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Phytosociological survey of arboreous species in conserved and desertified areas in the semi-arid region of Paraíba, Brazil

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The objective of this study is to perform a phytosociological survey of the arboreous composition in conserved and desertified areas of the semiarid region of Paraiba State. Twenty-two conserved areas (CA) with native vegetation (Caatinga) where there has been no clear cut logging since 1984, and Twenty-two desertified areas (DA) having a difficult re-establishment of vegetal coverage over the past 10 years were selected. Plots with 100 m^2 were established and the species were identified. The perimeter at 0.30 m ground level (PGL) and at breast height, 1.30 m (PBH) was measured. Subsequently, the absolute density (AD), relative density (RD), absolute frequency (AF), relative frequency (RF), absolute dominance (ADo), relative dominance (RDo), importance value index (IVI) and coverage value index (CVI) were calculated. There were 63 species of trees in CA and 9 in DA. The most frequent species were *Caesalpinia pyramidalis* and *Croton sonderianus* in CA, and *Mimosa tenuiflora* and *Croton sonderianus* in DA. CA showed an AD (4,845 I ha^{-1}) higher than DA (895 I ha^{-1}). The ADo order was *C. pyramidalis* > *Anadenanthera colubrina* > *Myracrodruon urundeuva in* CA, and *M. tenuiflora* > *C. pyramidalis* > *Aspidosperma pyrifolium* in DA. *C. sonderianus* (CA) and *M. tenuiflora* (DA) reached the highest IVI and CVI.

Key words: Caatinga, vegetation, biodiversity, environmental quality.

INTRODUCTION

The desertification process triggers major changes in the floristic composition of the Caatinga (Sousa et al., 2015). This happens mainly due to anthropic actions known as deforestation for firewood purposes, exploration of clay deposits, and intensive use of the land through inappropriate agricultural mechanisms (cutting and

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burning), salinization, extensive grazing and overgrazing (Nimer, 1988; Galindo et al., 2008; Alves et al., 2009; Costa et al., 2009; Sá et al., 2010; Aquino and Oliveira, 2012). The adoption of strategies is mandatory to minimize this problem (Damasceno and Souto, 2014; Barros, 2011).

The impact of the anthropic action on the physiological dynamics of vegetation causes its features to change to an even lower and thinner Caatinga, with a severe selection of species (Alves, 2009). In this context, it is clear that the phytosociologycal survey provides information about the geographical distribution of the species and about the vegetation structure, depicting the impact of the anthropic action on the vegetation-soil-climate complex. This data can be used for action planning to preserve, conserve and recover the forest ecosystems (Chaves et al., 2013). This consequently leads to the development of more sustainable activities in the semi-arid areas.

Despite the importance of phytosociological studies, the studies carried out in Brazil are still insufficient, and a thorough analysis is necessary so actions on the conservation of natural resources can be taken (Freitas and Magalhães, 2012).

Considering the importance of the vegetal structure for planning the conservation and recovery of the natural resources and for the mitigation of the consequences of the desertification process, this study aimed to perform a phytosociological survey of tree layers in areas of conservation and desertification in the semi-arid region of Paraíba State.

MATERIALS AND METHODS

This study was carried out in 22 conserved areas (CA) and 22 desertified areas (DA) (Figure 1) of the semi-arid region of Paraíba State, Brazil, from October 2015 to May 2016. The region has a semi-arid climate, with a dry period of 6 to 11 months in 85.3% of the area (Nimer, 1979) where the annual precipitation is lower than 800 mm (Sousa et al., 2012).

The conserved areas (CA) were selected considering the non-occurrence of clear cutting since 1984, based on temporal images of the past 30 years, using the Landsat Annual Timelapse 1984-2012. Subsequently, the selected areas were compared with the images of the Landsat satellite 8, and confirmed in the field.

The desertified areas (DA) were selected considering the difficulty of the vegetation cover to re-establish, using temporal images (past 10 years) Landsat 7 (bands 3, 4 and 5) and 8 (bands 4, 5 and 6), with the help of the Earthengine. The period of the images is correspondent with the period of the highest rainfall and low incidence of clouds, which excludes water as a limiting factor for plant growth. After selecting the areas, based on remote sensing techniques, the next step was to locate them, by using Google Earth and Garmin 60CSX GPS navigation, and to evaluate the arboreous coverage of the field.

