EQUATIONS AND FORM FACTOR BY SPECIES INCREASE THE PRECISION AND ACCURACY FOR ESTIMATING TREE VOLUME IN THE AMAZON

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Resumo

Equação e fator de forma por espécie aumentam a precisão e exatidão na estimativa do volume de árvores na Amazônia. O ajuste de equações volumétricas, bem como o fator de forma por espécie representam ferramentas valiosas para a condução de planos de manejo sustentáveis. Assim, o objetivo deste estudo foi avaliar o emprego de equações volumétricas e do fator de forma para estimativa do volume de madeira em espécies florestais nativas do bioma Amazônia. Duzentas e dezenove (219) árvores, distribuídas entre onze espécies foram abatidas e arrastadas até o pátio de estocagem para a cubagem pelo método de Smalian. Foram testados oito modelos matemáticos de simples e dupla entrada cujas variáveis independentes foram diâmetro a 1,30 m do solo e altura comercial. As variáveis dependentes foram volume comercial com casca, por espécie e para o mix de espécies. As estatísticas foram analisadas conjuntamente com os gráficos de volume observado e estimado e os de dispersão dos resíduos e a média dos resíduos. Foi calculado o fator de forma por espécie e para o mix das espécies. De modo geral, o modelo que resultou em melhor estimativa, quando ajustado, foi a de Schumacher-Hall. O mesmo pode ser observado para o mix de espécies. O fator de forma médio foi de 0,7978, diferindo do estabelecido pela legislação, que é igual a 0,7.
Palavras-chave: madeiras nativas, cubagem, manejo florestal, equações de volume.

Abstract

The adjustment of volumetric equations, as well as the form factor by species, represents valuable tools for conducting sustainable management plans. So the goal of this study was to evaluate the employment of volumetric equations and form factor to estimate the wood volume of native species from the Amazon biome. Two hundred nineteen trees, distributed in eleven species, were cut down and dragged to the storage patio for scaling by the Smalian method. Eight mathematical models were tested with simple and double entries, whose independent variables were their DBH and diameter at commercial height. The dependent variables were the commercial volume outsidebark, by species and for the mix of species. The statistics were analyzed alongside a graph for the observed and estimated volumes, and a graph for the residual dispersion and the average residual. The form factor was calculated both by species and for the mix of species. In general, the model that resulted in the best estimative was the Schumacher-Hall method. The same can be observed for the mix of species. The average form factor was 0.7978, differing from the established by the legislation, which is equal to 0.7.
Keywords: native woods, cubing, forest management, volume equations.

INTRODUCTION

Considered as the largest tropical Forest in the world, the Brazilian Amazon represents a great variety of natural resources due to its plant associations, which in turn, are influenced by environmental factors intrinsic to each ecosystem which constitutes the biome (LIMA *et al.*, 2014). Given their richness and diversity, these forests are targets for controlled and predatory exploitation of timber and non-timber resources.

In uneven-aged forests, the increasingly accurate knowledge of Forest stock is closely related to the definition of the criteria, for instance, which species to manage, what the forest production potential is, and above all, which conservation degree and environmental preservation it presents. (SCOLFORO; MELO, 1997).

The volumetric estimate of a tree species may be carried out by the two most usual forms. The first one of them, and most precise one, uses mathematical models adjusted with rigorous scaling data from sample-trees, which shall generate volumetric equations. Such mathematic models need diameter values, or the combination of diameter and height of the trees measured in the field, with predictor variables in the volumetric estimate.

The second methodology makes use of a form factor, which is the correction of the tree's cylindrical volume, determined by its diameter and height (CHAPMAN; MEYER, 1949). Thus, quantifying real volumes provides with obtaining volume and form factor equations which shall be used in the individual tree volume estimate (SCOLFORO; THIERSCH, 2004).

In management plans for the Amazon biome, the determination of commercial volume stock must comply with the standards established by legal normalization, in which, in the first year of production the volume must be estimated by using the form factor of 0.7 for all species (MATO GROSSO, 2014). Starting its second year, the timber stock must be estimated by the volumetric equation specifically developed for the area where the management plan is being performed. (BRASIL, 2009).

