Original Research Article

Floristic analysis and phytosociology in an area of Caatinga, Brazil

ABSTRACT- Studies on the composition and structure of vegetation can provide important information for decision-making and the application of forest-management techniques. The aim of this research was to analyse an area of Caatinga using vegetation characterisation and forest inventory in the Rocha Eterna Community, in the district of São João do Piauí, Brazil. Simple Random Sampling was used, installing 17 sampling units of 20 x 20 m. The phytosociological parameters of the horizontal and vertical structure, the floristic diversity of the species and the timber production in the area were evaluated. Fabaceae was the most representative family. The three most representative species in the area were *Senna acuruensis* (Benth.) H.S. Irwin & Barneby, *Sideroxylon obtusifolium* (Roem. & Schult.) T.D.Penn. and *Mimosa tenuiflora* (Willd.) Poir. The Shannon-Weaver diversity index (H') for the area was 1.74 nats.ind^{-1}. The estimated basal area for the area was 8.68 m².ha^{-1}. The estimated actual volume was 36.56 m³.ha^{-1}. Species diversity in the fragment under study was considered low.

Keywords: Floristic diversity. Vegetation structure. Survey of the Caatinga, Phytosociology

1. INTRODUCTION

Caatinga vegetation covers most of the area of semi-arid climate in the Northeast of Brazil (Giulietti et al., 2004). The vegetation is composed of herbaceous and woody species, including cacti and bromeliads, with an emphasis on the xerophytic and deciduous aspect, a typical characteristic of the species, which display great heterogeneity in relation to their phyto-physiognomies and horizontal and vertical structures (Prado, 2003).

The degradation of the Caatinga through anthropogenic action, deforestation and the burning of forested areas for agricultural activities is increasingly compromising the natural resources and sustainability of the biome. Further, there is little understanding of the biome, especially of how to use the resources it offers, as there are particular aspects of the Caatinga that must be considered if it is to regenerate and again be exploited (Tabarelli et al., 2000; Vasconcelos et al., 2017).

Research into floristic and phytosociological composition in forests of the Caatinga Biome is an important tool for detailing plant species diversity and verifying how they are distributed in a given environment using structural analysis, which allows an estimation of the distribution of individuals by species and consequently by family (Souza, 2009).

Phytosociological studies also aid in forest management planning, environmental impact studies and forest restoration and reclamation projects in degraded areas, and may also indicate the potential use for a given species through information on richness and abundance, volumetric potential and diameter-class distribution that will influence its use, whether for wood, charcoal, cuttings or posts, among others (Santos et al., 2017a).

Studies on the composition and structure of vegetation can provide basic information for decision-making in the application of forest-management techniques (conservation and maintenance), so that any intervention in the forest should be planned and preceded by a detailed inventory, which would provide information such as estimates of the floristic composition, and of the horizontal, vertical and parametric structures (Souza, 2003).

It should be noted that forest inventories are still scarce in the southern region of the State of Piauí, so that research which evaluates the conditions under which the natural vegetation is found is extremely important. This study therefore aimed to analyse an area of caatinga vegetation using vegetation characterisation and forest inventory in the Rocha Eterna Community, in the district of São João do Piauí.

2. MATERIAL AND METHOD

2.1 Study Area

The research work was carried out with the support of the Non-Governmental Oraganisation SOS Sertão in a fragment of Caatinga of approximately 200 ha in the Rocha Eterna Community of the district of São João do Piauí, in the microregion of the Upper Middle Canindé. The area is located at 08º21'29 S latitude and 42º14'48" W logitude, and is about 482 km from the state capital, Teresina.

The city of São João do Piauí has an average altitude of 222 m above sea level, with minimum temperatures of 22ºC and maximum temperatures of 39ºC, and a climate that is considered semi-arid, hot and dry. The average annual rainfall is 500 mm, with two periods a year: a rainy season lasting from 3 to 4 months and a dry season during the remaining months (Aguiar; Gomes, 2004).

