 trees, thus having the idea of the variability between the volumes of the trees that make up the considered population (Mello, 2004).

Following this precept, 32 sample trees were cubed to determine the rigorous volume using the methodology of *Smalian*, according to the model (Finger, 1992):

$$v = v_0 + \sum_{i=1}^{n} v_i + vc$$

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Where: v = volume, v_0 = stump volume, v_i = volume of cross sections and v_c = cone volume.

With the data obtained in the cube, the individual volumes were calculated for each of the sample trees. The artificial form factor was obtained by the ratio between the strict volume and the volume of the cylinder with a diameter of 1.3 m according to the expression (Finger, 1992):

$$f_{1,30} = \frac{\text{rigorous volume}}{\text{cylinder volume with diameter } d_{1,3}}$$

Where: $f_{1,30}$ = artificial form factor; $d_{1,3}$= diameter measured at 1.30 m from the total height of the tree.

The data from these trees served as a basis for the adjustment of the artificial form factor models (Table 1).

The process was also tested: *Stepwise*: one with the dependent variable in pure form and the other in logarithmized form. the method of *Stepwise* consists of the inclusion of independent variables in decreasing order of simple linear correlation with the dependent variable and that, when they do not result in a significant improvement of the model, are eliminated (SOUZA et al., 2013). The level of significance used to build the models of this modality was 95%.

For the selection of the best models, the following statistical analyzes were considered: Adjusted coefficient of determination, the standard error of the estimate and the graphical analysis of the residuals

The adjusted coefficient of determination (R^2Aj), expressed as the amount of total variation explained by regression. When the value found is closer to 1, the better the fit of the regression line. Considering this criterion, the mathematical model that presents the highest value of R^2aj is selected (SCHNEIDER; SCHNEIDER, 2008).

$$R^2aj = R - \left[\frac{K-1}{N-K}\right].(1-R^2)$$

Where: R^2aj= adjusted coefficient of determination; R^2= determination coefficient; K= number of coefficients in the equation; N= number of observations.

The standard error of the percentage estimate informs the goodness of the fit and how much, relatively, the model errs on average when estimating the dependent variable. When the dependent variable has

Number	Form Factor Equations
1	$f = \beta_0 + \beta_1 \frac{1}{d^2h} + \beta_2 \frac{1}{h} + \beta_3 \frac{1}{d^2} + \varepsilon_i$
2	$f = \beta_0 + \beta_1 \frac{1}{d^2h} + \beta_2 \frac{1}{dh} + \beta_3 \frac{1}{d} + \beta_4 \frac{1}{h} + \beta_5 \frac{1}{d^2} + \varepsilon_i$
3	$f = \beta_0 + \beta_1 \frac{1}{h} + \beta_2 \frac{h}{d} + \beta_3 \frac{h}{d^2} + \varepsilon_i$
4	$f = \beta_0 + \beta_1 \frac{d_{0,3}}{d^2} + \beta_2 \frac{h}{d^2} + \varepsilon_i$
5	$f = \beta_0 + \beta_1 \frac{d_{0,3}^2}{d^2} + \beta_2 \frac{h}{d^2} + \varepsilon_i$
6	$f = \beta_0 + \beta_1 \frac{d_{0,3}}{d^2} + \beta_2 \frac{h}{d^2} + \beta_3 \frac{1}{d} + \varepsilon_i$
7	$f = \beta_0 + \beta_1 \log d + \beta_2 \log h + \varepsilon_i$

Where: f = form factor; $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$= model coefficients; d= diameter at 1.3 meters above the ground; $d_{0,3}$ = diameter at 0.3 meters above the ground; $d_{0,5}$ = diameter at 0.5 meters above the ground; h = total height; log d= decimal logarithm of the diameter at 1.3 meters; log h= decimal logarithm of the total height;

Table 1: Artificial form factor models adjusted for the study area

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undergone some kind of transformation, it is necessary to recalculate the Syx, so that it can be compared to the equations whose dependent variable was not transformed. As used by Batista et al. (2001), this correlation is performed using the following formulas:

$$Syx = \sqrt{\frac{\sum_{i=1}^{n}(ffi-FFi)^2}{n-p}} \text{ e } Syx\% = \left(\frac{Syx}{\bar{ff}}\right) * 100$$

Where: ffi = Observed form factor; FFî= Form factor estimated by the equation; n= Number of observed data; p= Number of model coefficients.