Due to the variability found in natural forests, there is not an equation or even a form factor which consistently represents all species, making it important to investigate means of increasing precision and accuracy of such volumetric methods. Of the factors which most influence the formation of the tree, genetic material is one which can be isolated in uneven-aged forests through stratification, allowing more homogenic subsets of data in relation to the overall, making it possible to reflect on more accurate volumetric estimates.

Furthermore, it is important to obtain volumetric equations for each specific evaluation, for in Forest activity, there may not be misguided influence, which may incur incorrect quantification of volumetric stocks, which causes economical losses, compromising the forest management (GAMA *et al.*, 2017).

Apart from normative imposition, it is paramount and subject of interest of any forest manager to faithfully quantify the timber stock in the Forest. In this context, this stydy aimed to evaluate the application of volumetric and form factor equations for volume estimate in native Forest species in the Amazon biome.

MATERIAL AND METHODS

Study area

This study was conducted in a um *Plano de Manejo Florestal Sustentável* (PMFS) (Sustainable Forest Management Plan) with na área of 1,405.24 hectares, located in the municipality of Tabaporã, north region of the state of Mato Grosso, Brazil. According to the Segundo Köppen classification, the regional climate is characterized as tropical rainy (type Am), dry season in the period comprehending May to August, and precipitation between 2.500 and 2.800 mm from September to March, annual average temperature between 22 and 24° C (ALVARES *et al.*, 2013). As to its predominant vegetation, the plant cover is composed by Forest associated to the Planalto dos Parecis, transiting to Ombrophilous Forest/Seasonal Forest (MATO GROSSO, 2002).

Rigorous cubing

There were selected tress of eleven high commercial value and widely exploited and commercialized species by forest-based forming industriesin the region of the Southern Amazon, namel: *Hymenolobium petraeum* Ducke, *Ormosiaparaensis*Ducke, *Qualea paraensis* Ducke, *Ocotea puberula* (Rich.) Nee, *Erisma uncinatum* Warm, *Cedrelinga cateniformis* Ducke, *Dipteryx odorata* (Aubl.) Willd, *Apuleia leiocarpa* (Vogel) J.F.Macbr, *Trattinnickia burseraefolia* Mart, *Aspidosperma eburneum* Allem. ex Saldanha and *Bowdichia nitida* Spruce ex Benth.

The trees of each species selected for scaling were cut down and dragged to the stock patio for diameter measuring at 1.30 above ground (DBH) and commercial height (H). The scaling method employed to obtain the commercial volume of timber-tree (V) was the *Smalian*, in which diameter measures were taken at the heights of 0,10; 0,30; 0,70; 1,30;2,00 m and, subsequently, every two meters up to the commercial height (beginning of the presence of branches). The descriptive statistics on the dendometric variables and the number of scaled trees by species are observed on Table 1.

Table 1. Mean, minimum and maximum values of the diameter at 1.30 m above ground (DBH), commercial height (H), and commercial timber-tree volume (V) of trees measured in different species in the Amazon biome, in Tabaporã, Mato Grosso.

Tabela 1. Valores médios, mínimos e máximos das variáveis dendrométricas diâmetro a 1,30 m do solo (DAP), altura comercial (H), e volume comercial de madeira (V) de árvores mensuradas em diferentes espécies no bioma Amazônia, em Tabaporã, Mato Grosso.

Species	n	DBH (cm)			H (m)			V (m^3)		
		Avg.	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
H. petraeum	23	67,64	48,26	110,75	10,80	7,30	14,30	3,30	1,36	9,04
O. paraensis	12	83,10	51,15	131,14	9,72	4,30	13,10	5,01	0,80	12,93
Q. paraensis	28	68,51	49,18	95,59	13,85	10,73	17,40	3,96	1,82	9,18
O. puberula	22	57,60	33,23	69,66	8,85	4,20	11,30	2,06	0,79	3,04
E. uncinatum	26	75,40	43,70	123,79	13,36	8,70	19,50	4,83	1,16	13,08