The soils of the region are shallow, considered young, sometimes stony, still influenced by the underlying material, with a predominant vegetation of tree and shrub Caatinga, where the soils are of sedimentary origin and extremely sandy (Aguiar; Gomes, 2004; Nascimento et al., 2008).

The terrain in the region shows a flattened surface with areas of depression in which temporary lagoons form, surfaces of low plates, flat relief with smoothly undulating areas and altitudes varying between 150 and 300 metres, undulating surfaces and moving relief, corresponding to slopes with the residual extensions of plates, gradients and steep slopes, with valleys, elevations and tabular summit surfaces of flat relief (Aguiar and Gomes, 2004).

2.2 Data collection and processing

For the survey, an area of approximately 200 ha of native forest was selected, where 17 plots of 20 x 20 m (400 m^2) were randomly allocated, resulting in an inventory area of 6,800 m^2.

Inside the 17 plots, measurements were taken of the tree and shrub forest species having a circumference at breast height (CBH) equal to or greater than 10 cm, where they were identified *in loco* by means of their dendrological aspects; when possible, botanical material was collected for later identification and/or confirmation of the scientific names by consulting the literature. The APG II system (2003) was used to classify the plants up to species level.

After acquiring the data, the phytosociological parameters of the horizontal and vertical structure of the sampled species were evaluated (Felfili and Rezende, 2003) together with the floristic diversity, using the Shannon-Weaver Index (H'), the Simpson Dominance Index (C) and the Pielou Evenness Index (J'), as per Table 1.

Table 1. Shannon-Weaver diversity index (H'), Simpson dominance index (C) and Pielou evenness index (J').

Index	Designation	Formula
Diversity	Shannon-Weaver (H’)	$H' = \sum_{i=1}^{S} \left(\frac{nj}{N} . \ln \frac{nl}{N}\right)$

Dominance	Simpson (C’)	$C' = \sum_{i=1}^{S} \left(\frac{nj.(nj-1)}{N.(N-1)} \right)$
Evenness	Pielou (J’)	$J' = \frac{H'}{H'max}$,

Where: S = total number of sampled species; N = total number of sampled individuals; ni = number of sampled individuals of the ith species; Ln = neperian logarithm; Hmax = Ln (S) = total number of sampled species.

To calculate the volume, the DBH at 1.30 m including bark of adult trees measured in the sampling units was considered, applying the following formulae:

$$VCc/c = (\pi * (DBH^2) * Ht)/40000$$

(Equation 1)

where: VCc/c = cylindrical volume of the tree with bark; π = “pi” (3.1416...); DBH^2 = diameter at breast height, squared (in centimetres); Ht = total height of the tree (in metres); 40.000 = quadratic conversion factor from centimetres to metres (from the DBH);

$$VA = VCC * ff$$

(Equation 2)

where: VA = actual volume (in cubic meters - m^3); ff = form factor (0.9 dimensionless) (ZAKIA *et al*., 1988).

To estimate the stacked volumes, the following formula was applied:

$$VS = VR * fe$$

(Equation 3)

where: VS = stacked volume (in steres); VA = actual volume (cubic metres); fe = stacking factor (3.41 adimensional) (ZAKIA et al., 1988).

To describe the community structure, the following phytosociological parameters were estimated: absolute density (DA), relative density (DR), absolute frequency (FA), relative frequency (FR), absolute dominance (DoA), relative dominance (DoR), importance value index (IVI) and coverage value index (CVI).

Processing or computation of the field data was carried out using an Excel 2010 spreadsheet and the MATA NATIVA v3.01 software, used in floristic and phytosociological analysis.

3. RESULTS AND DISCUSSION

In the survey, 792 individuals were sampled, belonging to 6 families, 17 species and 15 genera. Of these species, two were identified by their common name only. Family Fabaceae was the most representative in number of species, together with Euphorbiaceae; only one species was registered for each of the remaining families, as shown in Table 2.

Table 2. List of identified species found in the sampling plots in the Rocha Eterna Community, Brazil.

