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Diameter distribution modeling for the management of four (4) plant communities in Magude district, Maputo province, Mozambique

Modelagem de distribuição de diâmetro para o maneio de quatro (4) comunidades vegetais no distrito de Magude, província de Maputo, Moçambique

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Abstract

The objective of the study was to test the Meyer model in the management of four plant communities located in the district of Magude in the province of Maputo. In the study were established in total 163

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rectangular plots of 100X20m, in each plot was measured the DBH 10cm of all trees. Were sampled 4243 woody individuals in all stands, which are distributed in 16 botanical families, 75 species and 32 genres. The botanical family with the highest number of species in the area was Fabaceae. The species *Acacia nigrescens* was the most prominent because it had the highest number of individuals in all communities. The dendrometric variables used in the model adjustment report a larger diameter of 50, 65, 60, 43cm in Duco, Motaze-Sede, Ungumbane and Waficula. The forest of Duco had a density of 88.9arvha^{-1} and a maximum basal area of 34.2603m^2, 119.14arvha^{-1} and basal area of 10.9654m^2 for Motaze-Sede, 86.88arvha^{-1} and basal area of 31.76247m^2 for Ungumbane and the community of Waficula had a density of 148.93arvha^{-1} and a basal area of 12.7844m^2. From the Meyer model it was observed the permanence of 55% of remaining basal area for the community of Waficula, 60% for the community of Duco, 58% for the community of Ungumbane 1 and 57% of remaining basal area for the community of Motaze the proportion of the basal area remaining the balanced communities and the Meyer model proved to be efficient to make the forests sustainable allowing exploration of the largest diameter classes.

Key words: basal area, sustained management, Liocourt quotient, Mayer model.

Resumo

O objetivo do estudo foi testar o modelo de Meyer no maneio de quatro (4) comunidades vegetais localizadas no distrito de Magude na província de Maputo. No estudo foram estabelecidas no total 163 parcelas rectangulares de 100X20m em 4 comunidades vegetais, em cada parcela mediu-se o DAP ≥10cm de todas árvores. Foram amostrados no total de 4243 indivíduos lenhosos em todo povoamento, que estão distribuídos em 16 famílias botânicas, 75 espécies e 32 gêneros. A Família botânica com maior número de espécies (11) na área foi Fabaceae. A espécie *Acacia nigrescens* foi à de maior destaque, pois apresentou o maior número de indivíduos em todas as comunidades. As variáveis dendrométricas utilizadas no ajuste de modelo observaram-se maior diâmetro de 50, 65, 60, 43cm em Duco, Motaze-Sede, Ungumbane e Waficula. A floresta de Duco teve uma densidade de 88.9arvha^{-1} e uma área basal máxima de 34.2603m^2, 119.14arvha^{-1} e área basal de 10.9654m^2 para Motaze-Sede, 86.88arvha-1 e área basal de 31.76247m^2 Para Ungumbane e a comunidade de Waficula teve uma densidade de 148.93arvha-1 e uma área basal de 12.7844m^2. A partir do modelo de Meyer observou-se a permanência de 55% de área basal remanescente para a comunidade de Waficula, 60% para a comunidade de Duco, 58% para comunidade de Ungumbane 1 e 57% de área basal remanescente para a comunidade de Motaze-sede, a proporção da área basal remanescente as comunidades balanceadas e o modelo de Meyer mostrou ser eficiente para tornar as florestas sustentado permitindo exploração das maiores classes de diâmetro.

Palavras-Chave: área basal, Maneio Sustentado, Quociente de Liocourt, Modelo de Mayer.

1. Introduction

The forestry sector in Mozambique plays an extremely important role for the country's economy and development, representing a major source of food, medicine, energy and building materials for the majority of the population (Ministry of Land Environment and

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Rural Development, 2018), and in addition to being used as building material, also as non-timber forest products (fiber, medicinal plants and food; for energy purposes), as well as subsistence agriculture (Hofiço *et al*., 2018), mainly in rural areas where 80% of the population is concentrated and has low income capital (Bila and Mabjaia, 2012).

However, there has been increased pressure on forestry, mainly for logging resources and charcoal production, which has been highly exploited for various purposes, including commercial purposes (wood, fiber and firewood), without concerns about conservation, the sustainability of the extraction of the processes of these resources and the temporal and spatial distribution of the species of this biome (Ribeiro *et al*., 2014).

The diametric structure of the forests of Mozambique particularly in the province of Maputo has registered profound changes, such as the drastic reduction of various plant communities, land degradation, overexploitation of a small number of forest species, especially *Acacia nigrescens, Albizia anthelmintica, Spirostachys africana,* which account for 70% of wood for coal production, woody fuel and wood for construction. This fact negatively affected the forests of the province of Maputo specifically the district of Magude, compromising the growth, sustainability and management of these species (Chavana, 2014).

