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Quantifying diameter distributions in seasonally dry tropical forest in Bahia, Brazil

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ABSTRACT: This study aims to investigate the diametric structure of a seasonally dry tropical forest in Bahia and to select the best functions for the stand and species of greater importance. Two subsets were selected for fitting and validation from pre- and post-selective harvest inventories. Normal, Log-normal functions were tested; Gamma, Weibull 2P, and Weibull 3P. The best fits were selected using the Kolmogorov-Smirnov test for Akaike information criterion. Negative exponential curves and positive skewness best described the diameter distribution. This behavior was observed for the species with the highest IV and the stand. The Log-normal function best describes the diametric structure of *Commiphora leptophioeeos*, *Manihot catingae*, and *Pataggonula bahiensis*. It is recommended to individually describe the diameter structures of *Aspidosperma pyrifolium*, *Pseudobombax simplicifolium*, and population by the Weibull 3P function. The Normal, Gamma, and Weibull 2P functions did not present feasible predictions for frequencies of the diameter classes in all analyzed cases.

Key words: continuous distributions; diametric structure; forest inventory; forest management

Quantificando distribuições de diâmetro em floresta tropical sazonalmente seca na Bahia, Brasil

RESUMO: Este estudo tem como objetivo investigar a estrutura diamétrica de uma floresta tropical sazonalmente seca na Bahia e selecionar as melhores funções para o povoamento e espécies de maior valor de importância. Dois subconjuntos foram selecionados para ajuste e validação a partir de inventários pré e pós-corte seletivo. Foram testadas as funções Normal, Log-normal; Gama; Weibull 2P e Weibull 3P. Os melhores ajustes foram selecionados pelo teste de Kolmogorov-Smirnov critério de informações de Akaike. A distribuição do diâmetro foi mais bem descrita por curvas exponenciais negativas e assimetria positiva. Esse comportamento foi observado tanto para as espécies de maior VI quanto para o povoamento. A função Log-normal descreve melhor a estrutura diamétrica das espécies *Commiphora leptophioeeos*, *Manihot catingae* e *Pataggonula bahiensis*. Recomenda-se descrever individualmente as estruturas diamétricas das espécies *Aspidosperma pyrifolium*, *Pseudobombax simplicifolium* e povoamento pela função Weibull 3P. As funções Normal, Gamma e Weibull 2P não apresentaram predições factíveis para frequências das classes diamétricas em todos os casos analisados.

Palavras-chave: distribuições contínuas; estrutura diamétrica; inventário florestal; manejo florestal

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Introduction

The Caatinga vegetation domain harbors a large proportion of the biodiversity among Brazilian ecosystems (DRYFLOR et al., 2016; Moonlight et al., 2021), contributes extensively to biogeochemical cycles, and provides numerous ecosystem services, including carbon sequestration and wood stocks (Althoff et al., 2018; García-Cervigón et al., 2020; Siyum, 2020). Despite their importance, they are among the most threatened forest ecosystems and, as a result, may be at greater risk than humid forests (Apgaua et al., 2015; Sunderland et al., 2015; Antongiovanni et al., 2018). Our current understanding of the importance of this ecosystem has been mainly established using approaches on the sustainability of wood production for firewood and charcoal production (Blackie et al., 2014; Meunier et al., 2015) and vegetation cover in different ways of land use (Schulz et al., 2018).

This information is widely used to guide projects and public policies aimed at protecting and correctly using vegetation (Gariglio et al., 2010). Although this information has improved our understanding of the sustainable use of the Caatinga in Bahia, it currently needs to address population numbers of species, tree densities, and especially trunk diameter distribution, essential for sustainable forest management. Estimates of density and diameter distribution at the stand and species level are valuable for understanding diversity and large-scale ecological processes (Lima et al., 2017), mainly because the diameter distribution of trees is a prominent component of vegetation structure, and explain patterns of growth dynamics and ecological succession processes (Bailey & Dell, 1973; Lima et al., 2021).

Diametric distribution in a given area of Caatinga vegetation is a significant metric to guide forest management practices and inform decision-making in public and non-governmental sectors. For example, many efforts in the Northeast region of Brazil, such as the Caatinga Forest Management Network, and DryFlor, among other projects by various research institutions, including the numerous initiatives of floristic inventories and vegetation monitoring, have motivated civil society and leaders politicians to promote the environmental management and sustainable use of Caatinga vegetation through the standardization of tree measurements and knowledge of the vegetation structure (DRYFLOR et al., 2016). Setting targets and generating new results from such projects requires a solid initial understanding of current and potential species-level numbers of diametric distribution at regional and local scales.