Even if the other parameters are favorable for choosing the best model, according to the adjustment to the data set, it is necessary to carry out a graphical analysis of the residual, because when viewing the regression line we can see whether or not there is a trend in the dependent variable, observe if they are independent and if there is a smaller variance dispersion. As the graphic evaluation is visual, it may involve some subjectivity, so it is used together with the statistics mentioned above (MIGUEL, 2009).

After selecting the model with the best accuracy, an artificial form factor table will be created, based on the amplitudes of the independent variables ($d_{0,1;}$ $d_{0,5;}$ dap; h) of the data obtained through rigorous cubing by the method of *Smalian*, starting with the smallest amplitude value for diameter and height, until reaching the maximum point, thus obtaining the artificial form factor for the stands.

STATISTICAL ANALYSIS

The program was used: *Excel 2016 for Windows*, *Minitab for Windows*, version 18.0 to perform the statistical calculations and the program *Sigmaplot for Windows*, version 10.0 for plotting graphs.

RESULTS AND DISCUSSION

The DAP (cm) for the VM clone 58 (*E. urophylla x E. camaldulensis)* and hybrid seeds of (*E. urophylla* x *E.grandis)* arithmetic mean values of 16.15 cm and 15.10 cm were identified, respectively. The dispersion of DBH data (cm) over the period of time evaluated is considered low (CV% < 20), according to Kanieski et al (2012).

For dendrometric variable Ht (m) with shell for the VM 58 (*E. urophylla* x *E. camaldulensis*) and hybrid seeds of (*E. urophylla* x *E. grandis)* arithmetic mean values of 24.34 m and 22.99 m were identified, and the data dispersion over the evaluated time period is considered low (CV% < 20), indicating low variation in the data indicating that the values can be fully accepted to interpret the scope of the sample (Table 2).

The asymmetry and kurtosis coefficient values found for the DBH variable (cm) indicate a positive and platykurtic asymmetric distribution, that is, there is a concentration of individuals with DBH below the average. For the variable HT (m), the asymmetry coefficient is negative, indicating a platykurtic curve, that is, the frequency curve distribution has a higher degree of openness than the normal curve distribution, with a certain degree of deviation to the right side. (Table 2).

The number of trees cubed per diameter class corresponded to the distribution of absolute frequency of the stand per class, varying from 15 to 20%, so that individuals of all DBH (cm) and Ht (m) were sampled (Table 2). Miranda et al. (2015) also used this methodology to evaluate the effect of the rigorous cubage sampling method on the precision of volumetric estimates in clonal plantings of *Eucalyptus grandis W. Hill ex Maiden* x *Eucalyptus urophylla*, located in Bahia, with age varying from 58.7 to 65.2 months, where they adjusted two databases, the first with a fixed number of trees in all diameter classes and the second considering the proportion to the diameter distribution

Parameters/clone	VM 58		Hybrid seeds	
	Ht (m)	DAP (cm)	Ht (m)	DAP (cm)
Minimum	21,81	12,58	16,00	11,15
Maximum	26,70	21,34	27,00	19,11
Average	24,34	16,15	22,99	15,10
Standard deviation	1,43	2,48	3,37	2,76
Total average	25	18,15	26	11,64
Median	24,41	16,56	23,6	15,20
Variance	2,04	6,14	11,34	7,64
Asymmetry	-0,1333	0,1637	-0,6581	0,0491
Kurtosis	-0,9162	-0,4554	-0,5642	-1,3305
CV %	2,0432	6,1466	11,3419	7,6447

DAP (cm)	Ht (m)						
	15-17	17-19	19-21	21-23	23-25	25-27	Total
12-16	1	1	2	4	3	4	15
16-20				2	6	7	15
20-24					1	1	2
Total	1	1	2	6	10	12	32

Where: DBH= Diameter at breast height, CV= Coefficient of variation Ht= total height in meters.

Table 2: Descriptive statistics for the DBH (cm) and Ht (m) variables and number of cubed trees according to the distribution of diameter classes.

of the stand. The results obtained showed that the greatest precision was obtained with proportional sampling, which demonstrates a reduction in time and costs of the rigorous cubing operation.