Therefore evaluation of the diametric structure of plant communities can be done through the Liocourt method that allows inferring about the past and the future of plant communities. The diameter structure of a forest allows to characterize the available wood stock before an exploration, in addition to providing information that assists in making decisions about the need for forest replacement.

The present work objective to test the Meyer model in the management of four (4) plant communities in the district of Magude.

2. Material and methods

The study was conducted in four (4) communities in the district of Magude, located in the extreme North of Maputo Province, is located between parallels 26º 02' 00" south latitude between 32º 17' 00" East longitude (MAE, 2012), as illustrated in figure 1.

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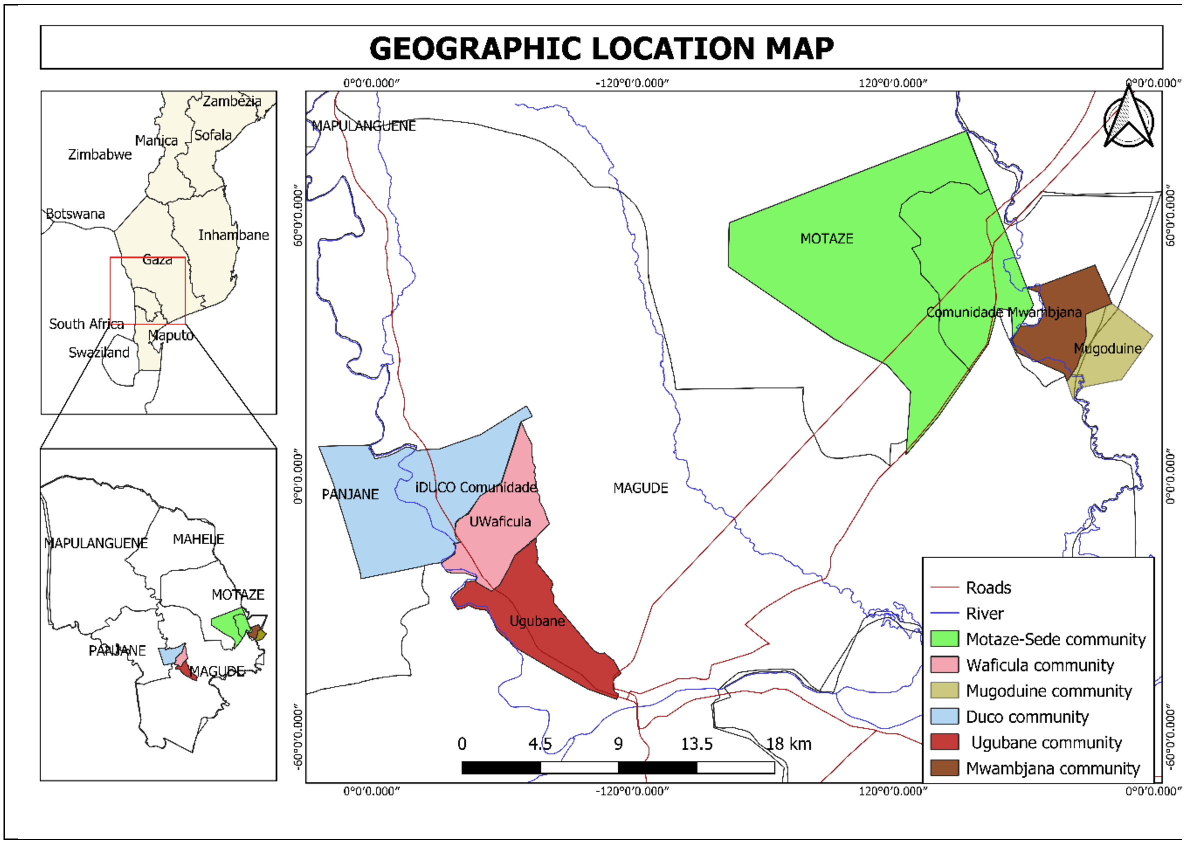
Figure 1. Location of the study area in Magude district, Maputo Province, Mozambique.



2.1. Description of the four (4) communities

The community of Motaze-sede, is located in the district of Magude, Administrative Post of Motaze is bordered to the North by the river Muzimuchope, South with the Pontia community to the southeast with the Nwanote community and the Noreste with the Tlawenae Community and the locality Mwambjana occupying 964 km2 and a productive forest area of 16795ha corresponding to 64.95% of the total community area.