From a local perspective, there is a reason why an accurate analysis of the diameter distribution of the Caatinga vegetation in the state of Bahia is necessary, mainly to guide action plans aimed at environmental sustainability. Modeling the diameter distribution through probability density functions is an exciting alternative for this type of problem (Lima et al., 2015; Lima et al., 2017), mainly because it can predict tree densities in a diameter size range for any species and generate results to guide management plans for wood production (Lima et al., 2018; Palahí et al., 2007). Methods that provide reliable and low-cost information are essential in forest monitoring.

Weibull, Log-normal, and Gamma are classical models often applied to analyze diameter distribution in tropical forests (Bailey & Dell, 1973; Burkhart, 2021). Other investigations highlight the potential of alternative models for predictions that support forest conservation and management (Pond & Froese, 2015). This work aims to investigate the diametric structure of a Caatinga forest in Bahia and select suitable continuous distributions through the fitting and validation of probability density functions. It is intended to answer the following questions: what is the behavior of the diameter distributions of the stand and species? Which probability density functions best describe the distribution of stand and species diameters? Which functions do not provide adequate data for the Caatinga area under study?

Materials and Methods

Study area

The data of the present study come from a forest inventory carried out in the years 2015 and 2018 in the conservation unit - National Forest of Contendas do Sincorá, with a total area of 11,215.93 hectares, located in the municipality of Contendas do Sincorá, between the coordinates Latitude: 13° 45′ 44′′ South, Longitude: 41° 02′ 33′′ West, in the Southwest region of Bahia (Figure 1).

The predominant vegetation in FLONA, according to the phytogeographic classification considered by the Instituto Brasileiro de Geografia e Estatística (IBGE, 2012), is arboreal Caatinga; it is in a late successional stage. The region climate is hot semi-arid (BSwh type, according to the Köppen classification), with rainy periods from November to January. The fluctuation in precipitation varies from 500 to 1,000 mm per year, and the temperature is between 21 and 28 °C, with relative humidity ranging between 60 and 70% (Batista, 2017).

The Flona Contendas de Sincorá forms a valley composed of Serra das Grotas, Serra da Cabeça Inchada and Serra do Cipó. These depressions are slightly undulating, with an altitude variation from 300 to 400 m (Batista, 2017). The soils are classified as Argisols (podzolic red-yellow eutrophic), with a small part located to the Southwest composed of Latosols, specifically in the buffer zone. The hydrology in the Flona de Contes de Sincorá has two main streams, and the Garapa stream flows into the Contas River, where it meets the Goiabeira stream.

Forest inventory

The forest inventory was carried out following the protocol of measurements of permanent plots (Scientific Technical Committee of the Rede de Manejo Florestal da Caatinga), developed in two stages: pre-harvest inventory

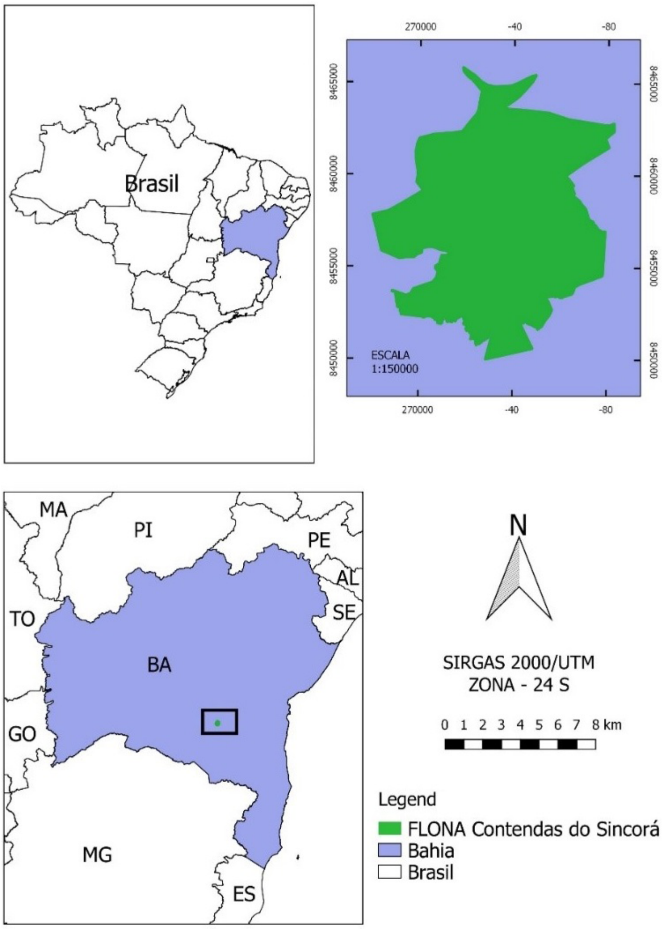

Figure 1. Location of the National Forest of Contendas do Sincorá where the forest inventory of arboreal Caatinga vegetation was carried out before and after selective cutting.