Family/Species	Common Name	Habit
Annonaceae		
Annona leptopetala (R.E.Fr.) H.Rainer	Bananinha	Arboreal
Bignoniaceae		
Jacaranda jasminoides (Thunb.) Sandwith	Chifre de carneiro	Arboreal
Combretaceae		
Terminalia fagifolia Mart.	Chapada	Arboreal
Euphorbiaceae		
Croton blanchetianus Baill.	Marmeleiro	Arboreal

Manihot glaziovii Müll.Arg.	Maniçoba	Arboreal
Fabaceae		
Machaerium acutifolium Vogel	Violete	Arboreal
Poincianella pyramidalis (Tul.) L.P.Queiroz	Catingueira	Arboreal
Bauhinia cheilantha (Bong.) Steud.	Mororó	Arboreal
Pityrocarpa moniliformis (Benth.) Luckow & R.W.Jobson	Catandúva	Arboreal
Senna acuruensis (Benth.) H.S.Irwin & Barneby	Canela de Velho	Arboreal
Machaerium Pers.	Jacarandá de Sangue	Arboreal
Mimosa tenuiflora (Willd.) Poir.	Jurema preta	Arboreal
Piptadenia stipulacea (Benth.) Ducke.	Jurema Branca	Arboreal
Dimorphandra mollis Benth	Folha Miúda	Arboreal
Sapotaceae		
Sideroxylon obtusifolium (Roem. & Schult.) T.D.Penn.	Espinheiro	Arboreal
Undetermined		
Undetermined 1	Birro	Arboreal
Undetermined 2	Violete Preto	Arboreal

It should be pointed out that in other surveys already carried out in the Caatinga region, the families Fabaceae and Euphorbiaceae are commonly recorded as having the largest number of species. (Calixto Júnior and Drumond, 2014; Dias et al., 2014; Leite et al., 2015; Santos et al., 2017b).

Family Fabaceae presented 9 species, these with around 8 genera; the genus Machaerium was repeated and represented by two species; the genus has around 140 species, among which, Jacaranda stands out with numerous variations.

It is common in floristic and phytosociological surveys for the most representative species to be Fabaceae and Euphorbiaceae, considered as one of the most numerous families among plants groups.

Vasconcelos et al. (2017) showed similar results for the number of species of family Euphorbiaceae in studies carried out in the district of São Francisco, Piauí; however, being an ecotone of the Cerrado and Caatinga biomes, this was an area with a higher floristic diversity index as well as having a greater number of species and individuals per unit area (absolute density).

In a survey carried out in an area of Caatinga in the State of Paraíba, Oliveira et al. (2009) found that the families Fabaceae and Euphorbiaceae excelled in the number of species and also had a large total number of individuals. Rodal (2002), found that the families Fabaceae and Euphorbiaceae were the most representative in phytosociological studies of the woody component in an area of Caatinga in the district of São Raimundo Nonato, Piauí.

The aim of this study was to register species of the tree and shrub stratum, however, the only component found was arboreal, although some shrub species were seen outside the plots. What demonstrates the development of species in the area is their being better established in the forest; management should be seen as a positive way of maintaining biodiversity, compared to intense extraction of the vegetation.

The most abundant species in the inventoried region were *Senna acuruensis* (339), *Sideroxylon obtusifolium* (178) and *Mimosa tenuiflora* (Willd.) Poir. (130) (Table 3).

Table 3. List of inventoried species, in the Rocha Eterna Community, in the district of São João do Piauí. .