C. cateniformis	33	86,31	53,51	148,36	10,29	4,20	17,44	4,83	1,04	15,66
D. odorata	18	67,24	51,91	95,93	10,49	7,10	14,34	2,98	1,39	6,30
A. leiocarpa	14	86,00	61,70	126,59	9,94	6,75	14,13	5,37	1,79	11,91
T. burseraefolia	16	88,73	52,25	166,77	11,79	4,20	15,62	6,40	0,85	21,89
A. eburneum	15	61,27	47,16	90,60	8,41	5,10	12,12	2,23	0,78	5,92
B. nítida	12	81,02	52,79	113,93	10,78	6,20	13,10	4,74	1,24	10,38
Mix	219	74,30	33,23	166,77	10,99	4,20	19,50	4,10	0,78	21,89

In which: n = number of sampled trees; DBH = diameter at 1.30 m above soil (cm); H = commercial height (m); V = timber-tree commercial volume (m³); Avg. = average; Min. = minimum; Max. = maximum.

Volume Estimates

The average form factor and the adjusted modesls were obtained by considering the data stratification: i) per species and ii) per mix of species (mix). The form factor was obtained for all scaled trees, given by the reason of the volume observed in the scaling and cylindrical volume. Thus, from each species and each species mix it was obtained the mean form factor, its dispersion confidence inerval measurements with avarage at 95% probality. For volume estimative using equations, 8 simple and double-entry volumetric models were tested (Table 2), though the ordinary least square methods.

Table 2. Simple and double-entry mathematical models evaluated in the commercial timber-tree volume estimate of eleven native species from the Amazon biome, Tabaporã, Mato Grosso.

Tabela 2. Modelos matemáticos de simples e dupla entrada avaliados na estimativa do volume comercial de madeira de onze espécies nativas do bioma Amazônia, Tabaporã, Mato Grosso.

Model (M)	**Mathematical Structure**	**Author**
1	$V = \beta_0+\beta_1 DAP+ \beta_2 DAP^2+ \varepsilon_i$	Hohenadl-Krenn
2	$V=\beta_0+\beta_1 DAP^2 H+ \varepsilon_i$	Spurr (1952)
3	$V=\beta_0+\beta_1 DAP^2+\beta_2 DAP^2 H+ \beta_3 H+ \varepsilon_i$	Stoate (1945)
4	$V=\beta_1 DAP^2+\beta_2 DAP^2 H+ \beta_3 DAPH^2+\beta_4 H^2 +\varepsilon_i$	Naslund
5	$V=\beta_0+\beta_1 DAP+ \beta_2 DAP^2+ \beta_3 DAPH+ \beta_4 DAP^2 H+ \beta_5 H+\varepsilon_i$	Meyer
6	$Ln(V)=\beta_0+\beta_1 Ln(DAP)+ \beta_2 Ln(H)+ Ln(\varepsilon_i)$	Schumacher-Hall (1933)
7	$Ln(V)=\beta_0+\beta_1 Ln(DAP)+ \beta_2 \left(\frac{1}{DAP}\right) + Ln(\varepsilon_i)$	Brenac
8	$Ln(V) = \beta_0 + \beta_1 Ln\left(DAP^2 H\right) + Ln(\varepsilon_i)$	Spurr (ln)

In which: DBH = diameter at 1.30 m above soil (cm); H = commercial height (m); V = commercial volume (m³); β_0..., β_5 = model parameters to be adjusted; Ln = natural logarithm; ε_i = random estimative errors.

The selection criteria of the Best equations was based on the adjusted coefficient of determination ($R^2_{aj.}$),standard error of estimate (S_{yx}), graphical analysis of residuals and on the significance of coefficients by the test t (95% probability). After selecting the best equation for each species and mix of species, it was evaluated the residual normality by the *Shapiro-Wilk* test, with 95% probability. Furthermore, it was analyzed the projection matrix H to verify the occurrence of outliers in the data and value of DFFITS, DFBETAS and Cook’s distance to determine influential points in the models.