in 2015 and post-harvest inventory in 2018. In 2015 three blocks were launched (primary units), with 16 plots of 20 × 20 m (secondary units - 400 m^2) in each block, totaling 48 plots. The total area sampled is approximately 19,200 m^2 (Batista, 2017). The area destined for the inventory has approximately 50 ha. In each plot, all shrub-tree individuals with a circumference measured at the base of the trunk (Cb -0.30 m at ground level) ≥ 6 cm were measured and identified. Individuals that presented bifurcations had their base diameters calculated by the equivalent diameter (Burkhart, 2021). The five species with the highest importance value in the area were selected through the characterization of the phytosociological parameters obtained by Batista (2017) in the same study area, as shown in Table 1.

Table 1. Species with the highest importance value in the Contendas de Sincorá National Forest in 2015.

Species	Family	IV (%)
Commiphora leptophioeeos (Mart.) J.B.Gillett	Burseraceae	53.64
Manihot catingae Ule	Euphorbiaceae	30.08
Aspidosperma pyrifolium Mart.	Apocynaceae	28.54
Pseudobombax simplicifolium A. Robyns	Malvaceae	24.51
Pataggonula bahiensis Moric	Boraginaceae	21.61

Source: adapted from Batista (2017).

Diameter distributions modeling

Histograms of the frequencies of the number of individuals per hectare by diameter class were generated to verify the distribution pattern of tree species and stands. The observed curves were submitted for fitting and validation through probability density functions. Two- and three-parameter Weibull functions, Normal, Log-normal, and Gamma, were used to describe the diameter data. All functions had their parameters obtained by the Maximum Likelihood method (Table 2).

For data compilation and parameter estimation, R software (R Core Team, 2022) was used through the Fitdistriplus (Delignette-Muller et al., 2022) and Mass (Ripley et al., 2022) packages. Then, curves of estimated frequencies were drawn on the histogram of observed frequencies, by diameter class, for all fitted functions. The accuracy of the estimated frequencies was analyzed using the Akaike Information Criterion - AIC (Equation 1) and the Kolmogorov-Smirnov Test - KS (Equation 2) at a 5% probability level.

$$\mathrm{AIC} = -2\ln\left(\mathrm{L}\right) \pm 2\mathrm{K} \tag{1}$$

where: L is the probability and k is the number of parameters. The goodness of fit of each function is expressed by the

Table 2. Probability density function (PDF) and parameter estimation methods to describe diameter distributions at the stand and species level.

PDF	Functional Relationship	Parameter estimation methods
Normal	$f(X) = \frac{1}{\sigma\sqrt{2\pi}}\exp\left(-\frac{1}{2}\right).\left[\left(\frac{x-\mu}{\sigma}\right)\right]^2$	Maximum Likelihood
Log–Normal	$f(X)\frac{1}{x.\sigma.\sqrt{2\pi}}.\exp\left[-\frac{1}{2}\left(\frac{Ln(x)-\mu}{\sigma}\right)^2\right]$	Maximum Likelihood
Gamma	$f(X) = \frac{1}{\Gamma(\alpha)\beta^{\alpha}}X^{\alpha-1}.e^{(-X/\beta)}$	Maximum Likelihood
Weibull 2P	$f(X) = \left(\frac{\gamma}{\beta}\right)\left(\frac{x}{\beta}\right)^{\gamma-1}\exp\left[-\left(\frac{x}{\beta}\right)^{\gamma}\right]$	Maximum Likelihood
Weibull 3P	$f(X) = \left(\frac{\gamma}{\beta}\right)\left(\frac{x-\alpha}{\beta}\right)^{\gamma-1}\exp\left[-\left(\frac{x-\alpha}{\beta}\right)^{\gamma}\right]$	Maximum Likelihood

Where: X - diameter variable (cm); μ - arithmetic mean of the diameter (cm); σ - standard deviation of the random variable X; π - constant "pi" (3.1416); exp - base of the Naperian logarithm of the diameter; Ln(x) - Naperian logarithm of the diameter; α - shape parameter to be estimated (α = minimum diameter); β - scale parameter to be estimated (β > 0); Γ(α) - gamma function of α; γ - shape parameter (γ > 0).

smallest value of AIC or log-likelihood. The AIC allows comparing models by penalizing functions with more parameters (Lima et al., 2015).

$$D_n = \frac{SUP_x \left| FO_x - FE_x \right|}{n} \quad (2)$$

where: FO_x - observed cumulative frequency; FE_x - expected cumulative frequency; n - number of observations; Dn - calculated D-value of the test. The Dn value was compared with the value from the Kolmogorov-Smirnov table at a probability level of 95% (Machado et al., 2009). This test was used to verify the following hypotheses: H_0 = observed and estimated frequency curves are similar, and H_1 = observed and estimated curves are different.