The average height and DBH values found in Table 2 are well below the average values found by Oliveira et al. (2014) in the southern region of the state of Bahia, in which values of 32.8 m and 21.2 cm were obtained for total height and DBH, respectively, in a stand of

Eucalyuptus sp. at 7 years of age, Simões et al (1980) obtained similar mean values, the mean total height of 22.28 m, mean DBH of 14.37 cm, with a spacing of 3x2 m, for the species *E. grandis* in the southern region of the state of São Paulo. In a 54-month-old eucalyptus clone, De Morais Neto et al (2014) found a symmetrical characteristic for diameter and presenting itself as platykurtic, for height found a moderate positive and leptokurtic asymmetry.

The models adjusted for the artificial form factor showed diversified responses to the measures of adjustment precision and significance of the regression coefficients (Table 3). All models reported significance at the 5% probability level for the statistics, rejecting the hypothesis of no regression, concluding, therefore, that at least one independent variable is related to a value of the dependent variable. As for the standard error of the estimate ($S_{yx\%}$) all models were less than 10% and with adjusted coefficient of determination ($R^2_{aj.}$) less than 50% for models 1 to 7 for clone VM 58 and 4.5, and 7 for hybrid seeds (*E. urophylla* x *E. grandis*).

For the clone VM 58 (*E. urophylla x E. camaldulensis*) an adjusted coefficient of determination was found (R^2aj.) from 0.041 to 0.690, which shows low values, as they must be close to 1 (COLOMBINI et al. 2015). While we can see that the standard error results of the estimate (Syx%) in percentage ranged between

4.87 and 8.92, proving to be satisfactory because they are below 15%, highlighting the model: *Stepwise* for presenting the value of 4.87. This next value found by Amorim (2014) in which its smallest standard error of the estimate of 4.24 in a hybrid stand: *Eucalyptus urophylla* vs. *Eucalyptus grandis*, in the state of Pará at the age of eight.

For hybrid seeds (*Europhylla* x E. *grandis*) was the stand with the best walls observed, with R^2aj. from -0.006 to 0.86 for the 8 models and for *Stepwise* with the value of 0.867. The standard error of the estimate (Syx%) has a range of 7.46 to 18.36, highlighting the model *Stepwise* with the lowest value, being 7.46.

As for the standard error of the estimate, the authors above obtained values similar to those found in this work. Both et al (2011) also found values similar to these in 8 of the 16 models tested for *Tectona grandis*.

The procedure: *Stepwise* showed superiority in relation to the other models. The seven models for both VM 58 (*E. urophylla x E. camaldulensis*) as for hybrid seeds (*E.urophylla* x *E. grandis*) reported the highest values of Syx%, proving to be unsatisfactory for estimating the artificial form factor. Contrary to procedure: *Stepwise* which proved to be superior for all measures of fit accuracy.

VM 58								
Parameter statistics								
Model	β_0	β_1	β_2	β_3	β_4	β_5	R^2_{aj}	$S_{yx\%}$	CV%
1	1,949	-12,145	-37,607	308,691	-	-	0,360	7,00	6,11
2	9,691	-3,979	5975,54	-248,18	-223,65	1664,78	0,259	7,24	6,22
3	0,197	0,237	0,25315	-1,3956	-	-	0,071	8,44	4,43
4	0,435	-1,261	1,1500	-	-	-	0,039	8,58	3,57
5	0,448	-0,049	0,741	-	-	-	0,037	8,59	3,56
6	0,448	-1,011	1,2224	-0,6059	-	-	-0,041	8,93	3,58
7	-0,029	-0,286	0,6009	-	-	-	0,179	7,93	4,70
Stepwise	2,5200	-0,042	0,026	-0,697	11,41	-35,08	0,691	4,87	8,75
Hybrid seeds									
Parameter statistics									
Model	β_0	β_1	β_2	β_3	β_4	β_5	R^2_{aj}	$S_{yx\%}$	CV%
1	0,069	0,7847	12,0786	-41,77	-	-	0,628	11,16	15,34
2	-2,749	11714,7	-1988,2	67,361	92,497	-401,16	0,674	10,45	16,19
3	1,322	-3,105	-0,739	4,1975	-	-	0,692	10,16	15,89
4	0,387	5,6669	-3,1111	-	-	-	0,424	13,89	12,95
5	0,812	-0,1621	-1,0169	-	-	-	0,193	16,45	10,03
6	0,135	-17,942	-3,9966	32,101	-	-	0,691	10,18	15,88
7	1,420	0,5639	-1,1725	-	-	-	0,706	9,93	15,84
Stepwise	-1,330	-0,022	-0,0684	2,967	-	-	0,867	7,46	18,30

In which: β_0, β_1, β_2, β_3, β_4 e β_5= regression coefficients; R^2aj= adjusted coefficient of determination; $S_{yx\%}$ = Standard error of the estimate and CV%= percentage variation coefficient.