Scientific Name	N	DA	DR(%)	FA	FR(%)	DoA	DoR	CVI (%)	IVI (%)
Senna acuruensis (Benth.) H.S.Irwin & Barneby	339	498.529	42.8	100	14.78	10.228	80.08	61.44	45.89
*Sideroxylon obtusifolium (*Roem. & Schult.) T.D.Penn.	178	261.765	22.47	88.24	13.04	0.562	4.40	13.44	13.30
Mimosa tenuiflora (Willd.) Poir.	130	191.176	16.41	94.12	13.91	0.425	3.32	9.87	11.22
Pityrocarpa moniliformis (Benth.)	31	45.288	3.92	94.12	13.90	0.163	1.28	2.60	6.39
Bauhinia cheilantha (Bong.) Steud.	15	22.059	1.89	52.94	7.83	0.029	0.22	1.06	3.31
Croton blanchetianus Baill.	31	45.588	3.91	35.29	5.22	0.065	0.51	2.21	3.21
Terminalia fagifolia Mart.	7	10.294	0.88	23.53	3.48	0.574	4.5	2.69	2.95
Manihot glaziovii Müll.Arg.	13	19.118	1.64	35.29	5.22	0.105	0.82	1.23	2.56
Undetermined 2	11	16.176	1.39	35.29	5.22	0.104	0.82	1.10	2.47
Dimorphandra mollis Benth.	9	13.235	1.14	29.41	4.35	0.062	0.48	0.81	1.99
Jacaranda jasminoides (Thunb.) Sandwith	4	5.882	0.51	23.53	3.48	0.087	0.68	0.59	1.55
Undetermined 1	7	10.294	0.88	17.65	2.61	0.149	1.17	1.03	1.55
Machaerium acutifolium Vogel	6	8.824	0.76	11.76	1.74	0.093	0.73	0.74	1.07
Piptadenia stipulacea (Benth.) Ducke	3	4.412	0.38	17.65	2.61	0.005	0.04	0.21	1.01
Annona leptopetala (R.E.Fr.) H.Rainer	5	7.353	0.63	5.88	0.87	0.025	0.2	0.41	0.57
Poincianella pyramidalis (Tul.) L.P.Queiroz	1	1.471	0.13	5.88	0.87	0.06	0.47	0.30	0.49
Machaerium Pers.	2	2.941	0.25	5.88	0.87	0.038	0.3	0.27	0.47
Total	**792**	**1164.706**	**100**	**676.47**	**100**	**12.772**	**100**	**100**	**100**

The values are in descending order of IVI. Where N = number of individuals, FA = Absolute Frequency (%), FR = Relative Frequency (%), DA = Absolute Density (ind.ha-1), DR = Relative Density (%), DoA= Absolute Dominance (m2.ha-1), DoR= Relative Dominance (%), IVI = Importance Value Index (%), CVI

For the importance value index (IVI), which estimates the ecological importance of a given species in the community, and comprises the sum of each value of the relative parameters, the species *Senna acuruensis* had the highest value, of 45.89%, followed by *Sideroxylon obtusifolium* with 13.30%, *Mimosa tenuiflora* with 11.22% and *Pityrocarpa moniliformis* with 6.39%.

The species *Senna acuruensis*, *Sideroxylon obtusifolium* and *Mimosa tenuiflora* also presented the highest values for coverage in the area; the species are important, as together they account for 84.75% of the individuals sampled in the area.

Due to species distribution, these values are related, with *Senna acuruensis* and *Mimosa tenuiflora* present in all the inventoried plots, and *Sideroxylon obtusifolium* occurring in nearly all the plots. The species *Croton blanchetianus* Baill., although presenting considerable values for density, was not among the five species with the greatest IVI, since it did not stand out as to frequency. All the parameters can be seen in table 3.

The Shannon-Weaver diversity index (H') for the area was 1.74 nats.ind^{-1}, the Simpson Dominance index (C) was 0.74 and the Pielou Evenness index (J') was 0.60.

The Simpson Dominance Index (C) seen in this study also presented lower results than in other studies in the area of Caatinga, such as that of Sousa, et al. (2017) of 0.88 in Bom Jesus, Piauí, and 0.93 seen by Vasconcelos et al. (2017) in São Francisco do Piauí. The Shannon index (H'), 1.74 nats.ind^{-1}, was lower than those found in other studies in the Caatinga, such as Rodal et al. (1998), Rodal et al. (2006) and Ferras et al. (2006).

This value is considered low, a fact related to the climate conditions and associated with the types of soils predominant in these regions (Trovão, 2004). When evaluating the values of these two indices, it is correct to say that the study area has less diversity when compared to other areas located in the same region.