The evaluation of the arboreous vegetation was carried out in 100 m^2 (10 x 10 m) plots. In each plot, the identification of the arboreous species was based on regional knowledge, with the help of a local guide, and on literature (Lorenzi, 1992; Lorenzi, 1998, 2009; Siqueira Filho et al., 2009; NUPEEA, 2010; Castro and Cavalcante, 2011; INSA, 2011; Maia-Silva et al., 2012). Every tree whose base of the trunk was in the plot was included, even when the stem and canopy were over the borders.

After measuring the arboreal component, the following phytosociological parameters were calculated:

I - Absolute Density per area proportional (AD): represents the average number of trees of a given species, per unit of area (I ha^{-1}).

$$ADi = Ni / A \quad (1)$$

Where:
Ni = number of units of the species i;
A = total area sampled (ha).

II - Relative Density (RD): Percentage of the number of units of a given species in relation to the total number of sampled units.

$$RDi = (Ni \times 100)/n \quad (2)$$

Where:
Ni = number of units of the species i;
N = total number of units.

III - Absolute Frequency (AF): is the percentage of sample units with occurrence of the species, in relation to the total number of sample units.

$$AFi = (Pi \times 100)/P \quad (3)$$

Where:
Pi = number of plots in which the species occurred;
P = total number of plots.

III - Absolute Frequency (AF): is the percentage of plots with occurrence of the species, in relation to the total number of plots.

$$AFi = (Pi \times 100)/P \quad (4)$$

Where:
Pi = number of plots in which the species occurred;
P = total number of plots.

V - Relative Frequency (RF): obtained from the relationship between the absolute frequency of each species and the sum of the absolute frequencies of all sampled species.

$$RFi = (AFi \times 100) / \Sigma AFi \quad (5)$$

VI - Absolute Dominance (ADo): occupancy rate of the environment by units of a species (m^2 ha^{-1}), calculated from the sum of basal area.

$$ADoi= BAi / A \quad (6)$$

Where:
BAi = individual basal area of a species (m^2), based on the diameter of the stem from 0.3 m or 1.3 m of the ground, when the units were lower or taller than 1.3 m, respectively;
A = total sampled area (ha).

VII - Relative Dominance (RDo): represents the relationship between the basal area of a species and the total basal area of all sampled species.

$$RDo = (BAi/TBA) \times 100 \quad (7)$$

Where:
BAi = is the basal area of each unit of the species;