Skewness and kurtosis

The skewness and kurtosis coefficients were calculated according to the methodology recommended by Machado et al. (2009), which establishes the following criteria: positive asymmetric distribution if the descriptive values of the diameter referring to the mode are smaller than the median and smaller than the arithmetic mean; and negatively skewed distribution if mode > median > arithmetic mean. If the skewness coefficient in the module is between 0.15 and 1, the distribution is considered moderate (tending towards a symmetrical distribution). If it is greater than 1, the slope is strong (asymmetric).

The kurtosis, in turn, is the degree of flattening or relative elevation of a distribution evaluated concerning a normal distribution. Curves can be called leptokurtic if it has a relatively high peak, harmful excess, and kurtosis coefficient < 0.263, platykurtic if the curve has a flatter top with positive excess and a kurtosis coefficient > 0.226, and mesokurtic if it has a kurtosis coefficient = 0.263.

Functions validation

The validation analysis consisted of predicting the frequencies by diameter class based on the function parameters obtained in the fit. The functions that presented the best fit according to the K-S and AIC test values, with the 2015 data, were submitted to a validation process with the 2018 database. As new K-S values were obtained and compared with the p-value defined at 95% probability, new diameter distribution curves were generated for the data. The best functions were chosen to predict the diameter structure of the studied Caatinga vegetation.

Results

Diameter structure

The descriptive statistics of diameter are presented in Table 3. The general average of the diameter values found for 2015 to 2018 was 8.2 ± 4.71 and 8.23 ± 4.67 cm, respectively. Although there was no significant difference in these values (p > 0.001), there was a high percentage variation (CV%) in the measured diameters of 57.50 and 56.73% for the two years analyzed. The management systems applied in the area show an average reduction of approximately 67.48% of individuals considering all trees in the stand in the years 2015 to 2018.

Among the species with the highest importance value, *Pseudobombax simplicifolium* and *Patagonula bahiensis* presented more minor and more significant reductions of individuals, respectively. Despite this discrepancy, the diameter structure of these species suggests similarity in asymmetry and kurtosis with the stand data and between the years analyzed. *Commiphora leptophioeos* and *Manihot catingae* presented the highest density of tree individuals (> 90 %), significantly concentrated in the smaller diameter classes, but they presented similar structures even after selective cutting. This result guarantees the similarity between the median and mode. In general, the species with the highest IV selected suggest unimodal distributions with positive skewness, meaning that the measures of central tendency (mode, median, and mean) and skewness coefficients, with a higher density of individuals located on

Table 3. Descriptive statistics from the datasets of the diameter for the total stand (all species) and for the species with the highest IV found in the National Forest of Contendas de Sincorá in the Southwest region of Bahia (2015 and 2018).

Descriptive measure	All species		Species									
			C. leptophloeos		*M. catingae*		*A. pyrifolium*		*P. simplicifolium*		*P. bahiensis*	
	2015	2018	2015	2018	2015	2018	2015	2018	2015	2018	2015	2018
Absolute frequency	3518	1144	250	92	247	108	212	75	113	51	292	44
Mean	8.2	8.23	10.3	8.76	8.98	8.56	8.53	8.68	8.82	8.56	8.57	8.5
Standard error	0.07	0.07	0.29	0.15	0.2	0.14	0.23	0.15	0.15	0.13	0.15	0.14
Median	6.8	6.8	8.5	7.1	7.1	7	7.65	7.1	7.2	7	7	7
Mode	5	5	5	5	5	5	5	5	5	5.5	5	5
Standard deviation	4.71	4.67	6.28	5.31	5.45	5.16	3.38	5.1	5.11	5.14	4.84	5.11
CV%	57.5	56.73	60.94	60.66	60.75	60.34	39.67	58.7	57.91	60.05	56.52	60.14
Amplitude	61.11	61.11	48.29	60.5	48.29	60.9	19.49	50.4	48.29	60.9	48.29	60.9
Variance	22.22	21.82	39.41	28.21	29.74	26.68	11.45	25.96	26.1	26.44	23.45	26.16
Skewness	3.51	3.38	2.74	3.61	3.31	3.72	1.45	3.27	3.39	3.65	3.62	3.74
Kurtosis	20.69	18.7	10.35	20.16	15.21	21.46	2.53	15.59	16.16	20.84	19.06	21.82

CV% - coeficient of variation.

