ASSESSING THE FEASIBILITY OF THE BDq METHOD FOR THE SUSTAINABLE MANAGEMENT OF THE CAATINGA[1]

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ABSTRACT - The BDq method is based on the concept of a balanced forest, in which the current growth can be periodically removed while maintaining the initial diameter distribution of the forest. This study aimed to analyze the technical feasibility in the application of three cutting intensities and six scenarios in sustainably managed Caatinga vegetation. The study was carried out at the Fazendas Baixa da Oiticica, Rancho da Velha, and Tabuleiro de Dentro, located in the municipality of Upanema (state of Rio Grande do Norte), with an area of around 343 hectares. We established 11 plots of 20 × 20 m and measured all individuals with a circumference at breast height (CBH) ≥ 6 cm within these plots. The individuals were identified in the field, and the APG IV classification system was adopted to organize the list of scientific names and families. Three management alternatives were proposed, namely reducing 40% (Scenario 1), 50% (Scenario 2), and 60% (Scenario 3) of the basal area and the actual volume for the application of the BDq method. In total, 1,680 individuals distributed in 10 families, 18 species, 16 genera, and 7 diameter classes were inventoried. Considering rational, sustainable harvesting, and following the theoretical rules of dynamic processes, cuts may not be carried out in larger diameter class centers (22.45, 27.45, and 32.45 cm). Scenario 3 showed the most effective results, as it allows the harvesting of the highest number of individuals and provides a greater economic return.

Keywords: De Liocourt quotient. Diametric distribution. Dry forest.

USO DO MÉTODO BDq EM UMA ÁREA DE CAATINGA SUBMETIDA AO MANEJO FLORESTAL

RESUMO - O método BDq está baseado no conceito de floresta balanceada em que o crescimento corrente pode ser removido periodicamente enquanto se mantêm a distribuição de diâmetros inicial da floresta. O trabalho teve por objetivo analisar a viabilidade técnica na aplicação de três intensidades de corte e seis cenários em vegetação da Caatinga submetida ao manejo florestal sustentável. O trabalho foi desenvolvido na Fazendas Baixa da Oiticica, Rancho da Velha e Tabuleiro de Dentro, situados no município de Upanema-RN, com área de 343,0472 hectares submetidas ao manejo. No processo amostral foram alocadas 11 parcelas de 20 m x 20 m. Foram mensurados todos os indivíduos com circunferência a altura do peito (CAP) ≥ 6 cm. Os indivíduos foram identificados in loco, sendo adotado o sistema de classificação APG IV para organização da lista dos nomes científicos e famílias. Para a aplicação do método BDq, foram propostas três alternativas de manejo, com 40% (Cenário 1), 50% (Cenário 2) e 60% (Cenário 3) de redução da área basal e volume real. Inventariou-se 1.680 indivíduos distribuídos em 10 famílias, 18 espécies, 16 gêneros e sete classes de diâmetro. Levando em consideração a exploração racional, sustentável e, seguindo os preceitos teóricos dos processos dinâmicos, não pode realiza-se cortes nos centros de classes de maiores diâmetro (22,45; 27,45 e 32,45 cm) e, a combinação que apresentou os resultados mais efetivos foi o cenário 3, pois possibilita a exploração de um número maior de indivíduos conferindo maiores rendimentos econômicos.

Palavras-chave: Quociente De Liocourt. Distribuição diamétrica. Floresta seca.

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INTRODUCTION

The Caatinga biome is the ecosystem with the largest vegetation coverage in northeastern Brazil. Its geoecological area comprehends approximately 844,453 km^2, under subequatorial latitudes between 2º45' and 17º21' S. Its area accounts for approximately 70% of the northeastern region and for 11% of the Brazilian territory and is included in the drought polygon (ALVES, 2007). Although it has suffered from substantial deforestation, it contributes to the economy of the northeastern region through the provision of environmental services, albeit only under sustainable use (SOTERO et al., 2013).

Sustainable use of the Caatinga is a propagator of the local economy, reducing the rate of deforestation and, consequently, preserving the biome and its essential environmental functions (ARAÚJO, 2015). The sustainable use of forest resources is achieved through reasonable forest management, aimed at minimizing the ecological impacts of harvesting and increasing the regenerative capacity of the forest (VERÍSSIMO; PEREIRA, 2015).