The community of Duco, belongs to the town of Moine, administrative post of Magude-sede, Magude District, Maputo Province. The locality of Moine consists of 9 villages, respectively, Moine-Sede, Duco, Ungucha, Hakamene, Machambuiana, Facazissa, Ungubane-1 and Ungubane-2. It has an extensive area of productive forest in about 1420 ha corresponding to 47.53% of the total area of the community.

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The community of Waficula, is located in the locality of Magude-sede in the Administrative post of Magude, Magude District, Maputo Province, This community borders the communities of Duco and Ungumbane occupying an area of 26 km^2 and a productive forest area of 326 ha corresponding to 17.86% of the community area.

The community of Ungubane that is part of the locality of Matchabe, administrative post of Magude-Sede, Magude District, Maputo Province. The community of Ungubane is located in the locality of Matchabe and is bordered to the north by the community of Waficula, to the east by the community of Nocandze, to the south by the community of Nhamuca and to the west by the river Uanetze Duco to the northwest and Cadnhoze to the northeast, Southwest is bounded by the river Uanetze, which separates it from the community of Inhongane.

2.2. Sampling design

A simple random sampling was adopted in which the sampling points were randomly distributed and georeferenced in Magude District Map and within the boundaries that make up the community of Motaze-sede (study area) from Google Earth. In the field, the sampling points were located from their geographic coordinates with the aid of the geographic positioning system (GPS).

Were established in total 163 rectangular plots of 100X20m in 4 communities: Duco with 52, Waficula with 28, Ungumbane 1 with 48, and Motaze-sede with 35 plots, corresponding to 0.2ha, totalizing 32.6ha of sampled area. In each established plot, with the help of a suta, data were collected regarding the main dendrometric parameter, Diameter at breast height (DBH) of all adult trees (DBH ≥10cm).

In each plot, the scientific and/or local names of all adult individuals were also recorded. Species identification by local names were done by community members with adequate knowledge of plant names as well as their use. The unidentified species in the field were harvested and pressed for later identification in the laboratory of the Gaza Polytechnic Institute (ISPG).

2.3. Data Analysis

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The data obtained in the field were organized and processed in the Spreadsheet in Microsoft Excel where it calculated the parameters (basal area, diameter distribution of plant communities). Meyer's model was adjusted in R studio version 3.6.1.

2.4. Meyer model

For the modeling of the four (4) communities (Duco, Waficula, Ungumbane and Motaze-sede) using the *Liocourt* method was used the methodology used by Dantas, D., Terra, M. C. N. S., and Calegario, N. (2020).

The number of trees per diameter class was estimated as a function of the value of the center of diameter class, according to the formula (02):

$$\hat{N}_i = f(DAP_i, \boldsymbol{\beta}) \qquad \text{(Equation 1)}$$

Where: $\hat{N}_i$ is the number of trees estimated per hectare, DBH- class of Diameter at Breast Height, and is the parameter vector.$\boldsymbol{\beta}$

A variation of the formula (2) is the substitution of the first parameter by its exponential, as follows:

$$N(DAP_i, \boldsymbol{\beta})_i = e^{\beta_0} e^{\beta_1 DAP_i} + \varepsilon_i = e^{\beta_0 + \beta_1 DAP_i} + \varepsilon_i \qquad \text{(Equation 2)}$$

The different estimated values of *β0 and* β1 *provide* different diametric structures, obtained by the ordinary least squares method. With the adjusted model, the quotient of De Liocourt *"q"* was calculated according to the formula below:

$$q = \frac{(\beta o + B1.Di)}{(\beta o + B1(Di+1))} \qquad \text{(Equation 3)}$$

Where: Di= Diameter corresponding to the centre of the i-th class of DBH;Di+1= Diameter corresponding to the centre of the i-th class of DBH immediately above; B0 and β1 are setting parameters.

After obtaining the value of the constant "q", the parameters β0 and β1 shall be recalculated with the following equations:

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$\beta 1 = \frac{ln\ (q)}{Dj-(Dj+1)}$. (Equation 4)

$\beta 0 = ln(\frac{40000 \times G}{\pi \times \sum_{j=1}^{J} D^2 \times e^{\beta 1 \times Dj}})$ (Equation 5)

Where: e = exponential; $\beta 0$ and β1= *desired* coefficients; G = basal area; Dj = DBH class center in cm; ln = neperian logarithm; π = Constant Pi; Dj+1 = center of the diameter class immediately above.