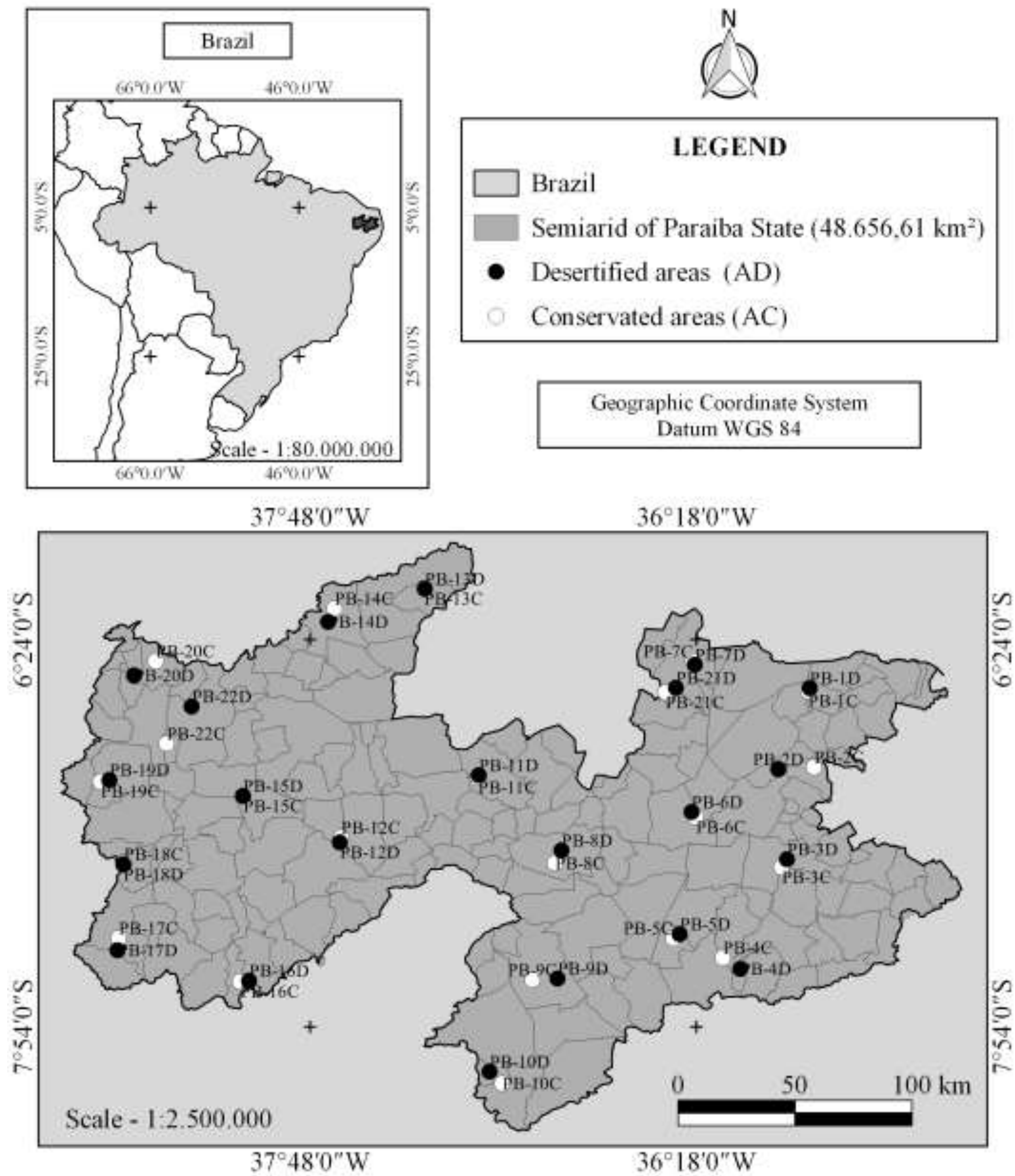

Figure 1. Geographic localization of the conserved (CA) and desertified areas (DA) in the semi-arid region of Paraíba State, Brazil.

TBA = is the sum of the basal areas of all species.

VIII - Importance Value Index (IVI): represents how well the species is established in the community. It is the result of the relative values already calculated for density, frequency and dominance, reaching, therefore, the maximum value of 300.

$$IVIi = RDi + RDoi + RFi \quad (8)$$

IX -Value of Coverage Index (VCI): is the sum of relative values and dominance of each species, up to a maximum value of 200.

$$VCIi = RDi + RDoi + RFi \quad (9)$$

RESULTS

The conserved areas had 5 to 17 species per plot, with an average value of 10 (±2.9), totaling 63 species (Table 1), while the desertified areas presented 1 to 4 species per plot, with an average value of 2 (±1.0), totaling 9 species (Table 2).

The most frequent species found in the conserved areas were *Caesalpinia pyramidalis* (77.3%), *Croton sonderianus* (77.3%), *Piptadenia stipulacea* (68.2%) and *Aspidosperma pyrifolium* (63.6%), while the remainder presented AF below 50% (Table 3). The most frequent species of trees found in the desertified areas were *Mimosa tenuiflora* (68.2%), *C. sonderianus* (31.8%), *C. pyramidalis* (31.8%), *Jatropha mollissima* (31.8%) and *A. pyrifolium* (18.8%) (Table 4).

The conserved areas presented a higher AD than the desertified areas, with 4,845 I ha^{-1} and 895 I ha^{-1} (Tables 3 and 4), respectively. *C. sonderianus* had the highest AD (1,345 I ha^{-1}) in the CA, followed by *C. pyramidalis* (573 I ha^{-1}). The highest AD the in DA were from *M. tenuiflora* (414 I ha^{-1}) and *C. sonderianus* (173 I ha^{-1}).