The BDq (basal-area-diameter-q-ratio) is one of the management tools used in forest regulation methods. It promotes actions for natural regeneration and establishes criteria for the removal of forest trees and harvest. This approach allows the least impact on the remaining population to obtain a more sustainable production (SOUZA; SOUZA, 2005; SOUZA; SOARES, 2013).

The BDq method is based on the concept of the balanced forest, and its application in selective logging leads to a remaining stock that promotes the maintenance of the forest diametric structure (SOUZA; SOARES, 2013). The BDq considers the different size classes (e.g., diameter distribution), which makes it an essential tool in decision making and management planning for a given area. The diametric distribution allows to characterize a forest typology and to examine the history of the species in the area, the number of trees to be harvested, natural regeneration, and the sustainability of the species after harvest (LIMA et al., 2014; RODE et al., 2015, SILVA et al., 2018).

However, few studies have applied the BDq for the Caatinga, and in this context, we analyzed the technical feasibility of the method, considering three logging intensities and six scenarios in the Caatinga biome against he background of sustainable forest management.

MATERIAL AND METHODS

Study area

The study was carried out in the rural properties Fazendas Baixa da Oiticica, Rancho da Velha, and Tabuleiro de Dentro, located in the municipality of Upanema, state of Rio Grande do Norte. The area under forest management covers 343.0472 hectares, situated between the geographical coordinates 5º29'58.2" S and 37º20'28.8" W.

The climate is characterized as BSh (warm and semi-arid) according to the Köppen classification, with 7 to 9 dry months and an irregular rainy season from February to July (ALVARES et al., 2013). Mean annual rainfall is 670 mm, with an annual water deficit of 1,000 mm and mean temperatures above 28°C throughout the year (IBGE, 2002).

The vegetation comprises Arboreal Steppic Savannah or hyperxerophilic Caatinga, with a sparse canopy with a height of 3 m, an arboreal stratum formed by low trees with clumps or thorns, and a periodic grassy-woody stratum with several cacti (IBGE, 2004).

The areas submitted to the Forest Management Plan have a long history of disturbance (for at least 30 years) since they are close to an industrial region where limestone and firewood as raw material are combined for the production of quicklime.

Data collection

Eleven sample units of 20 × 20 m were randomly allocated in the forest inventory carried out for data collection (BRASIL, 2005). All woody individuals with a circumference at breast height (CBH) $\geq$ 6.0 cm were measured within the sample units. The sampling curve was used to verify the sampling sufficiency of the forest inventory, which indicates the optimal size of the sample area by the accumulated frequency of species per plot.

Each stem was considered an individual to predict volume, with the following criteria: a) the trees or shrubs with a bifurcation between ground level and a height of 30 cm were considered distinct individuals (BRASIL, 2005); b) the trees or shrubs with a bifurcation above 30 cm from the ground level were considered as a single individual, and the different CBH's of the measured stems were homogenized by the formula of the equivalent circumferences: $CBH_i = \sqrt{\sum CBH_n^2}$. The diametric distribution was calculated based on diameter at breast height (DBH, obtained from the CBH), considering an amplitude of 5 cm.

The circumferences were transformed into diameter, and the basal area was subsequently calculated using the following formula:

$$G = \frac{\pi}{40000} \sum_{i=1}^{n} DBH^2,$$

where G = basal area; π = "pi" (3.1416...); DBH =

diameter at breast height (in centimeters); 40,000 = quadratic conversion factor from centimeters to meters (from DBH).

The total volume was calculated considering the DBH (with bark) of the measured trees and shrubs, using the following equations:

$$VC_{c/c} = \frac{\pi.(DBH)^2.HT}{40000}$$

$$VR = VC_{c/c}.ff$$

$$Vt = \sum_{i=1}^{n} VR,$$

where VCc/c = cylindrical volume of the individual tree with bark (in cubic meters - m³); HT = total height of the tree (in meters); VR = actual volume (in cubic meters - m³); ff = form factor (0.9, dimensionless); Vt = total volume of the sample (in cubic meters - m³) (ZAKIA; PAREYN; RIEGELHAUPT, 1988).