To obtain the parameter for the $\hat{\beta}'_0$ proposed structure it is necessary to specify the remaining basal area and the maximum diameter that will be left in the forest. The remaining basal area is given by the following expression:

$$G_{m^2.ha^{-1}} = \sum_{i=1}^{n} \frac{\pi}{40000} DAP_i^2 \times \widehat{N}_i = \sum_{i=1}^{n} \frac{\pi}{40000} DAP_i^2 \times e^{\widehat{\beta}'_0 + \widehat{\beta}'_1 DAP_i} = \sum_{i=1}^{n} \frac{\pi}{40000} DAP_i^2 \times e^{\widehat{\beta}'_0} \times e^{\widehat{\beta}'_1 DAP_i} \quad \text{(Equation 6)}$$

Where i *represents* to the diameter class and n the maximum class to be left after the prescription of the thinning. Applying the logarithm on both sides of the expression (08), we have:

$$\ln(G_{m^2.ha^{-1}}) = \ln\left(e^{\widehat{\beta}'_0}\right) + \ln\left(\frac{\pi}{40000} \sum_{i=1}^{n} DAP_i^2 \times e^{\widehat{\beta}'_1 DAP_i}\right) = \hat{\beta}'_0 + \ln\left(\frac{\pi}{40000} \sum_{i=1}^{n} DAP_i^2 \times e^{\widehat{\beta}'_1 DAP_i}\right) \quad \text{(Equation 7)}$$

Isolating the$\hat{\beta}'_0$, one has to:

$$\hat{\beta}'_0 = \ln\left(\frac{40000 \times G_{m^2.ha^{-1}}}{\pi \sum_{i=1}^{n} DAP_i^2 \times e^{\widehat{\beta}'_1 DAP_i}}\right) \quad \text{(Equation 8)}$$

Therefore, the number of remaining trees per diameter class for the new forest structure can be estimated by the following expression:

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$$\widehat{N}(G, DAP_{max}, q')_i = \frac{\frac{40000 \times G_{m^2.ha^{-1}}}{\pi \sum_{i=1}^{n} DAP_i^2 \times e^{\widehat{\beta}'_1 DAP_i}}}{\beta'_0} \times e^{\frac{\frac{\ln(q')}{\Delta D} \times DAP_i}{\beta'_1}} \quad \text{(Equation 9)}$$

Where: *G is* the remaining basal area per hectare, q' is *the new* quotient of *Liocourt* and n refers *to* the maximum *number* of diameter classes remaining after the proposed thinning.

3. Results And Discussion

Were sampled 4243 woody individuals in all communities, which are distributed in 16 botanical families, 75 species and 32 genres. The botanical family with the highest number of species (11) in the area was Fabaceae. The species *Acacia nigrescens* (N'khaia) was the most prominent because it presented the highest number of individuals in all communities (Duco with 182, Motaze with 295, Ungumbane 1 with 75 and 190 for the community of Waficula) totaling 742 individuals (Table 1 attached).

In Motaze-sede and Wafikula the specific richness is 33 species distributed in 10 botanical families in both communities, the Fabaceae family presented abundance and dominance in the order of 63.78% and 63.20% respectively.

The communities of Duco and Ungubane obtained greater specific richness with the universe of 48 and 47 species identified in each community respectively. In these communities was found a wealth of 11 and 13 botanical families. The family with the highest abundance in the community of Duco and ungubane is Fabaceae in the order of 49,933% and 31.67% respectively. On the other hand, the Anacardiaceae family presented higher dominance in both communities in the order of 29.74% and 15.77%.

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Tabela1: List of species found in the study area, X-occurrence of the species