Table 3: Regression coefficients and significance statistics for the artificial form factor models for the VM clone 58 (*E. urophylla x E. camaldulensis*) hybrid seeds (*E.urophylla x E. grandis*).

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Figure 1 (a and b) shows the graphic distribution of residues as a function of individual for the VM 58 clone and for the hybrid seeds (*E. urophylla* x *E. grandis*). For both cases, it was found that all models tended to overestimate the smallest and intermediate diameters and to underestimate the largest form factor values within the limits of allowed error. Furthermore, the residuals also showed signs of heteroscedasticity, when the variance is not constant along the regression line. It could be seen that the model *Stepwise*, showed a lower graphic dispersion of residues for the VM 58 clone and for the hybrid seeds (*E. urophylla* x *E. grandis*).

According to the results obtained for the Kolmogorov-Smirnov normality test, it was shown that the models are adequate to estimate the form factor, accepting the normality hypothesis (H_0), in which, the estimated data were adjusted to the models, where the bilateral critical values calculated at 5% and 1% of significance found were 0.295 and 0.366 for both the VM 58 clone and the hybrid seeds(*E. urophylla* x *E. grandis*), are less than the value de D_{tab} (95%) = 0,320 and D_{tab} (99%) = 0.391 we do not reject the null hypothesis and conclude that there is no evidence that the variances obtained for the data set are different, and the tabulated values were equal to the calculated critical values (Figure 2).

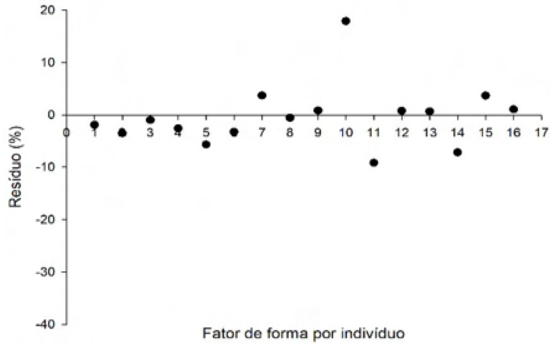
After indicating the models: *Stepwise* for the accurate estimates of the individual artificial form factor, a comparison of the real volume (through the cubed data) and the individual volume estimated by 2 methods was carried out: Estimated volume using the form factor = 0.5 (value used to calculate the volume of native species of the cerrado and, arbitrated for the planted stands of the region) and volume estimated through the use of the fact of form estimated by the models: *Stepwise.* (Table 4).

The average volume of the 32 trees using the form factor estimate given by the models: *Stepwise* showed more approximate responses with rigorous cubage for the two stands, being considered without significant difference by the Tukey test. On the other hand, the use of the 0.5 form factor provided an increase in the average and total volume of approximately 10.13% and 9.91%, respectively for the VM 58 and 2.34%, 1.94% for the hybrid seeds (*E. urophylla x E. grandis*). The results provided by the average form factors are a little serious, in view of the overestimation in relation to the observed volumes, which shows an indication of carrying out the determination of form factors at the species level.

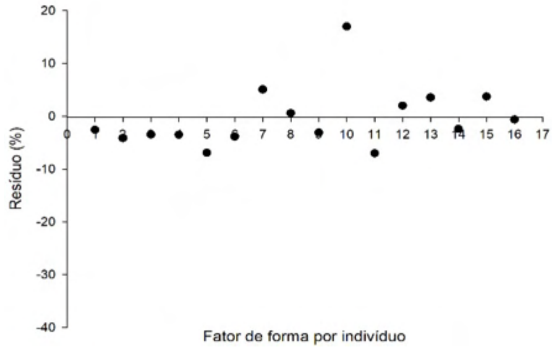
With the artificial form factor model in hand, the artificial form factor was determined para clone VM 58 (*E. urophylla x E. camaldulensis*) and hybrid seeds (*E. urophylla* x *E. grandis*). It can be observed that lower DBH with smaller heights have larger form factors decreasing with increasing diameter, until they remain approximately constant at 0.4749 in the largest diameters with an amplitude of 0.1319 for VM clone 58 (*E. urophylla x E. camaldulensis*) and 0.5930 with an amplitude of 0.2998 for hybrid seeds (*E. urophylla* x *E. grandis)*. These prove the trends of trees that, over time, begin to increase in diameter, acquiring a more cylindrical shape (Tables 5).