The species were identified in loco by their dendrological aspects (shape of the canopy, foliage, bark, and stem), popular names, and, when possible, by collecting botanical material for herborization (flowers and fruits) and subsequent identification to confirm their scientific names obtained from the literature. The Angiosperm Phylogeny Group IV system (2016) was adopted to organize the list of scientific names and species families.

Estimates of individuals´ frequency by diameter class and the De Liocourt Quotient "q"

The BDq selection method, reported by Meyer (1952) and employed by Campos, Ribeiro and Couto (1983), was applied to obtain a balanced forest structure. The diameter distribution model (MEYER, 1952) was adjusted to estimate the number of trees by diameter class, as mentioned by Campos and Leite (2013):

$$Yj = e^{\beta_0 + \beta_1.Dj}.\varepsilon_j,$$

where Yj = number of trees per hectare; e = base of the Neperian logarithm; β_0 and β_1 = parameters to be estimated; Dj = DBH class center, in cm; εj = random error.

The different estimated values of β_0 and β_1 provide different diametric structures, obtained by

the method of the ordinary least squares.

While β_0 indicates the relative density of the population for a given diameter class, β_1 indicates the rate of decrease in the number of individuals per class (CAMPOS; LEITE, 2013). The De Liocourt quotient (q) was calculated using the fitted model, according to the following equation:

$$q = \frac{e^{(\beta_0 + \beta_1 D_i)}}{e^{(\beta_0 + \beta_1 D_{i+1})}},$$

where q = ratio between the frequency of any diameter class by the immediate frequency above; D = DBH class center (cm).

After obtaining the quotient "q", the parameters β_0 and β_1 were calculated with the following equations:

$$\beta_1 = \frac{\ln(q)}{D_j - D_{j+1}}$$

$$\beta_0 = \ln\left(\frac{40000.G}{\pi.\sum_{j=1}^{J} D^2 j.e^{\beta 1.Dj}}\right),$$

where e = exponential; β_0 and β_1 = parameters to be estimated; G = remaining basal area; Dj = DBH class center, in cm; G = remaining basal area; ln = Neperian logarithm; π = "pi" (3.1416...); Dj + 1 = center of the diameter class immediately above.

Three scenarios were simulated using the BDq method for the analysis: Scenario 1 (S1), reducing 40%, Scenario 2 (S2), reducing 50%, and Scenario 3 (S3), reducing 60% of the observed basal area and volume in the population. Data tabulation, processing, and analysis were performed using the Microsoft Office Excel software.

RESULTS AND DISCUSSION

The sampling sufficiency (Figure 1) shown in the collecting curve indicates that the curve stabilizes from the eighth plot (3,200 m²) onwards. This finding suggests that the minimum floristic representation area was reached, leading to stagnation in the number of species found. Thus, the sampling sufficiency proved to be satisfactory for the study area, since it reached the minimum number of plots to adequately characterize the floristic composition.
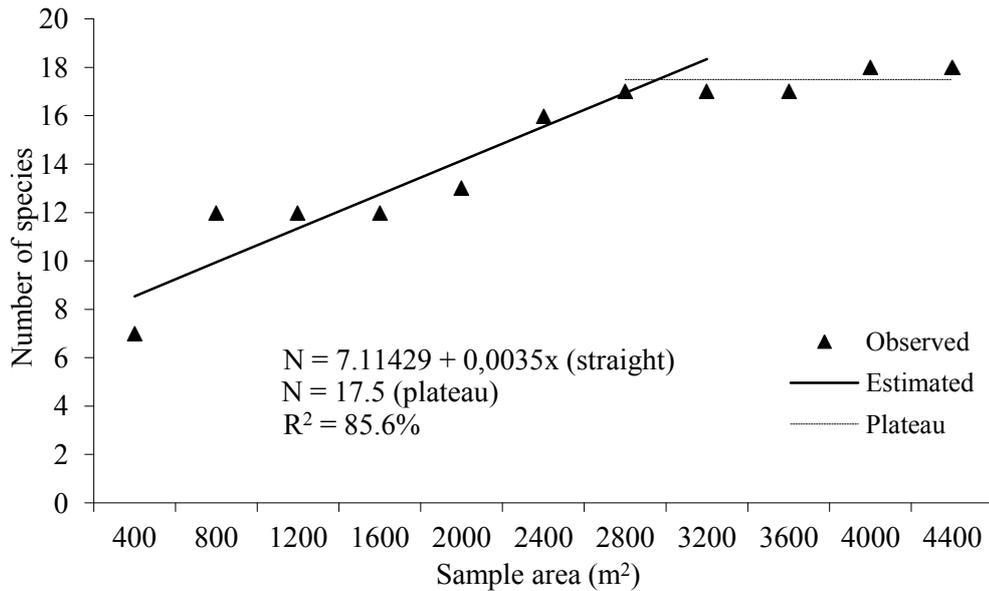
Figure 1. Graphical representation of the sampling sufficiency of the species inventoried in a fragment of the Caatinga, in the municipality of Upanema, state of Rio Grande do Norte.