			Communities			
Local name	**Scientific name**	**Botanical Family**	**Duco**	**Motaze**	**Ungumbane**	**Wafikula**
N'khaia	*Acacia nigrescens*	Fabaceae	X	X	X	X
N'sassane	*Acacia nilotica*	Fabaceae	X	X	X	X
N'xangua	*Acacia sp*	Fabaceae	X	X	X	X
Nxene	*Afzelia quanzensis*	Fabaceae			X	
Ndzangala nguva	*Albizia anthelmintica*	Fabaceae	X	X	X	X
Nala	*Albizia petersiana*	Fabaceae	X	X	X	X
Nulo	*Balanites maughamii*	Zygophyllales	X			
Nhiri	*Berchemia discolor*	Rhamnaceae	X	X	X	X
Xuncutso	*Boscia mossambicensis*	Capparaceae	X	X	X	X
Numanhama	*Cassia abbreviata*	Fabaceae	X			
Chivodzuane	*Combretum apiculatum*	Combretaceae	X	X	X	
Mondzu	*Combretum imberbe*	Combretaceae	X	X	X	
Xicalate	*Dalbergia melanoxylon*	Fabaceae	X		X	
Ndzenga	*Diclostachy sinerea*	Fabaceae	X	X	X	X
N'toma	*Diospyros mespiliformis*	Ebenaceae	X	X	X	X
Mpfampfa	*Dovyalis sp*	Salicaceae				
Xaquari	*Drypetes mossambicensis*	Putranjivaceae		X		
Ntsamunga	*Euclea divinorum*	Ebenaceae		X		
Nlhangulu	*Euclea natalensis*	Ebenaceae	X	X	X	X
Netha	*Euphorbia tirucali*	Euphorbiaceae	X			
Xtsalala	*Gardenia volkensii*	Rubiaceae	X			
Ntsotso	*Guibourtia conjugata*	Fabaceae	X		X	
Mbandzu	*Lochocarpus capassa*	Fabaceae	X		X	X
Mbalata ngati	*Maerua angolensis*	Capparaceae	X	X	X	X
N'wambo	*Manilkara mochisia*	Sapotaceae	X	X	X	X
Mbeswo	*Albizia adiantifolia*	Fabaceae			X	
Mbota	*Monodora junodii*	Annonaceae	X	X	X	X
Ntita	*Monanthotaxis cafrra*	Annonaceae			X	
Ncandju	*Anacardium occidentale*	Anacardiaceae			X	
Ndzololuane	*Albizia sp*	Fabaceae	X	X	X	X
N'khaia mavele	*Acacia mellfira*	Fabaceae	X	X	X	X
Ntsova beula	*Acacia sp*	Fabaceae	X			X
Rompfa	*Annona senegalensis*	Annonaceae			X	

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N'canho	*Sclerocarya birrea*	Anacardiaceae	X	X	X	X
Xilangamalho	*Spirostachys africana*	Euphorbiaceae	X	X	X	X
Ncuacua	*Strychnos madagascariensis*	Strychnaceae	X	X	X	
Nsala	*Strychnos spinosa*	Strychnaceae	X	X	X	
N'conola	*Terminalia sericeae*	Combretaceae	X		X	
Nculhu	*Trichilia emética*	Meliaceae			X	

It is verified that the Fabaceae family assumes the position of greater abundance, and greater dominance in most communities, Segundo (Hofiço *et al.*, 2018) in a study carried out *in* the Miombo forest in Zambézia, observed that the most important families, both in number of species and individuals in both areas, were Fabaceae and Euphorbiaceae. These families cover most of the woody species of Miombo flora.

Abundance of species of the family Fabaceae, especially of the genus acacia in closed forests can be an indicator of an initial stage of succession after anthropic disturbances. The high abundance of the Fabaceae family also occurs as a result of the massive abundance of species of the genus Acacia that reach 63% of the individuals measured (Silva, 2018).

3.1. Descriptive analysis of the four (4) communities

The results of the descriptive statistics of the communities in relation to DBH, basal area, standard deviation, coefficient of variance and density are shown in Table 1.

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Table 1. Descriptive analysis of the variables used in the adjustment of Meyer's model.

	Descriptive analysis by communities			
Parameters	**Duco**	**Motaze sede**	**Ungumbane**	**Waficula**
N trees.ha^{-1}	88.9	119.14	86.88	148.93
DBH min	10	10	10	10
DBH max	50	65	60	43
G min (m^2)	1.7417	0.2867	0.261145	0.5688
G max (m^2)	34.2603	10.9654	31.76247	12.7844
Average	0.0023	0.0029	0.0035	0.0032
Sd	0.00264	0.00330	0.00437	0.00307
CV%	10.998	15.954	12.952	17.117

G min/max= basal area (G m^2); CV%= Coefficient of variance of basal area (G m^2); Sd= Basal area standard deviation (G m2); DBH= diameter breast height (cm); min=minimum; max=maximum; N trees. ha^{-1}= Number of trees per hectare.

From the descriptive analysis of the dendrometric variables used in the model adjustment, the largest diameter of 50, 65, 60, 43cm is reported in Duco, Motaze-Sede, Ungumbane and Waficula, the minimum diameter of 10cm was pre-defined in the methodology for all communities. The forest of Duco had a density of 88.9treesha^{-1} and a maximum basal area of 34.2603m^2, 119.14treesha^{-1} and basal area of 10.9654m^2 for Motaze-Sede, 86.88treesha^{-1} and basal area of 31.76247m^2 for Ungumbane and the community of Waficula had a density of 148.93ha-^{1} and a basal area of 12.7844m^2. Statistically analyzing the coefficient of variance in the communities was 17,117% for Waficula, 15,954% for Motaze-Sede, 12,952% for Ungumbane and 10,998% for the community of Duco.

3.2. Diameter structure of the four (4) Magude communities

The diameter distribution for the communities (Figure 2) demonstrates a typical pattern of unequivocal forests, with an inverted J distribution. Most individuals are in the smallest diameter classes with a progressive decrease in their frequencies as the diameter increases, a fact also observed by (Dantas *et al*., 2020).