For eucalyptus, the form factor values are usually close to 0.50, that is, the real volume of wood is equivalent to 50% of the cylindrical volume. However, the form factors vary with genetic material, age and site, with values ranging from 0.40 to 0.60 or higher. Cipriani et al. (2015) also found similar values to this study for hybrid of *E. grandis* x *E. urophylla* at 7.7 years of age with a mean value of 0.553.

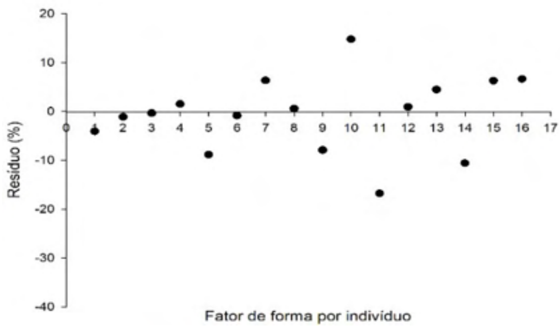
In general, the artificial form factor generated by the models tend to reach the average of 0.4675 for the VM 58 clone. (*E.*



Model 1



Model 2



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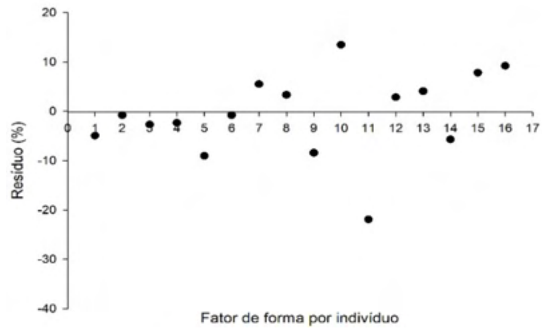

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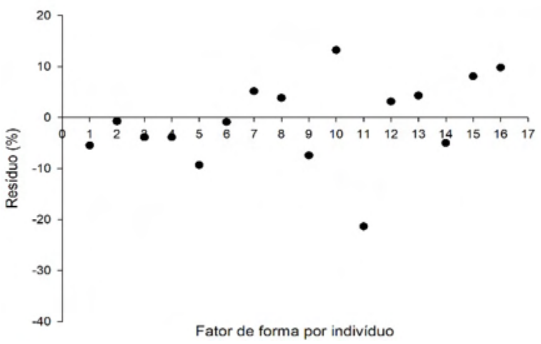

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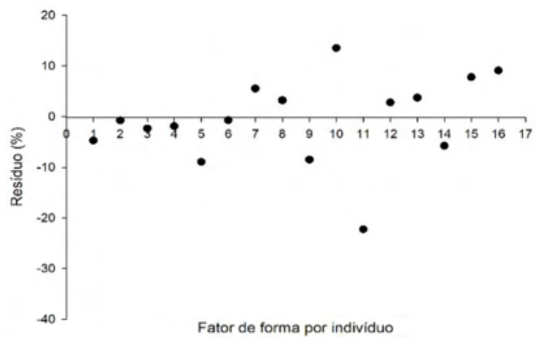

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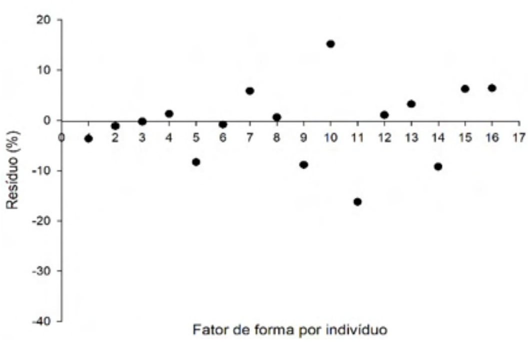

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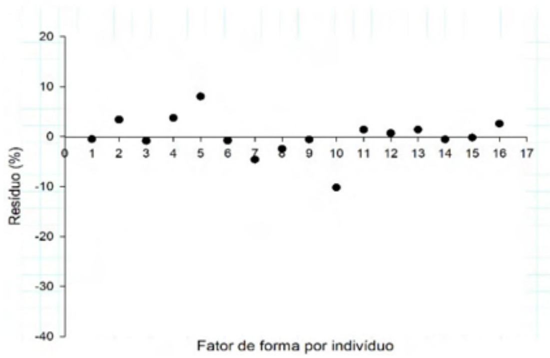