Regarding ADo, it was noted that *C. pyramidalis* (72.56 m^2 ha^{-1}), *Anadenanthera colubrina* (69.06 m^2 ha^{-1}), *Myracrodruon urundeuva* (49.06 m^2 ha^{-1}), *Schinopsis brasiliensis* (43.06 m^2 ha^{-1}), and *C. sonderianus* (21.56 m^2 ha^{-1}) showed the highest values in the conserved areas (Table 3). *M. tenuiflora* (9.87 m^2 ha^{-1}), *C. pyramidalis* (4.05 m^2 ha^{-1}), *A. pyrifolium* (2.52 m^2 ha^{-1}), *Prosopis juliflora* (2.43 m^2 ha^{-1}) and *J. mollissima* (0.92 m^2 ha^{-1}) (Table 4) had the highest ADo values in the desertified areas.

The species *C. sonderianus* (13.7%), *C. pyramidalis* (12.6%) and *A. colubrina* (8.0%) had the highest IVI in the CA, while *M. tenuiflora* (41.9%), *C. pyramidalis* (15.9%) and *C. sonderianus* (12.6%) showed the highest IVI in the AD (Tables 3 and 4, respectively).

The coverage value index (CVI) showed a pattern similar to IVI, with higher values for *C. sonderianus* (16.6%), *C. pyramidalis* (14.9%) and *A. colubrina* (9.7%) in AC, and *M. tenuiflora* (46.8%), *C. pyramidalis* (16.3%) and *C. sonderianus* (11.4%) in AD (Tables 3 and 4, respectively).

DISCUSSION

The diversity of species is the main feature that determines the ability of a system to survive during and after a period of adversity, that is, the resilience of the system (Salgado-Laboriau, 1994). In this context, we can say that the present anthropic activities promote the reduction of the arboreous diversity in the desertified areas, lowering, consequently, the environmental quality of the Caatinga biome in the semi-arid region of Paraíba State. This corroborates the work of Costa et al. (2009).

The anthropic action, in addition to reducing the number of species, also affects the distribution of those remaining in the desertified areas, affecting the emergence of those adapted to stricter requirements, such as *M. tenuiflora* (Lima, 1996), *J. molissima*, *A. pyrifolium* and *C. pyramidalis* (Silva et al., 2004). It is also noted that some characteristics of the former three species reduce the impacts of pressure of use by population and by domestic animals (Souza et al., 2015), showing low density for building and firewood usage, or toxicity to animal consumption (Souza, 2008; Lima and Soto-Blanco, 2010; Dantas et al., 2012).

The highest AD in conserved areas suggests a greater protection of the soil against erosion processes, especially by water, decreasing soil and nutrients losses (Martin Filho et al., 2009; Ramos et al., 2014), and consequently increasing the vegetation resilience. The highest density of species in conserved areas also increases the production of litter, levels of organic matter, infiltration capability and storage of water in the soil, thus reducing the susceptibility to water scarcity (Mendonça et al., 2009). The highest values of ADo of the species in CA relate to a number of factors, including the potential of some species, such as *M. urundeuva* and *A. colubrina*, which can reach 14 and 15 m in height in the Caatinga (Lorenzi, 1992). Other factors are better conditions for plant growth and development, as previously seen, and time to accumulate biomass, as these areas did not suffer clear cutting for at least 32 years. Although *C. pyramidalis* reaches only 10 m high, that is, 66% of *M. urundeuva*'*s* and *A. colubrina*'s height, it has characteristics that counterbalance that of the latter in biomass production, such as tolerance to periods of water stress (xerophile) and easy regeneration after cutting (Lorenzi, 2002; Lorenzi, 2009). In the DA, the best-adapted species to the water stress conditions reached the highest values of ADo. The species adapted to these conditions have some advantages in relation to those not adapted, which tend to face greater difficulties to getting established and disseminated. The IVI expresses numerically the importance of a given species amongst the trees of a community (Poggiani et al., 1996). Therefore, the maximum value of 13.7% (*C. sonderianus*) indicates a better distribution of the IVI amongst the species in the conserved areas, that is, a better balance between the species and, consequently, a higher quality of vegetation. Regarding DA, *M. tenuiflora*'*s* IVI of 41.9% points this species out as the most ecologically important for this environment, corroborating data from Freitas et al. (2007). According to this author, *M. tenuiflora*'s ability to dominate the environment is due to its high capacity to regrow, revealing a good adaptation to the degraded environments of the Caatinga.