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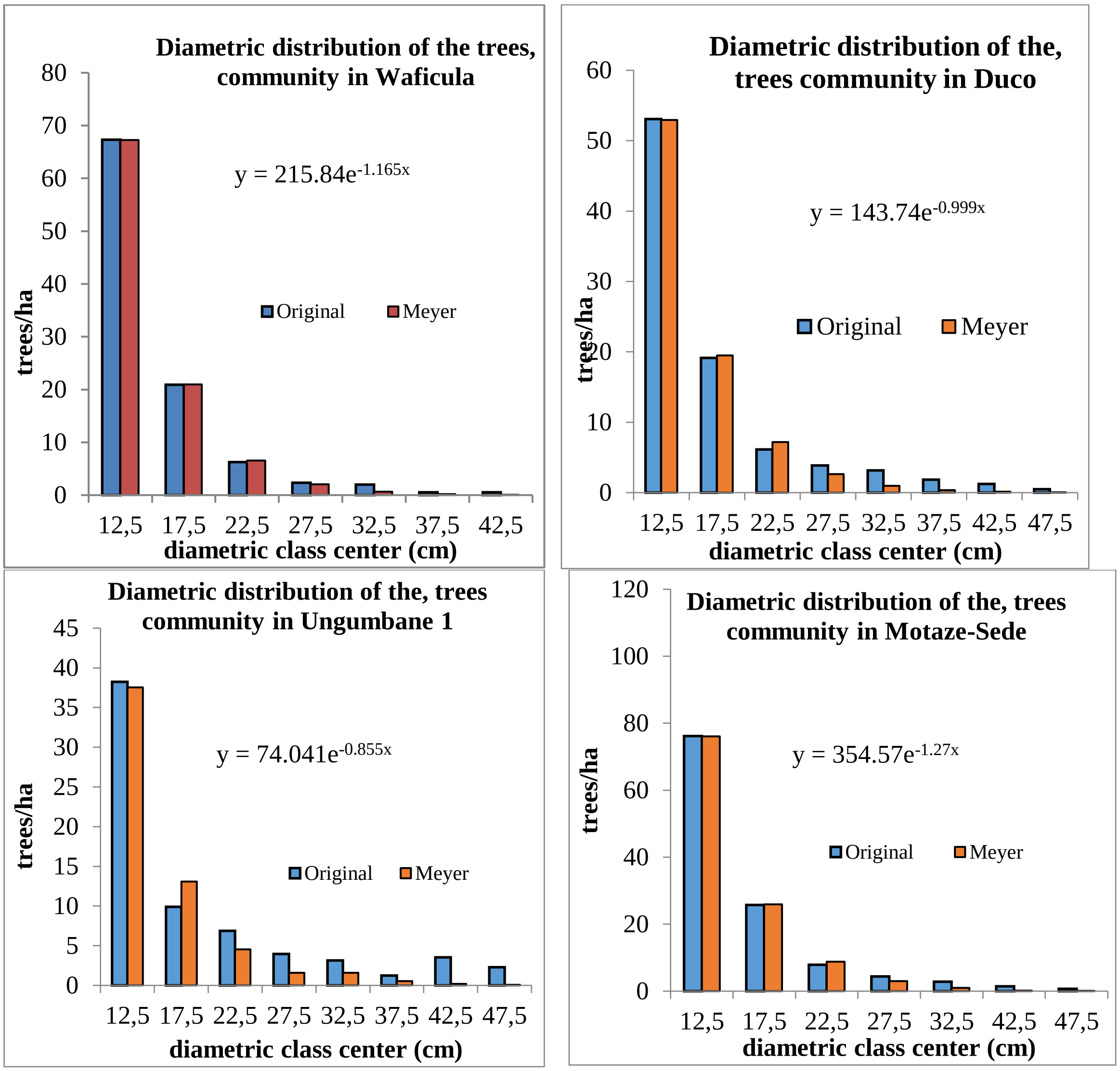
Figure 2. Observed and estimated diametric distribution in Waficula, Duco, Ungumbane, and Motaze Sede.



The frequencies estimated by the Meyer model follow a negative geometric progression (Figure 2) in all communities, indicating that this vegetation community is in imbalance. The imbalance can be explained by the genetic potentiality of most species in presenting small size, or even due to forest exploitation in the past, mainly for charcoal production.

It is also verified that the Meyer model shows a strong tendency to underestimate the number of plants in the diameter classes with class center above 12.5cm in all communities.