Model *Stepwise*

(a)

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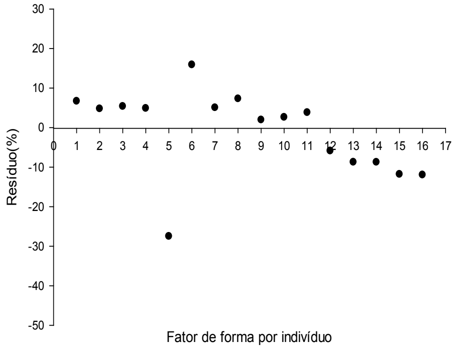
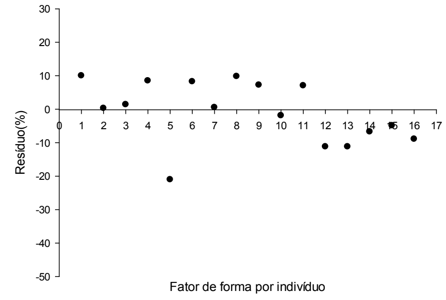
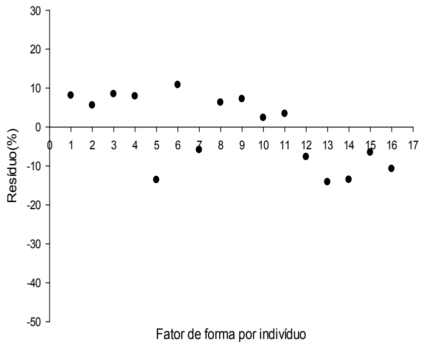


Model 1



Modelo 2



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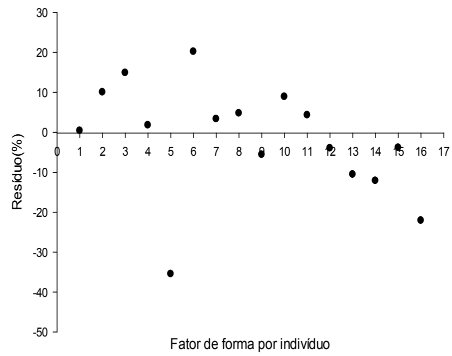

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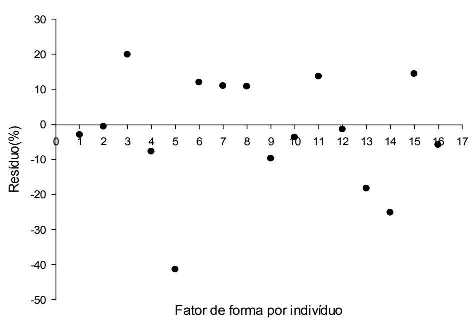

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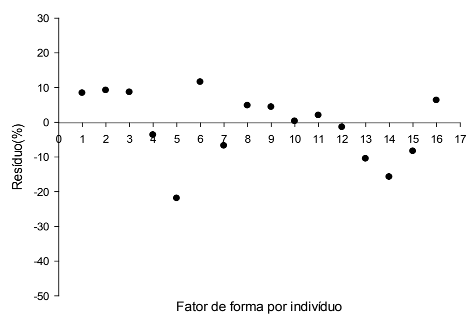
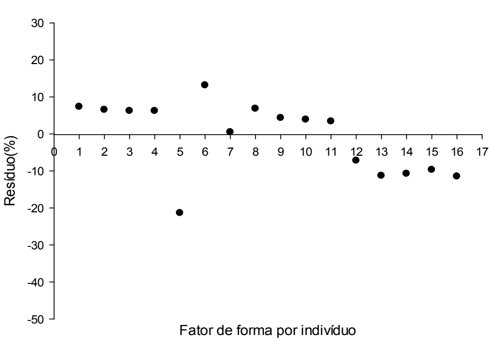
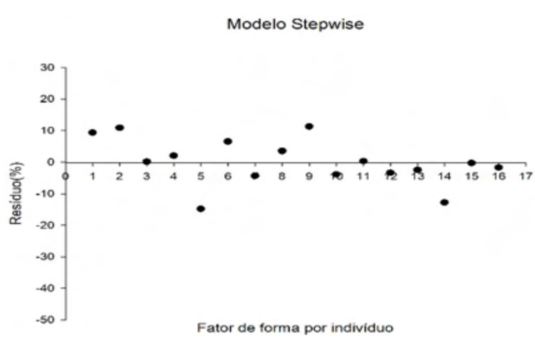