Subsequently, it was evaluated the precision and accuracy of the estimates of each selected equation and mean form factor (per mix of species) from the graphical analysis of standard errors and simple linear regression. To that end, an adjustment was made on a simple linear regression ($y=\beta_0+\beta_1 X_i+e_i$), with values estimated in function of the observed values. The hipotheses H_0: $\beta_0=0$ e H_0: $\beta_1=1$ were tested through the t test, at 95% probability. If accepted, it is verified that the estimated values are close to the observed, portraying a regression line which intercepts the origin with a 45° slope ($\beta_0=0;\beta_1=1$), which characterizes accuracy. Yet, the determination coefficient (R^2) and Pearson’s correlation (R) of the regression were precision indicators.

All analyses were done on the software R version 2.12.2 (R Core Team, 2011). The graphics were elaborated on *Microsoft Office Excel®*.

RESULTS

The average form factor for the mix of species was 0.7978, in which the lower and upper confidence limits for the average were 0.7868 and 0.8088, respectively (Table 3). The variation coefficient ($CV_{\%}$), for the mix of species was 10.33%, presenting variability in the form among the verified species. In contrast, the species *Ormosia paraensis*, *Erisma unciatum* and *Trattinnickia burseraefolia* presented a variation coefficient ($CV_{\%}$) above of the species mix, denoting a high variability in form factor among individuals of such species.

It stands out for presenting a more cylindrical form (upper form factor), the *Ocotea puberula, Apuleia leiocarpa, Aspidosperma eburneum* and *Hymenolobium petraeum*, all of them with a mean from factor above 0.80. In contrast, the species *Cedrelinga cateniformis, Qualea paraensis,* and *Erisma uncinatum* presented a greater conicity (lower form factor).

Table 3. Descriptive statistics and confidence interval for the average of the evaluated form factor, by species and species mix, for the estimate of the commercial volume of wood from eleven forest species in the Amazon biome, Tabaporã, Mato Grosso.

Tabela 3. Estatística descritiva e intervalo de confiança para a média do fator de forma avaliado, por espécie e mix de espécies, na estimativa do volume comercial de madeira de onze espécies florestais no bioma Amazônia, Tabaporã, Mato Grosso.

Species	n	$\overline{FF}$	s^2_{FF}	s_{FF}	$s^2_{\overline{FF}}$	$s_{\overline{FF}}$	e	CV%	IC: $\overline{FF} - t.s_{\overline{FF}} \leq \mu \leq \overline{FF} + t.s_{\overline{FF}}$
H. petraeum	23	0,805	0,006	0,081	0,024	0,017	0,035	10,14	0,7705 ≤ μ ≤ 0,8411
O. paraensis	12	0,800	0,006	0,083	0,013	0,024	0,053	10,42	0,7472 ≤ μ ≤ 0,8531
Q. paraensis	28	0,760	0,005	0,071	0,011	0,013	0,027	9,35	0,7331 ≤ μ ≤ 0,7883
O. puberula	22	0,882	0,003	0,055	0,016	0,011	0,024	6,26	0,8576 ≤ μ ≤ 0,9066
E. uncinatum	26	0,770	0,006	0,082	0,012	0,016	0,033	10,69	0,7377 ≤ μ ≤ 0,8042
C. cateniformis	33	0,745	0,005	0,071	0,017	0,012	0,025	9,64	0,7200 ≤ μ ≤ 0,7709
D. odorata	18	0,777	0,005	0,072	0,016	0,017	0,036	9,38	0,7411 ≤ μ ≤ 0,8136
A. leiocarpa	14	0,837	0,003	0,060	0,023	0,016	0,034	7,19	0,8028 ≤ μ ≤ 0,8723
T. burseraefolia	16	0,774	0,009	0,094	0,013	0,023	0,050	12,25	0,7236 ≤ μ ≤ 0,8246
A. eburneum	15	0,830	0,002	0,052	0,020	0,013	0,029	6,32	0,8018 ≤ μ ≤ 0,8599
B. nitida	12	0,790	0,005	0,071	0,000	0,020	0,045	9,02	0,7452 ≤ μ ≤ 0,8359
Mix	219	0,792	0,006	0,082	0,000	0,005	0,011	10,33	0,7868 ≤ μ ≤ 0,8088

In which: n = number of sampled trees; $\overline{FF}$ = average form factor; s^2_{FF} = form factor variance; $s^2_{\overline{FF}}$ = average form factor variance $s_{\overline{FF}}$ = average form factor standard deviation; e = sample error; CV = variation coefficient (%); IC = confidence interval for average form factor, with 95% probability; t = table t value of the Student distribution, with 95% probability and n-1degrees of freedom.