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The large number of small and thin individuals may indicate the occurrence of severe disturbances in the past; (Moreira *et al*., 2014) warned that the higher density of smaller individuals does not indicate the absence of regeneration problems, and should be considered with caution, demonstrating the need for a more detailed analysis.

3.3. Forest regulation of plant communities

The values of the coefficients (β0 and β1) of the Meyer model for the studied forests were 642.615 and -0.1997 for the community of Duco, for Waficula was from 1.239 to -2.331, for Umbungane 1 was from 526.2267 to -0.21121 and for Motaze sede or from -125.2 to 2.155, Approaching adjusted the value by (Souza, 2005) with coefficients 1.432 to -20.1997, considering that These types of Fragments also have the same Characteristics. Lower coefficient values correspond to the higher cutting intensity in the lower diametric classes, maintaining greater number of remnants in the upper classes, occurring the opposite with higher coefficient values. (Hess *et al*., 2010)

3.4. Plant community of Waficula

The Liocourt method for the Waficula community allowed the permanence of individuals in all diametric classes except for the class center of 17.5 and 22.5cm, allowing a remaining basal area of 55% (Table 4)

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Table 3. Frequency distribution (nha^{-1}), of the basal area (m^{2}ha-1) of the original structure, the remaining structure and the structure removed to the desired maximum diameter of 20cm, per center of diameter class in the Waficula community.

CC	Original Structure			Stru. Remaining	Stru. Removed	
	Ni	Original	G (m^{2}ha^{-1})	Meyer	NR	G (m^{2}ha^{-1})
12.5	377	67.321	0.8262	67.288	0.033	0.8258
17.5	117	20.893	0.5025	20.981	-0.088	0.5046
22.5	35	6.250	0.2485	6.542	-0.292	0.2601
27.5	13	2.321	0.1379	2.040	0.282	0.1212
32.5	11	1.964	0.1630	0.636	1.328	0.0528
37.5	3	0.536	0.0592	0.198	0.337	0.0219
42.5	3	0.536	0.0760	0.062	0.474	0.0088
47.5	2	0.357	2.0132	0.013	0.344	1.7951
Total	561	100.179	4.0264	97.760	4.127	2.1254

CC= class center (cm), ni=number of individual, G=basal area per hectare (Gha^{-1}); NR= number of trees to be removed hectares (Nha^{-1}).

Silva (2018), aiming to stratify the volumetric production and propose the regulation of forest production through the Liocourt method based on area, diameter and quotient (BDq) recommended the exploration of 20% and 50% of basal area in each diameter class, the balanced structure of the forest community, with this favors the next cutting cycle with volume available for harvesting, similar results found in this study.

3.5. Plant community of Duco

In the community of Duco a total basal area of 2.1350 m^{2}ha^{-1} was obtained, in which the established management regime allows a remnant of 1.1806 m^{2}ha^{-1} of basal area, equivalent to 60% and a total number of trees to be removed of 6.6Arvha^{-1} (Table 5).

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Table 4. Frequency distribution (nha^{-1}), of the basal area (m^{2}ha^{-1}) of the original structure, the remaining structure and the structure removed to the desired maximum diameter of 20cm, per center of diameter class in the community of Duco.

CC	Original Structure			Stru. Remaining	Stru. Removed	
	Ni	Original	G (m2ha-1)	Meyer	NR	G (m2ha-1)
12.5	552	53.077	0.5787	52.9	0.2	0.6494
17.5	199	19.135	0.4065	19.5	-0.4	0.4689
22.5	64	6.154	0.2254	7.2	-1.0	0.2855
27.5	40	3.846	0.2203	2.6	1.2	0.1571
32.5	33	3.173	0.2416	1.0	2.2	0.0808
37.5	19	1.827	0.1973	0.4	1.5	0.0396
42.5	13	1.250	0.1759	0.1	1.1	0.0188
47.5	5	0.481	0.0893	0.0	0.4	0.0086
Total	925	88.942	2.1350	83.8	6.6	0.9544

CC= class centre (cm), ni=number of individual, G=basal area per ha (Gha^{-1}); NR= number of trees to be removed hectares (Nha^{-1}).

Souza and Souza (2005), in order to analyze the selective post-harvest diameter structure of the dense Ombrophilous forest, recommended that periodic removal of trees should occur in the smallest size classes, Aiming at balancing the distribution of diameters and above all, the conduction of the forest to a balanced structure throughout the cutting cycle, with continuous use of timber forest products.

3.6. Plant community of Ungubane 1

In the community of Ungubane was obtained a total basal area corresponding to 2,336 m^{2}ha^{-1} allowing the permanence of 58% (1.3701 m^{2}ha^{-1}) of basal area, the established management prescribed the removal of 13,210treesha^{-1} in all classes except the 17.5cm class (Table 6).