The parameter CVI conveys the ecological importance of the species in horizontal distribution terms so that the maximum value of 16.6% (*C. sonderianus*) also gives evidence of a more balanced importance among the species in the CA than in the DA. As much as the IVI, this parameter reflects the effect of the anthropic action in the Caatinga biome, where the number of arboreous species is low and where there is an environmental imbalance, a more severe water scarcity and the predominance of species more adapted to these desertified conditions.

Conclusions

The process of desertification reduces the diversity of the arboreous species in the semi-arid region of Paraíba

Table 1. Number of species and plants from each species, in the conserved areas of the semi-arid region of Paraíba State.

No.	Species	Plot - PB																					
		1C	**2C**	**3C**	**4C**	**5C**	**6C**	**7C**	**8C**	**9C**	**10C**	**11C**	**12C**	**13C**	**14C**	**15C**	**16C**	**17C**	**18C**	**19C**	**20C**	**21C**	**22C**
1	*Amburana cearensis* (Fr. Al.) A. C. Smith	1	0	1	0	0	0	0	3	0	0	0	0	0	1	1	1	0	2	0	2	0	0
2	*Anadenanthera colubrina* (Vell) Brenan	0	0	1	0	0	0	0	0	2	4	0	0	3	1	2	0	6	3	0	2	0	1
3	*Annona leptopetala* (R.E.Fr.) H.Rainer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
4	*Aspidosperma pyrifolium* Mart.	0	6	2	11	10	2	1	0	7	7	24	9	3	0	0	0	0	0	0	1	1	3
5	*Astronium graveolens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
6	*Bauhinia cheilantha* (Bong.) Steud.	0	1	1	0	0	0	0	0	0	2	0	0	0	15	1	10	2	6	0	0	2	0
7	*Bauhinia forficata* Link	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
8	*Caesalpinia ferrea* Mart. ex Tul. var. ferrea	0	0	0	0	0	0	0	0	4	2	0	0	13	1	0	0	0	0	0	0	0	0
9	*Caesalpinia pyramidalis* Tul.	1	4	18	11	5	6	15	4	1	2	0	12	0	8	5	8	11	0	0	10	5	0
10	*Capparis flexuosa* L.	0	0	0	4	0	0	0	0	1	0	0	1	0	0	0	0	3	0	1	0	0	0
11	*Capparis yco*	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	*Cedrela odorata* L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
13	*Chloroleucon dumosum* (Benth.) G.P.Lewis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
14	*Combretum glaucocarpum* Mart.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	16	4	2	0	0	0
15	*Combretum leprosum* Mart.	0	0	0	0	0	0	0	2	0	0	3	2	0	0	5	0	0	0	1	2	0	1
16	*Commiphoraâ leptophloeos*-(Mart.) J.B. Gillett	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	3	0
17	*Cordia trichotoma*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0
18	*Coutarea hexandra* (Jacqu.) Schum.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
19	*Croton sp.*	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	*Croton nepetifolius* Baill.	0	0	0	0	0	14	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
21	*Croton rhamnifolioides* Pax & Hoffm	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
22	*Croton sonderianus* Muell. Arg.	0	0	6	6	28	1	27	17	0	0	8	12	31	27	39	11	6	19	26	25	7	0
23	*Desmodium tortuosum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
24	*Eremanthus arboreus* (Gardner) MacLeis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
25	*Erythroxylum plungens*	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
26	*Erythroxylum sp. 1*	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	*Erythroxylum sp. 2*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
28	*Fagara rhoifolia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
29	*Genipa americana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
30	*Guapira opposita* (Vell.) Reitz	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
31	*Jatropha mollissima* (Pohl.) Baill	4	0	0	1	1	1	2	0	0	2	0	0	0	0	0	0	0	0	0	0	4	0
32	*Libidibia ferrea* (Mart. ex Tul.) L.P.Queiroz	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
33	*Luetzelburgia auriculata* Duck	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
34	*Manihot dichotoma* Ule	0	0	2	0	1	0	5	2	0	0	0	0	0	2	0	1	0	0	0	0	1	0
35	*Maytenus rigida*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1. Contd.