This preliminary survey is essential to determine whether the established sample size is sufficient to represent the community. As mentioned by Schilling and Batista (2008), sample representativeness indicates whether the floristic composition and the density of individuals per species are satisfactory. In this study, 1,680 woody individuals were sampled, with representatives from 10 botanical families, 18 species, and 16 genera. The family Fabaceae had the highest number of species (9) of all families in the area. The families Anacardiaceae, Boraginaceae, Brassicaceae, Burseraceae, Combretaceae, Euphorbiaceae, Malvaceae, and Oleaceae were represented by only one species, corresponding to 46.74% of all sampled individuals. The species *Combretum leprosum* ("mofumbo") was the most prominent one, presenting the highest number of individuals (406). The species *Amburana cearenses* and *Bauhinia cheilantha* were recorded in all plots. Among all measured individuals, 138 were dead (Table 1).

The number of species inventoried is low when compared to other phytophysiognomies in Brazil, for instance, Ombrophilous Forests, Seasonal Forests, and Savannas. However, this is almost a standard for the semi-arid northeast (Estepic Savannah) due to the long history of disturbance or degradation, dating back to colonial times.

As highlighted by Medeiros et al. (2018), the composition and structure of the vegetation vary significantly on a regional scale (micro and macro scales) due to abiotic (e.g., soil, altitude, and rainfall) and anthropogenic factors. These authors found 304 individuals from 8 families and 13 species in a fragment of the Caatinga in the municipality of São Mamede, state of Paraíba. Marangon et al. (2013) inventoried 1,227 individuals from 18 families in a conserved area in the municipality of Floresta, state of Pernambuco. Similarly, Lemos and Meguro (2015) estimated 6,014 individuals (ha) from 20 families in the state of Aiuaba-Ceará, while Leite et al. (2015) reported 3,069 individuals from 24 families in the region of Teixeira, state of Paraíba.

Therefore, floristic and phytosociological surveys show a high variability in the composition and density of individuals from different environments in the Caatinga, as noted by Amorim, Sampaio and Araújo (2005). The authors found considerable physiognomic variation and changes on a local scale in the Caatinga, which are easily recognizable and generally linked to easily identifiable environmental changes.

Santos et al. (2017) observed that the families Fabaceae and Euphorbiaceae were the most abundant ones, both in the number of species and individuals, in a study carried out in different areas of the Caatinga in the state of Paraíba. These families cover most of the woody species of the Caatinga biome (CALIXTO JÚNIOR; DRUMOND, 2014), which has also been mentioned by Leite et al. (2015) and Holanda et al. (2015).

Table 1. List of inventoried woody individuals in the forest management area.