Model 6



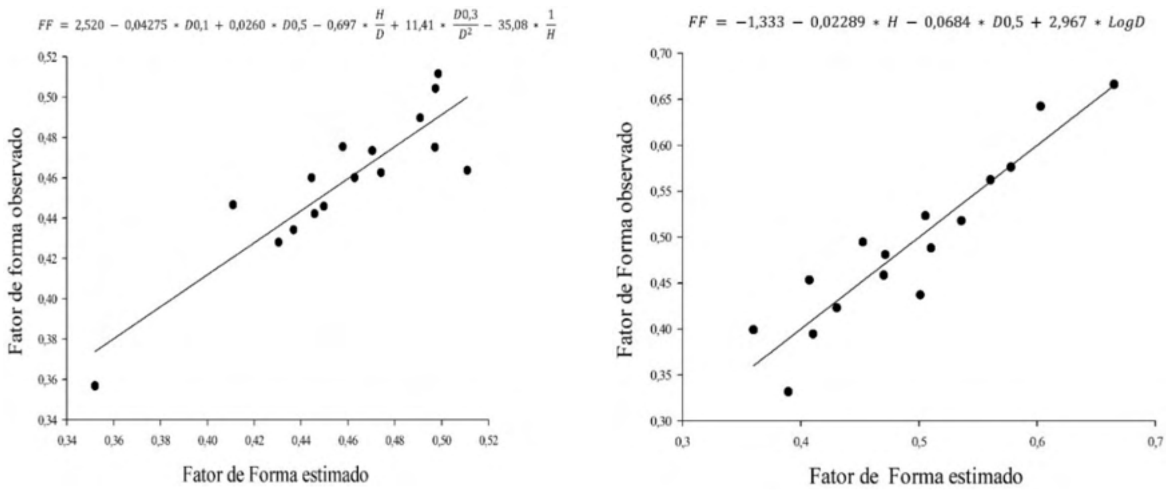
Model 7



Model Stepwise

(b)

Figure 1: Graphical distribution of residues for the clone of VM 58 (*E. urophylla x E. camaldulensis*) (a) and for hybrid seeds (*E. urophylla* x *E. grandis*) (b).



(a) (b)

Figure 2: Observed and estimated form factor for clone: VM 58 (*E.urophylla x E.camaldulensis*) (a) and hybrid seeds (*E.*urophylla x *E grandis)* (b)

Fator de forma estimado = Estimated shape factor

		Average (m^3)	Standard deviation	CV (%)	minimum (m^3)	maximum (m^3)	total (m^3) *
VM 58	*Smalian*	0,2322	0,0686	29,5311	0,1403	0,3445	3,7158^{a}
	Stepwise	0,2314	0,0691	29,8557	0,1457	0,3538	3,7031^{a}
	fator 0,5	0,2558	0,0800	31,2787	0,1473	0,4135	4,0925^{b}
hybrid seeds	*Smalian*	0,2109	0,0967	45,8404	0,0953	0,4145	3,3750^{a}
	Stepwise	0,2123	0,0964	45,4163	0,0947	0,3909	3,3975^{a}
	factor 0,5	0,2159	0,0918	42,5162	0,0976	0,3728	3,4539^{b}

Where: N = number of individuals calculated the volume; Dev pad= standard deviation; Cv (%) = coefficient of variation; *= volume of the 16 individuals;

Table 4: Comparisons of artificial form factor determination by different methods.