36	*Mimosa arenosa* (Willd.) Poir	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	*Mimosa ophthalmocentra* Mart. ex Benth	0	0	1	0	0	18	0	1	1	4	0	0	0	0	0	0	0	0	0	0	0	0
38	*Mimosa tenuiflora* (Willd.) Poir	0	0	0	0	0	0	0	2	0	0	14	2	3	0	0	0	0	0	0	0	0	0
39	*Myracrodruon urundeuva* Fr. All.	0	0	0	0	1	1	0	0	7	0	0	0	0	0	4	2	0	0	5	2	0	0
40	Not Identified 1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	Not Identified 2	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
42	Not Identified 3	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	Not Identified 4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	Not Identified 5	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
45	Not Identified 6	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
46	Not Identified 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	13	0	0	0	0
47	Not Identified 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0
48	*Parapiptadenia zehntneri* (Harms)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
49	*Piptadenia stipulacea* (Benth.) Ducke	12	9	0	11	3	0	2	1	0	3	0	0	0	5	4	2	0	13	17	1	9	2
50	*Piptadenia viridiflora* (Benth.)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	*Pisonia tomentosa* Casar	0	1	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	*Pseudobombax marginatum* (A. St.-Hil., J. & C.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
53	*Randia armata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
54	*Sapium glandulatum* Pax	4	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	*Schinopsis brasiliensis* Engl.	3	2	0	3	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
56	*Senegalia tenuiflora* (L.) Britton & Rose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0
57	*Senna trachypus* (Benth.) H.S.Irwin & Barneby	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
58	*Sideroxylon obtusifolium* (H. ex. R. & S.)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
59	*Spondias tuberosa L.*	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	*Tabebuia impetiginosa*	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	*Tocoyena brasiliensis* Mart.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
62	*Ximenia americana* L.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	*Ziziphus joazeiro* Mart.	15	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	2	2	0	1
Total number of plants per plot		**41**	**26**	**65**	**48**	**49**	**45**	**71**	**33**	**45**	**31**	**52**	**38**	**53**	**71**	**63**	**43**	**49**	**73**	**58**	**49**	**32**	**25**
Total species in each plot		**8**	**9**	**17**	**8**	**7**	**9**	**13**	**9**	**12**	**13**	**5**	**6**	**5**	**10**	**10**	**12**	**9**	**13**	**10**	**11**	**8**	**12**

State. The most frequent species in the conserved areas are *Caesalpinia pyramidalis* (77.3%), *Croton sonderianus* (77.3%), *Piptadenia stipulacea* (68.2%) and *Aspidospermapyrifolium* (63.6%), while in the desertified areas *Mimosa tenuiflora* (68.2%), *C. sonderianus* (31.8%), *C. pyramidalis* (31.8%) and *Jatropha mollissima* (31.8%) are more frequent.*C. sonderianus, J. mollissima, Caesalpinia pyramidalis* and *Aspidosperma pyrifolium* both occur in conserved and desertified areas.

The absolute density (AD) in the conserved areas is higher than in the desertified, reaching 4,845 I ha^{-1} and 895 I ha^{-1}, respectively. The absolute dominance (ADo) followed the order

Table 2. Number of species and plants from each species, in the desertified areas of the semi-arid region of Paraíba State.