However, the study area presented greater diversity when compared to Caatinga vegetation in other regions; as for example, an area studied by Holanda et al. (2015) in Cajaseirinhas, Paraíba, where the vegetation structure in remnants of caatinga with a history of disturbance showed a value of 1.5 nats.ind^{-1}.

The value for the Pielou Eveness Index (J') found in this study (J = 0.60) was similar to that found by Pereira Júnior et al. (2012) of J = 0.63. These values for species distribution are considered low when compared to other areas of Caatinga; in Monteiro, Paraíba, a greater value, corresponding to J = 0.73 was found by Pegado et al. (2006), indicating the more even distribution of plant species throughout the area.

The vegetation had a mean height of 4 m for the 792 individuals inventoried, reflecting well the characteristics of the vegetation for height and population density. Distribution of the basal area and of the estimated actual volume by diameter class shows that the highest values were found for a diameter class of between 6.5 and 11.5 cm, followed by the class between 1.5 and 6.5 cm (Table 4).

Table 4. Distribution of Basal Area (BA), Actual Volume (VA) and Stacked Volume (VS) for diameter class, on the Rocha Eterna property, Brazil.

Class	N	BA ($m^2.ha^{-1}$.)	Act. Vol ($m^3.ha^{-1}$.)	Stacked Vol ($st.ha^{-1}$)
1.5 |- 6.5	436	0.682	2.4405	11.92
6.5 |- 11.5	169	0.951	3.5398	17.28
11.5 |- 16.5	71	1.055	4.186	20.44
16.5 |- 21.5	48	1.338	5.4146	26.44
21.5 |- 26.5	27	1.214	5.0391	24.60
26.5 |- 31.5	20	1.317	5.9434	29.02
31.5 |- 36.5	16	1.424	6.5183	31.82
36.5 |- 41.5	3	0.336	1.4607	7.13
41.5 |- 46.5	1	0.139	1.0001	4.88
46.5 |- 51.5	0	0	0	0.00
51.5 |- 56.5	1	0.228	1.0259	5.01
Total	792	8.684	36.568	**178.54**

The three species of greatest abundance in the vegetation represent 84.75% of the sampled population. It was found that the basal area in this region was very low, this is related to the high importance value index found in the primary-stage species. It may also be related to disturbances in the area (the history of land use), which may have influenced vegetation dynamics. The sampling error was found to be 17.46%, which was acceptable and gave satisfactory results.

Considering the sum of the basal area of the individuals per hectare, the value found in this study was greater than (7.6 $m^2.ha^{-1}$), that found by Santos et al. (2017b), (7.6 $m^2.ha^{-1}$), who evaluated the woody component of a fragment of Caatinga located in another area in the district of Upanema, in the State of Rio Grande do Norte. Amorim et al. (2005) evaluated the structure of tree and shrub vegetation in an area of Caatinga in the district of Serra Negra do Norte, also in the state of Rio Grande do Norte, in the microregion of Western Seridó, where a lower value (6.1 $m^2.ha^{-1}$) was also found.

This difference can be explained by the fact that these areas are located in a different region of the Caatinga, in another State, and also because in both the above studies the basal area was calculated from data obtained from the woody stratum (trees + shrubs), whereas in the present study, only tree-like individuals were considered (see Table 2).

The Actual Volume in the area was greater than that reported by Santos et al. (2017b), who found a value of 30.03 $m^3.ha^{-1}$ in the town of Desterro, in the district of Teixeira, Paraíba, and lower than those found by Leite et al. (2015), of 40.40 $m^3.ha^{-1}$ also in the district of Teixeira, Paraíba, in the microregion of Serra do Teixeira. However, this value was greater than the values found by Xavier et al. (2005) when assessing the timber potential of the microregions of Sousa and Itaporanga, and who calculated a volume of 17 $m^3.ha^{-1}$ and 20.51 $m^3. ha^{-1}$ respectively. It would seem that the habit of the components under study contributed to this significant difference between the areas, in addition to environmental factors, that have a different effect in each locality.