In general, Spurr (2), Schumacher-Hall (6), and Spurr logarithmized (8) models were the only ones whose adjustments presented statistics significance in all model parameters. For the species *Aspidosperma eburneum* and the mix, in addition to the above mentioned models, Stoate model (3) resulted in significant parameters. Thereby, for all species, the volumetric models presented statistics significance considering as predictor variables the diameter at 1.30 m above soil (DBH) and commercial height (H).

In relation to the best adjustment models (Table 4), it was verified that for the majority of the species and for the species mix, the Schumacher-Hall model was the one resulting in lesser errors ($S_{yx\%}$) associated to the greater values of adjusted determination coefficient ($R^2_{aj.}$). only for the specieses *Apuleia leiocarpa*, *Trattinnickia burseraefolia*, *Aspidosperma eburneum* Spurr logarithmized model (8) resulted in lesser errors ($S_{yx\%}$), although not exceeding a difference of 0.65%.

Table 4. Adjusted parameters from the best models and adjustment statistics, by species and mix of species, in estimating of commercial timber-tree volume for eleven forest species in the Amazon biome, Tabaporã, Mato Grosso.

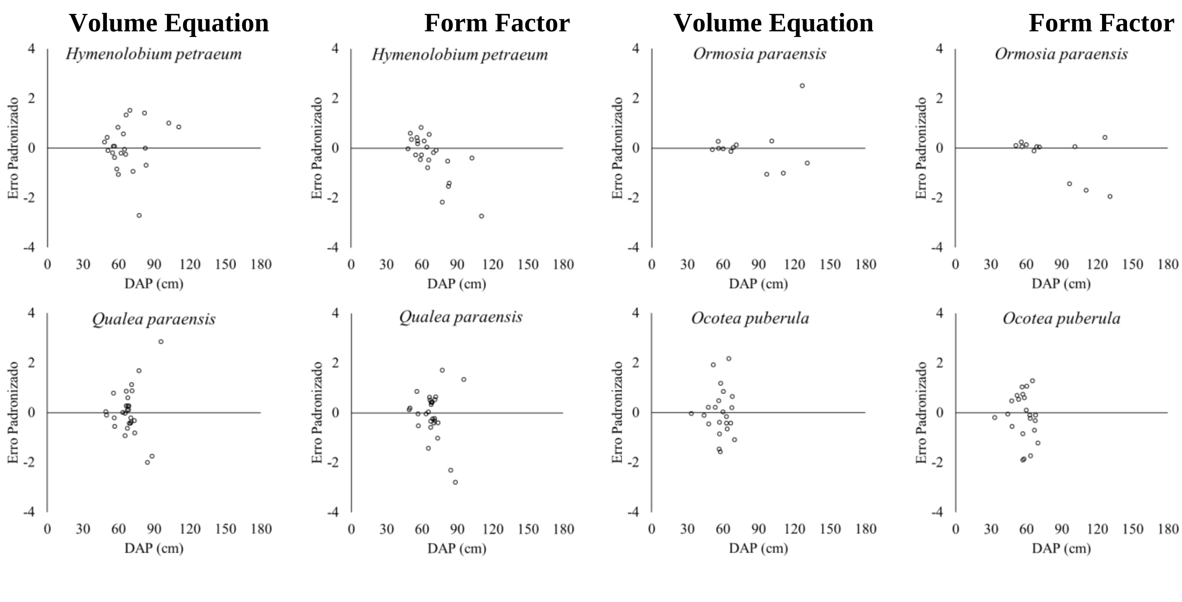
Tabela 4. Parâmetros ajustados dos melhores modelos e estatísticas de ajuste, por espécie e mix de espécies, na estimativa do volume comercial de madeira de onze espécies florestais do bioma Amazônia, Tabaporã, Mato Grosso.