No.	Species	Plot - PB																					
		1D	2D	3D	4D	5D	6D	7D	8D	9D	10D	11D	12D	13D	14D	15D	16D	17D	18D	19D	20D	21D	22D
1	*Aspidosperma pyrifolium* Mart.	0	0	0	0	3	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
2	*Caesalpinia pyramidalis* Tul.	0	2	0	9	6	1	5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
3	*Croton sonderianus* Muell. Arg.	0	25	0	1	0	0	0	0	2	0	0	0	0	0	0	0	4	1	0	2	0	3
4	*Jatropha mollissima* Muell. Arg.	0	1	0	3	3	2	2	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0
5	*Libidibia ferrea* (Mart. ex Tul.) L.P.Q.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0
6	*Mimosa tenuiflora* (Willd.) Poir	0	0	29	0	0	0	2	0	1	0	1	6	8	2	3	1	1	8	10	2	7	5
7	*Piptadenia viridiflora* (Benth.)	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	*Prosopis juliflora* (Sw.) DC.	0	0	0	0	0	1	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
9	*Solanum paniculatum*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of plants per plot		**9**	**28**	**29**	**13**	**12**	**4**	**10**	**4**	**11**	**2**	**1**	**6**	**8**	**2**	**5**	**2**	**5**	**10**	**10**	**4**	**7**	**10**
Total species in each plot		**2**	**3**	**1**	**3**	**3**	**3**	**4**	**3**	**4**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**3**	**1**	**2**	**1**	**3**

Table 3. Phytosociologycal parameters of tree species in the conserved areas of the semi-arid region of Paraíba, Brazil.

No.	Scientific Name	Common Name	NPE	NP	AD (I ha^{-1})	RD (%)	AF (%)	RF (%)	ADo (m^2 ha^{-1})	RDo (%)	IVI	IVI (%)	CV	CV (%)
1	*Amburana cearensis* (Fr. Al.) A. C. Smith	Cumarú	8	12	55	1.1	36.4	3.7	11.96	3.0	7.79	2.6	4.09	2.0
2	*Anadenanthera colubrina* (Vell) Brenan	Angico	10	25	114	2.3	45.5	4.6	69.06	17.1	24.09	8.0	19.46	9.7
3	*Annona leptopetala* (R.E.Fr.) H.Rainer	Bananinha	1	1	5	0.1	4.5	0.5	0.05	0.0	0.57	0.2	0.11	0.1
4	*Aspidosperma pyrifolium* (Mart.)	Pereiro	14	87	395	8.2	63.6	6.5	20.39	5.1	19.70	6.6	13.22	6.6
5	*Astronium graveolens*	Gonçalo Alves	1	10	45	0.9	4.5	0.5	1.78	0.4	1.84	0.6	1.38	0.7
6	*Bauhinia cheilantha* (Bong.) Steud.	Mororó	9	40	182	3.8	40.9	4.2	3.92	1.0	8.89	3.0	4.72	2.4
7	*Bauhinia forficata* Link	Mororó de espinho	1	1	5	0.1	4.5	0.5	< 0.01	< 0.1	0.56	0.2	0.09	0.0
8	*Libidibia ferrea* (Mart. ex Tul.)	Jucá	4	20	91	1.9	18.2	1.9	8.43	2.1	5.82	1.9	3.96	2.0
9	*Caesalpinia pyramidalis* (Tul.)	Catingueira	17	126	573	11.8	77.3	7.9	72.56	18.0	37.68	12.6	29.81	14.9
10	*Capparis flexuosa* L.	Feijão bravo	5	10	45	0.9	22.7	2.3	0.51	0.1	3.38	1.1	1.06	0.5
11	*Capparis yco*	Icó	1	2	9	0.2	4.5	0.5	0.22	0.1	0.71	0.2	0.24	0.1
12	*Cedrela odorata* L.	Cedro	1	2	9	0.2	4.5	0.5	8.56	2.1	2.77	0.9	2.31	1.2
13	*Chloroleucon dumosum* (Benth.) G.P.Lewis	Arapiraca branca	2	2	9	0.2	9.1	0.9	0.28	0.1	1.18	0.4	0.26	0.1
14	*Combretum glaucocarpum* (Mart.)	Sipaúba	4	23	105	2.2	18.2	1.9	1.49	0.4	4.38	1.5	2.53	1.3
15	*Combretum leprosum* (Mart.)	Mofumbo	7	16	73	1.5	31.8	3.2	1.26	0.3	5.05	1.7	1.81	0.9
16	*Commiphora leptophloeos* (Mart.) J.B. G.	Imburana	5	8	36	0.8	22.7	2.3	4.82	1.2	4.26	1.4	1.95	1.0
17	*Cordia trichotoma*	Freijorge	2	3	14	0.3	9.1	0.9	0.91	0.2	1.43	0.5	0.51	0.3
18	*Coutarea hexandra* (Jacqu.) Schum.	Quina quina	1	1	5	0.1	4.5	0.5	< 0.01	< 0.1	0.56	0.2	0.09	0.0
19	*Croton nepetifolius* Baill.	Marmeleiro branco	2	24	109	2.3	9.1	0.9	0.43	0.1	3.28	1.1	2.36	1.2