4. CONCLUSION

Family Fabaceae had the largest number of individuals. The diversity found in the area was considered low, also displaying little uniformity in the distribution of vegetation when compared to other studies in areas of Caatinga in the State of Piauí, highlighting the regional variations, especially in population density.

The place where the Caatinga vegetation is found has an effect on the diversity indices.

The inclusion of only tree species in the study increased the values for basal area and volume compared to other areas of Caatinga, where these values were calculated from the complete woody stratum (shrub and tree).

The species that stood out for IVI in the fragment under study were *Senna acuruensis*, *Sideroxylon obtusifolium*, *Mimosa tenuiflora*, *Pityrocarpa moniliformis* and *Bauhinia cheilantha*.

REFERENCES

Aguiar RB, Gomes, JRC. Groundwater Source Registration Project, Piauí: Diagnosis of the Municipality of São João do Piauí-PI-CPRM-Fortaleza, 2004.

Amorim I.L, Sampaio EVSB, Araújo EL (2005). Flora and structured shrub-tree vegetation of an area of Caatinga do Seridó, RN. Brazil. Brazilian Botanical Act, Porto Alegre, v. 19, no. 3, p. 615-623. https://doi.org/10.1590/S0102-33062005000300023.

Calixto Junior J.T, Drumond MA (2014). Comparative study of the phytosociological structure of two Caatinga fragments at different conservation levels. Brazilian Forest Research, Colombo, v. 34, no. 80, p. 345-355

Days PMS, Diodate MA, Grigio AM (2014). Phytosociological survey of forest remnants in the municipality of Mossoró-RN. Caatinga Magazine, Mossoró, v. 27, no. 4, p. 183-190.

Felfili J.M, Rezende RP. Concepts and Methods in Phytosociology. Brasília: UnB, Department of Forest Engineering, 2003. 68 p. (Forest Technical Communications).

Ferraz JSF, Albuquerque UP, Meunier IMJ (2006). Use value and structure of woody vegetation on the banks of Riacho do Navio, Floresta, PE, Brazil. Brazilian Botanical Act, v.19, n.1, p.125-134. http://dx.doi.org/10.1590/S0102-33062006000100012.

Giulietti AM, Bocage Neta AL, Castro AAJ, Rojas CFLG, Sampaio EVSB, Virgínio J, Harley, RM. Diagnosis of native vegetation of the Caatinga biome. In: SILVA, J. D., TABARELLI, M., FONSECA, M. D., & LINS, L. V. Caatinga Biodiversity: Priority Conservation Areas and Actions. Brasilia: Ministry of the Environment, 2004, p. 48-90.

Netherlands AC, Lima FTD, Silva BM, Dourado RG, Alves AR (2015). Vegetation structure in caatinga remnants with different disturbance histories in Cajazeirinhas (PB). Caatinga Magazine, Mossoró, v. 28, no. 4, p. 142 - 150. http://dx.doi.org/10.1590/1983-21252015v28n416rc.

We read JR, Rodal MJN (2002). Phytosociology of the woody component of a stretch of Caatinga vegetation in the Serra da Capivara Piauí National Park, Brazil. Minutes Bot Bras. v. 16, no. P. 23-42. http://dx.doi.org/10.1590/S0102-33062002000100005.

Birth HTS, Light KS, Wolff LF, Birth MPSCB, Oliveira ME. Semi-Arid Plants: Knowledge and Uses in Nesting Marrecas. Teresina: Embrapa Mid-North, 2008.

Oliveira PTB, DMBM Thunder, Carvalho ECD, Souza BC, Ferreira LMR (2009). Floristic and phytosociology of four vegetation remnants in mountainous areas in Paraíba cariri. Caatinga Magazine, Mossoró, v. 22, no. 4, p.169-178.

Taken from MAC, Andrade LA, Felix LP, Israel MP (2006). Effect of biological invasion of mesquite - Prosopis juliflora (Sw.) DC. About the composition and structure of the caatinga shrubby tree stratum in Monteiro, PB, Brazil. Brazilian Botanical Act, v. 20, no. 4. p.887-898. http://dx.doi.org/10.1590/S0102-33062006000400013.