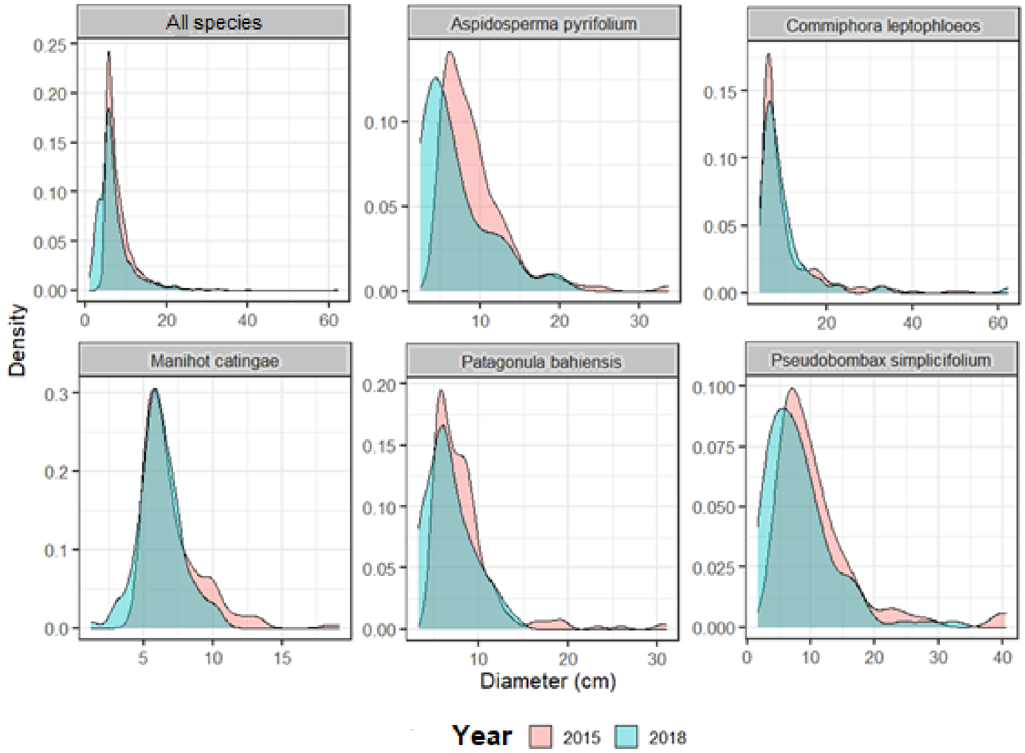

Figure 2. Diameter distributions for stands and species of greatest importance, separated for fitting (selective pre-harvesting inventory in 2015) and validation (selective post-harvesting inventory in 2018).

the left side of the distribution (Figure 2). This pattern means that the tails of the distribution extend to the right side, where the mean value of the diameters is greater than the mode and median.

Fitting and validation of models for stands and species before selective cutting

The parameter estimates of the functions are presented in Table 4. In Table 5, the statistical results of the fittings of each function obtained are presented. The prediction of the models in the diameter classes is shown for each species and stands in Figure 3. In general, all observed diameter distributions present the inverted-J shape. It is observed that the Normal, Gamma, and Weibull 2P functions did not adequately fit the observed frequency curves (p-value < 0.05) and produced non-feasible inferences with the observed data (Table 4). These functions diverged and underestimated frequencies in the initial diameter classes and converged with slight underestimates for classes > 20 cm in all cases (Table 5, Figure 3). For all species and stands, based on the K-S test and AIC values, the Weibull 3P and Log-normal functions fit better for all observed distributions and configure reliable frequency estimates (p-value < 0.05).

The values of the statistical scores classify the Weibull-3P and Log-normal functions as valid for predicting the diametric structure through statistical validation (Figure 4). Functions tend to describe functions satisfactorily and may suggest greater flexibility with increasing sampling. There is

Table 4. Results of the parameters of the probability density functions used to describe the diameter distributions for the stand and species.