Species	Model	β_0	β_1	β_2	$R^2_{aj.}$	S_{yx} (m^3)	S_{yx} (%)
H. petraeum	6	-8,459440*	1,861370*	0,73121000*	0,987	0,193	5,85
O. paraensis	6	-8,880290*	1,900680*	0,83549000*	0,994	0,637	12,71
Q. paraensis	6	-8,527500*	1,880900*	0,7329000*	0,921	0,458	11,58
O. puberula	6	-9,047170*	1,974470*	0,80140000*	0,985	0,105	5,13
E. uncinatum	6	-8,744520*	1,904970*	0,78028000*	0,963	0,566	11,73
C. cateniformis	6	-9,366800*	1,994750*	0,8421600*	0,985	0,366	7,58
D. odoraata	6	-8,770120*	1,969480*	0,65192000*	0,985	0,172	5,8
A. leiocarpa	8	-9,272200*	0,967600*	-	0,988	0,354	6,61
T. burseraefolia	8	-8,760200*	0,915600*	-	0,983	0,503	7,86
A. eburneum	8	-8,921010*	0,930220*	-	0,993	0,163	7,32
B. nítida	6	-9,588000*	2,203700*	0,57910000*	0,982	0,329	6,96
Mix	6	-8,867950*	1,910260*	0,81407000*	0,983	0,408	9,93

In which: β_0..., β_5 = adjusted model parameters; R^2_{aj}: adjusted determination coefficient; S_{yx}: estimate standardized error;*significant at 95% probability by Student test t.

Of the species in which the Schumacher-Hall model presented the Best performance, the greatest standardized error observed ($S_{yx\%}$) was for the species *Ormosia paraensis*, 12.71%. However, when it was analyzed the performance of all models for the species, such error was the lowest. Thereby, the data variability of the species may have influenced the adjustment performance.

Thus, aiming to standardize a model which allows obtaining the precise estimate of wood commercial volume, there were designed graphics of standardized errors resulting from the Schumacher-Hall model, and compared with the errors caused by the usage of the form factor for each species (Figure 1).