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Table 5. Frequency distribution (nha^{-1}), the basal area (m^{2}ha^{-1}) of the original structure, the remaining structure and the structure removed to the desired maximum diameter of 20cm, by center of diameter class in the community of Ungumbane 1.

CC	Original Structure			Stru. Remaining	Stru. Removed	
	Ni	Original	G (m^{2}ha^{-1})	Meyer	NR	G (m^{2}ha^{-1})
12.5	367	38.229	0.394384	37.549	0.680	0.460
17.5	95	9.896	0.217801	13.061	-3.165	0.3141
22.5	66	6.875	0.255913	4.543	2.332	0.1806
27.5	38	3.958	0.214872	1.580	2.378	0.0931
32.5	30	3.125	0.239947	1.580	1.545	0.1310
37.5	12	1.250	0.13337	0.549	0.700	0.060
42.5	34	3.542	0.464125	0.191	3.351	0.027
47.5	22	2.2917	0.415623	0.066	2.225	0.0117
Total	664	69.167	2.336035	59.121	13.210	0.9659

CC= class center (cm), ni= number of individuals, G=basal area per hectare (Gha^{-1}); NR= number of trees to be removed hectares (Nha^{-1}).

Hofiço, *et al.*, (2018) in a study conducted in the district of Mocuba for a forest of Miombo, the regulation of forest production recommended the removal of 15 trees per hectare in the set of frequency classes, for a minimum cutting diameter (DMC) of 40.0 cm with reduction of 2,42 m²ha^{-1} of basal area.

Study conducted by Hess *et al*., (2010) aiming to achieve sustained management with frequency regulation of individuals by the Liocourt method recommended management options based on three parameters: maximum desired diameter, remaining basal area, Liocourt quotient "q" where these parameters demonstrated a forest balance. For (Carvalho *et al*., 2016) species require a very broad spatial and temporal scale to achieve the balance between mortality and recruitment.

3.7. Plant community of Motaze-Sede

The community of Motaze Sede presented a total basal area of 2,464 m^{2}ha^{-1}, and it is required in this community, according to the Meyer model, a remaining basal area of 1,407m^{2}ha^{-1} in all classes so that the forest is regulated. In this position, the classes of 17.5 and 22.5cm are excluded because they present a tree deficit and cannot be explored (Table 7).

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Table 6. Frequency distribution (nha^{-1}), the basal area (m^{2}ha^{-1}) of the original structure, the remaining structure and the structure removed to the desired maximum diameter of 20cm, per center of diameter class in the community of Motaze Sede.

CC	**Original Structure**			**Stru. Remaining**	**Stru. Removed**	
	Ni	Original	G (m^{2}ha^{-1})	Meyer	NR	G (m^{2}ha^{-1})
12.5	533	76.143	0.813	76.055	0.0880	0.8630
17.5	180	25.714	0.562	25.892	-0.1775	0.6760
22.5	55	7.857	0.280	8.814	-0.9573	0.4470
27.5	31	4.429	0.253	3.000	1.4286	0.2670
32.5	20	2.857	0.243	1.022	1.8356	0.0900
42.5	10	1.429	0.190	0.118	1.3103	0.0250
47.5	5	0.714	0.123	0.040	0.6740	0.0110
Total	834	119.143	2.464	114.941	5.3364	1.0570

CC= centre of class (cm), ni= number of individual; G=basal area per hectares (Gha^{-1}); NR= number of trees to be removed hectares (Nha^{-1}).

In all communities it was observed that the diametric distributions showed a deficit of trees in the center of classes of 17.5 and 22.5cm, demonstrating that such communities are unbalanced, and with an adequate management practice, extinction of a group of species can be avoided.

This imbalance can be explained by the exploitation regime in the lower classes (building piles and charcoal production)

(Ribeiro *et al*., 2014) suggested that the regulation of diameter structure can contribute to the regeneration of species, decrease of competition, and the recovery of possible increments in diameter and volume, thus leading to a stability of the remaining vegetation throughout the cutting cycle.

Therefore, (Marangon *et al*., 2016) suggested that the need for thinning interventions, aims to maintain the canopy opening, and the positive reaction of the forest to luminosity.

4. Conclusion

The study demonstrated that the Meyer model is efficient in the management of plant communities suggesting that forest regulation based on the basal area can be an alternative for environmental management and sustainability.

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The diametric structure showed an imbalance in all vegetation communities with tree deficit in the smallest diameter classes indicated that the ecological communities are in the degraded state.

The community of Waficula has a greater number of individuals able to silvicultural activities and greater remaining basal area to ensure forest sustainability.

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