Pereira Junior LR, Andrade AP, Araújo KD (2012). Floristic and phytosociological composition of a caatinga fragment in Monteiro, PB. Holos, v. 6, no. 2, p. 73-87. https://doi.org/10.15628/holos.2012.1188.

Rodal MJN, Andrade KVA, Sales MF, Gomes APS (1998). Phytosociology of the woody component of a vegetation refuge in the municipality of Buíque, Pernambuco. Brazilian Journal of Biology, v.58, n.3, p. 517-526.

Rodal MJN, Birth LM (2006). The arboreal component of a dry forest in northeastern Brazil. Brazilian Journal of Biology, v.66, no.2A, p.479-491.

Santos WS, Henriques IGN, Santos WS, Ramos GG, Vasconcelos GS, Vasconcelos ADM (2017b) Floristic-phytosociological analysis and logging potential in a caatinga area under forest management. Scientific Farming in the Semiarid, Ducks, v.13, n.3, p.213-211, 2017b.

Santos WS, Souza MP, Nobrega GFQ, Medeiros FS, Alves AR, Hokanda AC (2017a) Floristic-phytosociological characterization of the woody component In a caatinga fragment in the municipality of Upanema-RN. Native, Sinop, v.5, no.2, p.85-91. 10.5935 / 2318-7670.v05n02a02.

Souza JS, Espírito Santo FDB, Fontes AL AL, Oliveira-Filho AT, Botezelli L (2003). Analysis of floristic and structural variations of the tree community of a semideciduous forest fragment on the banks of the Capivari river, Lavras - MG. Tree Magazine, Viçosa, v.27, n.2, p.185-206.

Souza, P. F. Analysis of the vegetation of a caatinga fragment in the jatobá reservoir microbasin. Patos-PB, 2009. 51 p. Course conclusion work (Forest Engineering) - Federal University of Campina Grande, Patos, PB, 2009.

DMBM thunder. Phytosociology and Ecophysiological Aspects of the Woody Component in Caatinga Fragments in the Bodocongó River Basin - Paraíba. 2004. 108f. Thesis (Doctorate in Natural Resources) - UFCG, Campina Grande.

Vasconcelos ADM, Henriques IGN, Souza MP, Santos WS, Santos WS, Ramos GG (2017). Floristic and phytosociological characterization in Caatinga area for forest management purposes in São Francisco-PI. Scientific Farming in the Semiarid, Ducks, v.13, n.4, p.329-337.

Xavier EPL, Paes JB, Lira Filho JA (2005). Wood potential of two microregions of Paraíba State. Biomass and Energy, v.2, n.2, p. 103-112.

Zakia MJB, Pareyn FGC, Riegelhaupt E. Weight and Volume Equations for Eight Native Woody Species of Seridó-RN. In: Forest Management Plan for the Seridó-RN Region. ch. 4, v. 1, Christmas: Project UNDP / FAO / IBAMA / BRA / 87/007, 1988.

Prado, E. P., & Van Mier, J. G. M. (2003). Effect of particle structure on mode I fracture process in concrete. Engineering fracture mechanics, 70(14), 1793-1807.

Nascimento, J. M., Shi, L. Z., Tam, J., Chandsawangbhuwana, C., Durrant, B., Botvinick, E. L., & Berns, M. W. (2008). Comparison of glycolysis and oxidative phosphorylation as energy sources for mammalian sperm motility, using the combination of fluorescence imaging, laser tweezers, and real-time automated tracking and trapping. Journal of cellular physiology, 217(3), 745-751.

Dias, C., Ejtemai, O., Sarvi, M., & Burd, M. (2014). Exploring pedestrian walking through angled corridors. Transportation Research Procedia, 2, 19-25.

Leite, K. R., Reis, S. T., Junior, J. P., Zerati, M., de Oliveira Gomes, D., Camara-Lopes, L. H., & Srougi, M. (2015). PD-L1 expression in renal cell carcinoma clear cell type is related to unfavorable prognosis. Diagnostic pathology, 10(1), 189.