Function	Coefficients	All species	Species				
			A. pyrifolium	*C. leptophloeos*	*M. catingae*	*P. bahiensis*	*P. simplicifolium*
Normal	$\hat{\mu}$	8.3281	9.1911	10.1412	7.0327	8.2171	11.0053
	$\hat{\sigma}$	4.3586	4.3226	7.2397	2.1499	3.8048	7.0364
Log-normal	$\hat{\mu}$	2.0327	2.1340	2.1618	1.9133	2.0355	22.5899
	$\hat{\sigma}$	0.3827	0.3915	0.5010	0.2606	0.3470	0.4918
Gamma	$\hat{\beta}$	5.9123	6.0977	3.3874	13.5624	7.2349	3.7448
	$\hat{\gamma}$	0.7100	0.6634	0.3340	1.9285	0.8804	0.3403
Weibull 2P	$\hat{\beta}$	2.0196	2.2153	1.6145	3.1247	2.2096	1.7426
	$\hat{\gamma}$	9.4253	10.3977	11.4624	7.8049	9.2756	12.4746
Weibull 3P	$\hat{\alpha}$	3.1983	3.6978	2.0725	4.3927	4.3983	4.3298
	$\hat{\beta}$	5.6962	6.0763	5.9228	2.8984	3.7955	6.3293
	$\hat{\gamma}$	1.3993	1.4070	2.1709	1.3505	1.4959	1.2802

Table 5. Performance of the probability density functions used to describe the distributions of stand diameter and species with the highest importance value.

PDF	Statistics	All species	Species				
			A. pyrifolium	*C. leptophloeos*	*M. catingae*	*P. bahiensis*	*P. simplicifolium*
Normal	Dtab (5%)	0.0332	0.0962	0.0998	0.1005	0.1079	0.1962
	Dcalc	0.2059	0.1592	0.2399	0.1710	0.1989	0.1967
	AIC	13904.37	1658.72	1818.81	1152.96	1260.38	4690.66
Log-normal	Dtab (5%)	0.0332	0.0962	0.0998	0.1005	0.1079	0.1962
	Dcalc	0.0297	0.0832	0.1546	0.1259	0.1097	0.0933
	AIC	11980.96	1505.09	1547.07	1049.33	1096.56	4136.27
Gamma	Dtab (5%)	0.0332	0.0962	0.0998	0.1005	0.1079	0.1962
	Dcalc	0.1419	0.1036	0.1785	0.1400	0.1345	0.1215
	AIC	12462.49	1540.24	1616.53	1077.44	1138.49	4265.46
Weibull 2P	Dtab (5%)	0.0332	0.0962	0.0998	0.1005	0.1079	0.1962
	Dcalc	0.2260	0.1723	0.2305	0.2088	0.2253	0.1840
	AIC	13251.96	1610.30	1675.75	1169.68	1220.07	4407.40
Weibull 3P	Dtab (5%)	0.0332	0.0962	0.0998	0.1005	0.1079	0.1962
	Dcalc	0.0281	0.0206	0.1578	0.0041	0.0350	0.0422
	AIC	11045.95	1501.54	1404.22	1001.63	1011.58	4106.98

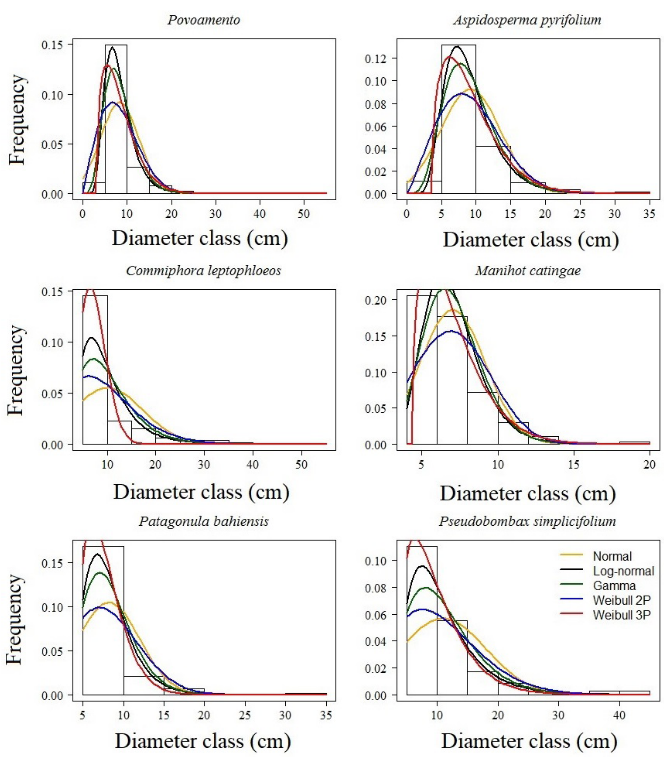

Figure 3. Functions fittted by diameter class for the stand and for the five species with the highest importance value.