	DAP (cm)	Ht (m) 21	22	23	24	25	26
VM 58	11	0,5587	0,5669	0,5707	0,5708	0,5677	0,5616
	12	0,5199	0,5315	0,5388	0,5424	0,5426	0,5400
	13	0,4853	0,4974	0,5233	0,5333	0,5381	0,5385
	14	0,4749	0,4818	0,4851	0,4852	0,4825	0,4773
	15	0,4517	0,4812	0,5040	0,5211	0,5331	0,5406
	16	0,4104	0,4428	0,4685	0,4885	0,5034	0,5138
	17	0,4749	0,4818	0,4851	0,4852	0,4825	0,4773
	18	0,4419	0,4518	0,4580	0,4610	0,4612	0,4590
	19	0,4321	0,4228	0,4448	0,4533	0,4574	0,4577
	20	0,4191	0,4101	0,4315	0,4397	0,4437	0,4440
	21	0,4066	0,3978	0,4185	0,4265	0,4304	0,4307

	DAP (cm)	Ht (m) 16	17	18	19	20	21	22	23	24	25	26	27
hybrid seeds	12	0,6380	0,6550	0,6650	0,6710	0,6970	0,6990	0,7197	0,7277	0,7310	0,7321	0,7553	0,7780
	13	0,6189	0,6354	0,6451	0,6509	0,6761	0,6780	0,6981	0,7059	0,7091	0,7101	0,7326	0,7547
	14	0,6003	0,6163	0,6257	0,6313	0,6558	0,6577	0,6772	0,6847	0,6878	0,6888	0,7107	0,7320
	15	0,5823	0,5978	0,6069	0,6124	0,6361	0,6380	0,6569	0,6642	0,6672	0,6682	0,6893	0,7101
	16	0,5648	0,5799	0,5887	0,5940	0,6170	0,6188	0,6371	0,6442	0,6471	0,6481	0,6687	0,6888
	17	0,5479	0,5625	0,5711	0,5762	0,5985	0,6003	0,6180	0,6249	0,6277	0,6287	0,6486	0,6681
	18	0,5205	0,5343	0,5425	0,5474	0,5686	0,5702	0,5871	0,5937	0,5963	0,5972	0,6162	0,6347
	19	0,4945	0,5076	0,5154	0,5200	0,5402	0,5417	0,5578	0,5640	0,5665	0,5674	0,5854	0,6030
	20	0,4697	0,4822	0,4896	0,4940	0,5132	0,5146	0,5299	0,5358	0,5382	0,5390	0,5561	0,5728
	21	0,4462	0,4581	0,4651	0,4693	0,4875	0,4889	0,5034	0,5090	0,5113	0,5121	0,5283	0,5442
	22	0,4239	0,4352	0,4419	0,4552	0,4631	0,4645	0,4782	0,4835	0,4857	0,4865	0,5019	0,5170

Table 5: Clone artificial form factor table: VM 58 (*E. urophylla x E. camaldulensis*) and hybrid seeds (*E.urophylla x E grandis*)

urophylla x E. camaldulensis) and 0.5937 for hybrid seeds (*E. urophylla x E. grandis).*A similar result was found by Amorim (2014), in a stand planted with the hybrid *E. urophylla* vs. *E. grandis* with eight years of age, with a spacing of 3 x 3 m, with a form factor of 0.5, a value that is also similar to Both et al (2010) with a stand of *Tectona grandis*. Oliveira (2011) found for *E. urophylla x E. grandis* aged 6.3 years average artificial form factor of 0.4705.

CONCLUSION

For the clone of VM 58 (*E. urophylla x E. camaldulernsis*) The model that best fitted the data was the *Stepwise* com R^2aj. of 0.691, Syx(%) of 4.87 and CV(%) of 8.87 from the equation: $ff = 2{,}520 + (-0{,}04275 * d_{0,1}) + (-0{,}0260 * d_{0,5}) + (-0{,}697 * \frac{h}{dap}) + (11{,}41 * \frac{d_{0,3}}{d^2}) + (-35{,}08 * \frac{1}{h})$. For hybrid seeds (*E. urophylla x E. grandis*) the model that best fitted the data was the *Stepwise* with R^2aj. of 0.867, Syx(%) of 7.46 and CV(%) of 18.307 from the equationo: $ff = (-1{,}333) + (-0{,}02289 * H) + (-0{,}0684 * d_{0,5}) + (2{,}967 * \log d)$. However, the use of the equation must be restricted to stands with similar characteristics to the one studied and under similar soil and climate conditions and driving regimes. The artificial form factor tables of the hybrid Eucalyptus VM 58 and seeds showed variation between 0.3978 and 0.5707 and 0.4239 to 0.7780 respectively.

The form factors found are in the expected range for eucalyptus (0.40-0.60) and can be used to calculate the real volume of wood in stands of *Eucalyptus* with similar characteristics, simply multiplying the cylindrical volume by the respective shape factor.

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