Family/Species	General name	Individuals	
		NºI	Plots
Anacardiaceae			
Myracrodruon urundeuva M. Allemão	Aroeira	7	5, 6, 8
Apocynaceae			
Aspidosperma pyrifolium (Mart.)	Pereiro	196	1, 2, 4, 8, 11
Boraginaceae			
Cordia oncocalyx Allemão	Pau branco	5	6, 8
Brassicaceae			
Capparis hastata (Jacq.)	Feijão bravo	5	10
Burseraceae			
Commiphora leptophloeos (Mart.) J.B.Gillett	Imburana de Cambão	43	1, 4, 6, 7, 8, 9, 10, 11
Combretaceae			
Combretum leprosum (Mart.)	Mofumbo	406	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Euphorbiaceae			
Croton blanchetianus (Baill.)	Marmeleiro	108	1, 3, 5, 11
Fabaceae			
Amburana cearensis (F. Allemão) A. C. Mith	Cumaru	9	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Anadenanthera colubrina (Vell.) Brenan var. *Cebil* (Griseb.) Altschul	Angico vermelho	14	9, 10
Bauhinia cheilantha (Bong.) Steud	Mororó	164	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Libidibia ferrea (Mart. ex Tul.) L.P.Queiroz var. *ferrea*	Jucá, Pau ferro	1	6
Mimosa caesalpiniifolia (Benth.)	Sabiá	102	2, 3, 8, 9, 10
Mimosa ophthalmocentra Mart. ex Benth.	Jurema de imbira	159	2, 4, 5, 6, 7, 8, 10, 11
Mimosa tenuiflora (Willd.) Poir.	Jurema preta	68	2, 3, 4, 5, 7, 11
Piptadenia stipulacea (Benth.) Ducke	Jurema branca	116	1, 2, 3, 4, 8, 9
Cenostigma pyramidale (Tul.) E. Gagnon & G.P.Lewis var pyramidale	Catingueira	124	1, 2, 3, 5, 6, 7, 8, 9, 10
Malvaceae			
Pseudobombax marginatum (A.St.-Hil.) A. Robyns	Embiratanha	3	7, 10
Oleaceae			
Ximenia americana L. var.	Ameixeira	12	2, 10, 11
Mortas		138	1, 2, 3, 4, 5,6, 7, 9, 10, 11
Total		1,680	

The diameter distribution followed the inverted "J" shape, common in uneven-aged forests, where the highest number of individuals is concentrated in the first two diametric classes, representing 89.16% of the inventoried individuals

for this study (Figure 2). This result shows that even after years of irrational harvesting for power supply in the calcination process, among other uses, the areas have a high resilience.
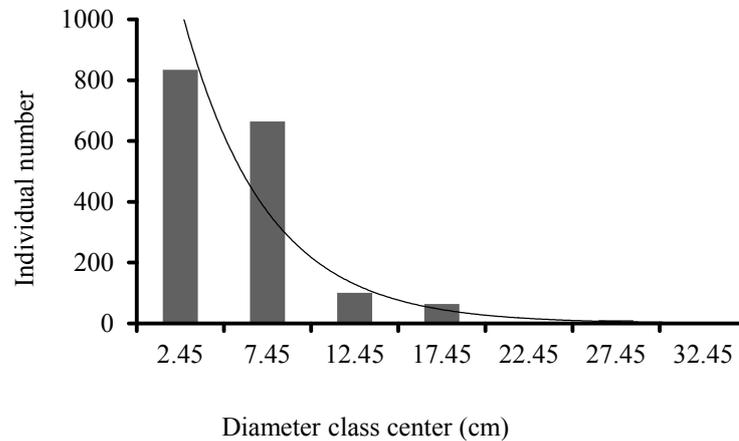
Figure 2. Distribution of the sampled individuals by diameter class in the forest management area.

As shown in Figure 2, there was a substantial number of individuals in the first two class centers, and from the second to the third class centers (7.45 and 12.45 cm), there was an abrupt decrease (84.9%). These results indicate that a reduced number of older individuals occurs in relation to the size of the size. However, these values appear higher when compared to other areas, such as in the study by Medeiros et al. (2018), who reported only 67% of individuals in the first three diametric classes.

According to Guedes et al. (2012), the higher concentration of individuals in the smallest diameters classes is characteristic of uneven-aged forests, indicating the potential for natural

regeneration in the community. Santana and Souto (2006) claimed that areas with a high number of individuals in the smallest diameter classes are frequent in the Caatinga, which may be a strategy for the forest to recover after anthropic interventions and long periods of drought.