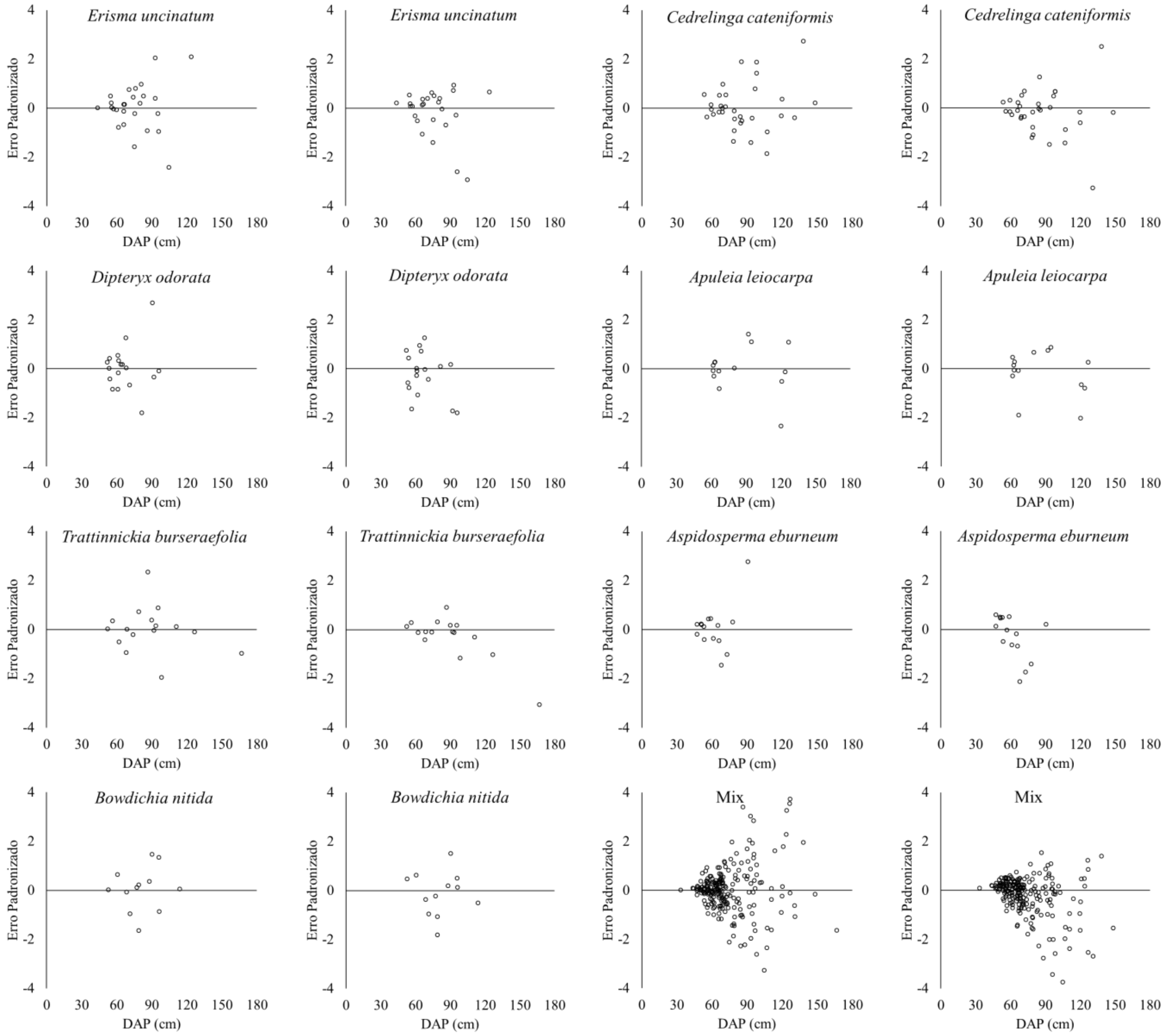


Figure 1. Graphical distribution of standardized errors as a function of the diameter at 1.30 m from the soil, obtained from the volumetric estimate by the average form factor and adjusted Schumacher-Hall model, by species and species mix, for eleven forest species in the Amazon biome, Tabaporã, Mato Grosso.

Figura 1. Distribuição gráfica dos erros padronizados em função do diâmetro a 1,30 m do solo, obtidos a partir da estimativa volumétrica pelo fator de forma médio e modelo ajustado de Schumacher-Hall, por espécie e mix de espécies, para onze espécies florestais do bioma Amazônia, Tabaporã, Mato Grosso.

Table 5. Normality test for the Schumacher-Hall model for each species, significance of the coefficients of the simple linear regression test and R^2, both for the estimated volume as a function of the observed one.

Tabela 5. Teste de normalidade para o modelo de Schumacher-Hall para cada espécie, significância dos coeficientes do teste da regressão linear simples e R^2, ambos para o volume estimado em função do observado.

Species	Equation				Form Factor		
	p-value			R^2	p-value		R^2
	Shapiro-Wilk	$\beta_0 = 0$	$\beta_1 = 1$		$\beta_0 = 0$	$\beta_1 = 1$	
Hymenolobium petraeum	0,6677	0,3210	0,2062	0,9909	0,0020*	0,0000*	0,9887
Ormosia paraensis	0,8111	0,5640	0,4157	0,9809	0,6013	0,0849	0,9799
Qualea paraensis	0,8972	0,0462*	0,0296*	0,9017	0,7839	0,8958	0,8976
Ocotea puberula	0,8565	0,6746	0,6438	0,9779	0,3272	0,2135	0,9707
Erisma uncinatum	0,0927	0,1936	0,1097	0,9541	0,7972	0,4710	0,9472

Cedrelinga cateniformis	0,3969	0,5033	0,3120	0,9882	0,4258	0,1085	0,9803
Dipteryx odorata	0,8901	0,2905	0,2074	0,9885	0,1629	0,0448*	0,9813
Apuleia leiocarpa	0,7414	0,9801	0,9746	0,9913	0,7565	0,4306	0,9914
Trattinnickia burseraefolia	0,2924	0,7008	0,6660	0,9897	0,0211*	0,0003*	0,9876
Aspidosperma eburneum	0,6052	0,0747	0,0289*	0,9901	0,6419	0,2082	0,9927
Bowdichia nitida	0,3912	0,4724	0,3621	0,9863	0,6549	0,7803	0,9837
Mix	0,1587	0,1232	0,0217*	0,9895	0,0004*	0,0000*	0,9757

In which: R^2: determination coefficient.