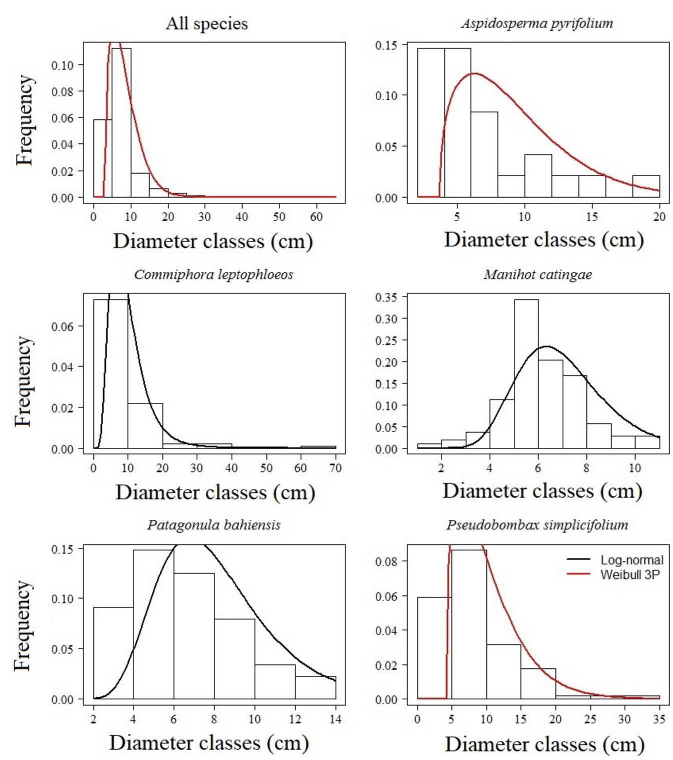

Figure 4. Validation of the best functions for the stand and for the five species with the highest importance value using the 2018 post-selective harvest data.

a slight tendency for the log-normal function about the left tail of the observed distribution, which does not establish statistical differences. This behavior was expected due to the low asymmetry value found for this species.

Discussion

Diameter distribution

Generally, a higher concentration of individuals was observed in the first diameter classes, configuring a specific behavior of uneven natural forests that defines the distribution as “inverted J-type”. These types of distribution are classified as unimodal with positive skewness (Lima et al., 2017; Lima et al., 2018). This is to be expected and can be attributed mainly to the high density and dispersion of the species with the highest importance value, which are often dominant at different successional stages (Lima et al., 2021). Furthermore, these data suggest that these main species can better exploit available environmental resources and have a solid resistance to drought (García-Cervigón et al., 2020). This decreased distribution in dry forests indicates that regeneration occurs continuously due to the species’ ability to adapt to arid environments (Lima et al., 2021).

Other uneven forest datasets may show the mode close to the mean but not within the first size class. However, this pattern should be maintained if the diameter distribution has a single peak with density concentration distortion on the left despite silvicultural interventions (Lima et al., 2017; Burkhart, 2021).

Diametric distribution is a crucial method for understanding the uniformity and growth of a stand or species. In addition to providing crucial information for forest inventories at different levels of structure and dynamics, it also reports detailed descriptions of the area concerning the variability of the tree and species density within diameter size classes. The individual distribution of a single species by histograms is an attempt to assess their developmental stages, as the tool provides the proportions of individuals per class.

Liocourt (1898) reported that the ratio between the number of trees of successive diameters follows a decreasing geometric series, often in the form of an "inverted J" in natural forests. Each species has specific developmental and adaptive abilities; therefore, the width of the stand diameter does not necessarily represent the range of the species. This study considered small amplitudes between the classes (maximum of 3 cm). Distribution behavior provides information about the area's successional stages; thus, it is possible to describe the structure of the entire forest or a species due to the large number of individuals sampled within the initial diameter classes.

The greater concentration of individuals in smaller diameter classes, both for the stand and for the species, points to a short life cycle with limited size due to genetic characteristics or short regeneration time, meaning that the forest is at the beginning of the process of regeneration (Lima et al., 2021). Another factor may be the limited growth potential of the area, making it difficult for individuals to develop to higher-diameter classes. By using the diameter distribution tool, decision-making will be reliable regarding intervention in the structure of the most representative species of dry forests.

Fitted and validation of the functions

Although there are variations in the number of classes for the population and species in the fitting and validation, the Log-normal and Weibull 3P functions described the observed data well and allowed possible generalizations. The poorest fittings are seen for the Normal, Weibull 2P, and Gamma functions, both for the stand and for the species with the highest IV. These functions substantially underestimate the frequency for the initial diameter classes and tend to overestimate the frequency from the intermediate classes. These results can be attributed to the low flexibility of these functions to generate descending curves with a high concentration of observations in the minor size classes (Lima et al., 2017).