Conversely, the distribution of the basal area by the center of diameter classes showed a non-monotonic manner, with the highest values found in the first three centers of diametric classes, representing 74.44% of the entire basal area. The basal area distribution followed the inverted "J" shape, as the number of individuals, indicating a regenerating community (Figure 3).
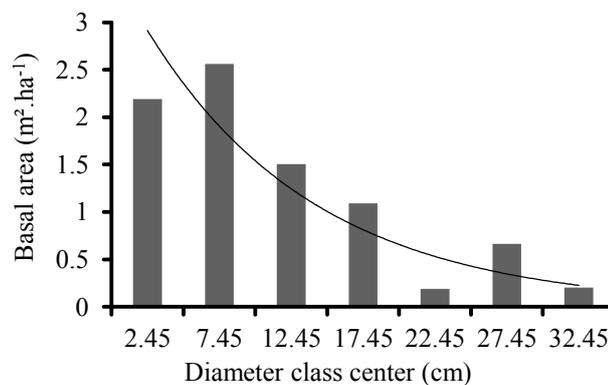
Figure 3. Distribution of the basal area by diameter class in the forest management area.

Comparing the diameter distributions (Figures 2 and 3), there is a small number of older individuals than the new ones (Figure 2). However, old individuals had higher sectional areas, resulting in substantial absolute dominance in the largest centers of diametric classes, which may correspond to matrix trees.

Although the total basal area was low (7.0499 m^2 ha^{-1}), this value does not deviate from the standard for dry forest areas in semi-arid environments. Areas with low human impact tend to have a higher basal area (G), as reported by Moreira (2014), who obtained a basal area of 9.977 m^2 ha^{-1} in

an area of the Caatinga located in the municipality of São José de Espinharas, state of Paraíba. In a similar study, Diniz (2011) estimated a basal area with twice (14.651 m^2 ha^{-1}) the value found in this study in a Caatinga area located in Diamante, state of Paraíba.

The estimated coefficients β0 and β1 for the Meyer model were β0 = 7.464229126, and β1 = -0.2092553462. After estimating the De Liocourt quotient "q" for basal area and obtaining the actual volume based on the center of the maximum diameter class (Dmax = 32.45 cm), β0 and β1 were recalculated (Table 2).

Table 2. Values of the β_0 and β_1 coefficients for basal area and remaining actual volume in the Caatinga area under forest management.

G m^2 ha^{-1}	Remaining basal area (m^2)	β_0	β_1
	4.44 (reduced by 40%)	6.564174924	-0.17
7.0499	3.52 (reduced by 50%)	5.863664107	-0.14
	2.82 (reduced by 60%)	5.072380072	-0.11
V m^3 ha^{-1}	Actual remaining volume (m^3)	β_0	β_1
	5.29 (reduced by 40%)	6.787655163	-0.17
8.8154	4.40 (reduced by 50%)	6.104046954	-0.14
	3.52 (reduced by 60%)	5.363928222	-0.11

The following De Liocourt quotient "q" values 2.3, 2.0, and 1.7 were randomly assigned to both the remaining basal area and the actual volume for all scenarios. Souza et al. (2013) tested combinations of BDq for five commercial tree species, in a phytophysiognomy different from that of this study, in the state of Amapá. The authors observed that, given the Dmax to be explored, the "q" value of 1.5 is recommended to remove individuals in the first four diametric classes, which makes the less harvested classes suitable for management. Therefore, the authors stated that it is more feasible to use a q > 2 to enhance regeneration and to explore a higher number of individuals in the suited classes for management. However, the ratio of 1.7 did not result in a deficit of trees in the diametric classes.

Using the "q" values, new distributions of the number of stems by diameter class were established for the remaining values and the harvest estimates. Table 3 shows the reduction of 40% (Scenario 1), 50% (Scenario 2), and 60% (Scenario 3) of individuals based on the observed basal area.

In Scenario 1, reducing 40% of the total basal area (2.81 m^2 of G), 82.68% of the individuals remained, which is equivalent to 1,379 stems. A harvest of 17.32% was estimated, which is

equivalent to 301 stems within the diametric classes, with the most representative ones being 2.45 (123 stems), 7.45 (72 stems), and 12.45 (42 stems). In this scenario, the withdrawal of individuals from the diameter classes centers 22.45 and 32.45 cm is not indicated, as there will be a stem deficit in the harvest environment.