DISCUSSION

In relation to the form factor, it was possible to observe that even the greater thinning species (*C. cateniformis*) presented an average form factor above the established by the legislation, of 0.7 (MATO GROSSO, 2014), implying underestimates of the wood commercial value in the first year of the management plan. When the lesser thinning was analyzed (*O. puberula*), the average form factor obtained was around 17% larger than the established by the legislation, amplifying even more the imprecision in this year of management.

Upper form factor values were also found by Figueiredo *et al.* (2009), evaluating the form factors for 20 forest species in the Amazon, with an average form factor of 0.874. Colpini *et al.* (2009) obtained average form factor of 0.7424 for different species in arborous vegetation of Open Ombrophilus Forest in the northwest region of the state of, while Thaines *et al.* (2010), at the Ituxi River basin in the state of Amazonas, obtained form factor of 0.75. In addition to being influenced by the species and age, the form is also related to the type of the site in which the arborous vegetation is established and for this reason caution should be exercised when using one single form factor for locations with contrasting edaphoclimatic conditions (SCOLFORO; THIERSCH, 2004).

Figueiredo *et al.* (2009) warn that when using the form factor for volume calculation, the option for calculation by species should be made, because of the great oscillation of the form factor among species. According to the observed, more expressively in the mix of species, the average form factor presented a tendency to underestimate the wood commercial volume, mainly for trees of greater diameter. Whereas, the presented tendency was less pronounced when analyzed by species.

Nevertheless, the volumetric models presented a more appropriate residual distribution to the estimate techniques, for denoting residuals more evenly around zero average. Higuchi *et al.* (2008) affirm that the mathematical models used to adjust the volumetric equations shall have a fine residual distribution, where the differences between the estimated and observed values, positive or negative must be distributed evenly along the estimated curve. Despite also presenting increase in the estimate standard error in trees greater in diameter, for the mix of species, the residual distributions by species were satisfactory, denoting superiority in relation to the usage of the form factor.

Among the volumetric models adjusted to the eleven species in study, the Schumacher-Hall model had the greatest performance, presenting the greatest adjustment statistics, caused by significant parameters (associated to predictor variables) in all adjustments carried out. The precision in the volume of native species in the Amazon biome using the Schumacher-Hall, Spurr and Spurr (log) models were also verified by Cysneiros *et al.* (2017), whose adjustments refer to 12 species present in a forest concession area , in National Forest of Jamari, in the state of Rondonia, Brazil. Furthermore, the less tendentious distributions were verified for this model.

The Schumacher-Hall model (linearized) has stood out in the volume estimate of different planted species (ANDRADE, 2017; SALES *et al.*, 2015), native from the Athlantic Forest biome (CORREIA *et al.*, 2017; VIBRANS *et al.*, 2012;) and in the Amazon (SILVA *et al*. 2018; SILVA; SANTANA, 2014; TONINI; BORGES, 2015;THAINES *et al.*, 2010; COLPINI *et al.*, 2009). Its superior acceptance and performance occurs, also, for presenting less tendentious volume estimates, in most cases (CAMPOS; LEITE, 2017).

Another important point to be considered is that the model provides a volume estimate using the height and diameter at 1.30 m above soil in original forms, generating a parameter for each variable and keeping the same formula structure of the cylinder volume. However, there is also the form correction, distributed in the potencies of each one of the model variables and in the Constant which generates the cylinder basis.

CONCLUSION

According to the obtained results, it is concluded that:

- The trees wood volume estimate, in the Amazon biome, must be conducted using equation or form factor by species, for the estimate for the mix of species generates elevated errors, preventing its usage.
- Volume equations by species must be preferentially used, for they reduce discrepant estimates, with fewer tendencies in residual distribution.
- The Schumacher-Hall was more adequate to the adjustments in the volume equations for commercial Forest species in the Amazon biome.

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