For *Manihot catingae*, *Commiphora leptophioeos*, and *Patagonula bahiensi*, the best fit was reported by the Log-normal function, probably due to the transformation of the diameter variable. This procedure stabilizes the variance; therefore, it is an alternative method to correct heterogeneity and reduce the amplitude by reducing deviations from the mean. Curves observed for the Stand, *Aspidosperma pyrifolium*, and *Pseudobombax simplicifolium* were described more accurately by the Weibull 3P function due to its greater flexibility with the addition of the location parameter (α) that controls an inflection point from the minimum diameter (Lima et al., 2015). The generalization of these functions selected in the fitting and validation proves the need to develop individual models that better describe the data and allow us to understand the dynamics, competition indices, asymmetry, and kurtosis of the distribution for seasonally dry forests.

Overall, the randomly selected database for fitting (pre-selective pruning) and validation (post-selective pruning) did not negatively affect the behavior of the distribution and the performance of the selected functions. This is attributed to the properties of the sample that directly interfere with the measures of dispersion, central tendency, asymmetry, and kurtosis (Lima et al., 2015). In addition to empirical plots, descriptive statistics can help select models to describe a distribution among parametric distributions. Asymmetry and kurtosis are especially useful for this purpose. A non-zero skewness reveals a lack of symmetry in the empirical distribution. At the same time, the kurtosis value quantifies the weight of the tails compared to the normal distribution for which kurtosis is equal to three (Lima et al., 2018). For decreasing distributions, increases in value concentration around lower classes result in higher kurtosis. Although kurtosis is often explained as the "degree of flattening" of the frequency distribution, this parameter indicates the degree of value concentration of the distribution around the center of the same distribution (Lima et al., 2018). This peculiarity was graphically associated with curves with more extended tails in the intermediate diameter classes, with a higher frequency peak in the initial classes; therefore, the distribution mode was characterized more clearly. In tropical dry forests, these characteristics of diameter distribution described by asymmetry and kurtosis can be influenced by the dynamics of the forest. Precipitation indices cause structural and ecological changes in tree growth and affect distribution, generally decreasing skewness and kurtosis values (Lima et al., 2021). As the increase of the diameter, the calculated probability drops exponentially to the right, and the selected functions generalize these estimates and capture the shift in the distribution.

Although the present analysis shows the effects of data selection for fitting and validation at the stand and species level, there are inherent limitations to the methods used in our analysis. It is essential to highlight that the difficulty is related to the traditional statistical methods that need to be more adequate (Lima et al., 2015). In general, it is inferred that the observed abundances adjust to the values predicted by the different models if the adherence tests do not show significant deviations. This is a misguided approach to the logic of significance testing, as it assumes that the distribution model is tested as the null hypothesis. As a consequence, acceptance will depend more on the test's strength than on the fit's quality.

Furthermore, these tests are not suitable for comparing different models as they assess the fit to one distribution at a time. Multiple tests cause other problems and are often inconclusive because different fitting models may look the same. The likelihood method is a potential solution to create protocols for simultaneously comparing many competing hypotheses. In this case, a simple alternative is to select the models according to the information indices (AIC) (Lima et al., 2015). The functions properly generalize the database of dry natural forests, whose distribution is decreasing. Therefore, they are often applied to forest measurements.

Conclusions

The seasonally dry tropical forest in Bahia presented diametric distributions with decreasing exponential curves and positive asymmetry. This behavior was observed for the species with the highest IV and the stand. Generalizing functions to the most important species ensures the need to develop individual models.

The Log-normal function showed flexibility in describing the diametric structure of *Commiphora leptophioeeos*, *Manihot catingae*, and *Pataggonula bahiensis*. It is recommended to individually describe the diameter structures of *Aspidosperma pyrifolium*, *Pseudobombax simplicifolium*, and population by the Weibull 3P function.

The Normal, Gamma, and Weibull 2P functions did not present feasible predictions for frequencies of the diameter classes in all analyzed cases.

Compliance with Ethical Standards

Author contributions: Conceptualization: RBL, JCSN; Data curation: RBL, JCSN, CPO, ACB, AP, PABB-G; Formal analysis: RBL, JCSN; Methodology: RBL, JCSN; Investigation: RBL, JCSN; Supervision: RBL, JCSN; Writing - original draft: RBL, JCSN; Writing - review & editing: RBL, JCSN, CPO, ACB, AP, PABB-G.

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