In Scenario 2, reducing 50% of G (3.52 m^2 of G), 70.42% of the individuals remained, representing 1,182 stems. A harvest of 29.58% was estimated, which is equivalent to 498 stems within the diametric classes, with the most representative ones being 2.45 (251 stems), 7.45 (125 stems), and 12.45 (63 stems). In this scenario, the same pattern as for Scenario 1 was verified, where harvesting is not allowed for the diameter classes centers 22.45 and 32.45 cm due to the deficit of stems.

In Scenario 3, reducing 60% of G (4.22 m^2 of G), 50.54% of the individuals remained, representing 849 stems. A harvest of 49.46% was estimated, that is, 831 stems within the diametric classes, with the most representative ones being 2.45 (471 stems), 7.45 (205 stems), and 12.45 (89 stems). Similar to Scenarios 1 and 2, harvesting will not be allowed for the diameter class centers 22.45 and 32.45 cm, as there will be a deficit of individuals.

Table 3. Distribution of the number of individuals per hectare for the observed, estimated, and expected structure for the remaining trees, estimated by diameter class center. Basal area reduction of 40% (Scenario 1), De Liocourt quotient "q" = 2.3; 50% reduction (Scenario 2), "q" = 2.0; and 60% reduction (Scenario 3), "q" = 1.7. Maximum diameter Dmax = 32.45 cm.

Class center	Observed value		Estimated value	Wanted Scenario 1	Wanted Scenario 2	Wanted Scenario 3
	Nº ha^{-1}	G m²ha^{-1}	Nº ha^{-1}	Nºha^{-1}	Nºha^{-1}	Nºha^{-1}
2.45	834	2.151	1.042	711	583	363
7.45	664	2.450	366	592	539	459
12.45	100	1.093	129	48	37	11
17.45	64	0.506	45	39	33	25
22.45	5	0.189	16	-10	-11	-12
27.45	11	0.513	6	2	3	4
32.45	2	0.203	2	-3	-2	-1
Total	1.680	7.0499	1.606	1.379	1.182	849

As seen in Table 3, the largest class centers (22.45, 27.45, and 32.45 cm), when there was no deficit, had a limited number of trees (27.45 cm) for the three scenarios, indicating a lack of individuals with robust stems.

In a study carried out in the Caatinga area in the municipality of São José de Espinharas (Paraíba state), Moreira (2014) simulated selective logging with a "q" quotient of 1.94 and a 40% reduction (3.99 m² ha^{-1}) of the total basal area (9.97 m² ha^{-1}). The authors obtained 981 remaining individuals (43.10% stems) and a harvest estimate of 1,294 stems, representing 56.1% of the trees. In the scenario with a 50% reduction in G (4.98 m² ha^{-1}), a harvest estimate of 64.2% (1,458 stems) was observed, with 35.8% remaining trees (817 stems). In the scenario with a 60% reduction in G (5.98 m² ha^{-1}), it was estimated that 28.7% of the stems remained (655 stems), with a harvest estimate of 71.2% (1,620 stems).

In another Caatinga area in the state of Paraiba, Diniz (2011) estimated a De Liocourt quotient "q" of 2.61 and simulated a reduction of 40% (6.5061 m² ha^{-1}) of the total basal area (14.651 m² ha^{-1}), with a recommended 50.72% logging (2,079.16 stems) of individuals (4,100 stems). In the 50% selective logging (7.3531 m² ha^{-1}), the harvest of 58.38% (2,393 stems) and the maintenance of 41.62% (1,707 stems) were recommended. In the 60% selective logging (8.791 m² ha^{-1}), there was a harvest of 66.71% (2,735 stems).

The intervention plan per hectare showed that the diametric structure remained balanced for the first four class centers in the three scenarios, even after harvesting. Thus, it is believed that the recruitment rate (regeneration via seed or regrowth) of the species compensates for their mortality and/or removal.

Table 4 shows the estimated values after simulating a reduction of 40, 50, and 60% of the actual volume for Scenarios 1, 2, and 3. In Scenario 1, reducing 40% (3.52 m³) of the total volume (8.8154 m³), 76.79% of the stems remained. A harvest of 23.21% was estimated, which is equivalent to 402 stems within the diametric classes, with the most representative being 2.45 (165 stems), 7.45 (97 stems), and 12.45 (57 stems). The stem deficit occurred from the diameter class center of 22.45 cm.

In Scenario 2, reducing 50% (4.40 m³) of the total volume, 62.38% of the stems remained. A harvest of 37.62% was estimated, representing 635 stems within the diametric classes, with the most representative ones being 2.45, 7.45, and 12.45, with 319, 159, and 80 stems, respectively. The stem deficit occurred for the larger diametric class centers.

In Scenario 3, reducing 60% (5.29 m³) of the Vt, 38.10% of the stems remained. A harvest of 61.90% was estimated, representing 1,043 stems within the diametric classes, with the first wo classes being he most representative ones with 846 stems. When comparing Scenario 3 for G and actual volume, we observed an unusual deficit of trees (-11) for the third class center (12.45 cm). A stem deficit was also calculated for the last three class centers (22.45; 27.45 and 32.45).

As seen in the different logging intensities for the respective scenarios (Tables 3 and 4), the technical importance of the BDq method in the managed areas is highlighted. The study allows for a long-term analysis of sustainable harvesting, ensuring regularity and stability in the demand for woody stems in conjunction with the maintenance of the dynamic forest processes.

The low number of stems in the largest diameter class centers is justified since there was a significant number (406) of small individuals inventoried in the area (*Aspidosperma pyrifolium*, *Croton blanchetianus*, *Bauhinia cheilantha*, *Mimosa caesalpiniifolia*, *Mimosa ophthalmocentra*, *Piptadenia* stipulacea, and *Cenostigma pyramidale*), spatially distributed with a shrub species (*Combretum leprosum*). Consequently, it is suggested that the largest trees, with higher importance, become more vulnerable to irrational harvesting, requiring technical and scientific prolific studies that allow the occurrence of dynamic processes.

Table 4. Distribution of the number of individuals for the observed, estimated, and expected structure for the remaining trees estimated by diameter class center. Actual volume reduction of 40% (Scenario 1), De Liocourt quotient "q" = 2.3; 50% reduction (Scenario 2), "q" = 2.0; and 60% reduction (Scenario 3), "q" = 1.7. Maximum diameter Dmax = 32.45 cm.

Class center	Observed value		Estimated value	Wanted Scenario 1	Wanted Scenario 2	Wanted Scenario 3
	N°	Vol m^3	N°ha^{-1}	N°ha^{-1}	N°ha^{-1}	N°ha^{-1}
2.45	834	0.8768	1.042	669	515	244
7.45	664	3.7416	366	567	505	408
12.45	100	1.4722	129	43	20	-11
17.45	64	0.7784	45	19	24	16
22.45	5	0.1936	16	-15	-15	-16
27.45	11	1.3504	6	0	-1	-2
32.45	2	0.4024	2	-5	-3	-2
Total	1.680	8.8154	1.606	1.278	1.045	637

Since there was a low number of individuals in the highest diameter class centers, it is recommended that, in the long term, enrichment planting is carried out to enable recruitment and, consequently, rescue and maintain the stability of valuable species (*Myracrodruon urundeuva, Cordia oncocalyx, Amburana cearensis, Anadenanthera colubrine,* and *Libidibia ferrea*) in the area.

Periodic logging should occur in the smallest size classes, according to Souza and Souza (2005). Such an approach will allow a balanced diameter distribution within the classes, leading to a balanced forest throughout the logging cycle and the continuous availability of timber forest products.

In all three scenarios, the diameter distribution showed a deficit of trees in the highest class centers (22.45, 27.45, and 35.45 cm) in contrast with the lowest ones. These findings demonstrate that there is a balance to the lowest class and that adequate management can prevent the local extinction of species groups in the future. Our results agree with Felfili (1997), who affirms that species require large spatial and temporal scales to achieve the balance between mortality and recruitment. Thus, since the BDq method offers several logging alternatives, it allows a better harvest structure and, consequently, an optimized timber production.

CONCLUSIONS

Considering rational, sustainable harvesting and following the theoretical principles of dynamic processes, which will guarantee the long-term establishment of a balanced forest for this Caatinga area, logging cannot be conducted in the highest diameter class centers.

Scenario 3 resulted in the most effective results, since, in technical terms, it enables the harvest of a higher number of individuals. Consequently, it provides higher economic outputs while simultaneously ensuring natural regeneration.

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