Table 3. Contd.

20	*Croton rhamnifolioides* (Pax & Hoffm)	Catinga branca	1	8	36	0.8	4.5	0.5	0.56	0.1	1.35	0.5	0.89	0.4
21	*Croton sonderianus* (Muell. Arg.	Marmeleiro	17	296	1345	27.8	77.3	7.9	21.56	5.3	40.98	13.7	33.11	16.6
22	*Croton* sp.	Not identified	1	2	9	0.2	4.5	0.5	0.34	0.1	0.73	0.2	0.27	0.1
23	*Desmodium tortuosum*	Rapadura de cavalo	1	1	5	0.1	4.5	0.5	0.01	< 0.1	0.56	0.2	0.10	0.0
24	*Eremanthus arboreus* (Gardner) MacLeis	Candeeiro	1	1	5	0.1	4.5	0.5	0.08	< 0.1	0.58	0.2	0.11	0.1
25	*Erythroxylum* sp. 1	Not identified	1	5	23	0.5	4.5	0.5	0.29	0.1	1.00	0.3	0.54	0.3
26	*Erythroxylum* sp. 2	Not identified	1	4	18	0.4	4.5	0.5	0.09	< 0.1	0.86	0.3	0.40	0.2
27	*Erythroxylum plungens*	Rompe-gibão	1	3	14	0.3	4.5	0.5	0.20	< 0.1	0.79	0.3	0.33	0.2
28	*Fagara rhoifolia*	Limãozinho	1	1	5	0.1	4.5	0.5	0.04	< 0.1	0.57	0.2	0.10	0.1
29	*Genipa americana*	Genipapo	1	2	9	0.2	4.5	0.5	0.58	0.1	0.79	0.3	0.33	0.2
30	*Guapira opposita* (Vell.) Reitz	Pau piranha	2	3	14	0.3	9.1	0.9	1.08	0.3	1.48	0.5	0.55	0.3
31	*Jatropha mollissima* (Pohl.) Baill	Pinhão bravo	7	14	64	1.3	31.8	3.2	1.08	0.3	4.82	1.6	1.58	0.8
32	*Libidibia ferrea* (Mart. ex Tul.) L.P.Queiroz	Pau Ferro	2	2	9	0.2	9.1	0.9	0.83	0.2	1.32	0.4	0.39	0.2
33	*Luetzelburgia auriculata* (Duck)	Pau serrote	1	1	5	0.1	4.5	0.5	0.11	< 0.1	0.59	0.2	0.12	0.1
34	*Manihot dichotoma* Ule	Maniçoba	7	13	59	1.2	31.8	3.2	5.66	1.4	5.86	2.0	2.62	1.3
35	*Maytenus rigida*	Bom-nome	1	1	5	0.1	4.5	0.5	< 0.01	< 0.1	0.56	0.2	0.09	0.0
36	*Mimosa arenosa* (Willd.) Poir	Mimosa calumbi	2	2	9	0.2	9.1	0.9	1.98	0.5	1.60	0.5	0.68	0.3
37	*Mimosa ophthalmocentra* Mart. ex Benth	Jurema de imbira	5	25	114	2.3	22.7	2.3	1.40	0.3	5.01	1.7	2.69	1.3
38	*Mimosa tenuiflora* (Wild.) Poir	Jurema preta	4	21	95	2.0	18.2	1.9	15.86	3.9	7.75	2.6	5.90	3.0
39	*Myracrodruon urundeuva* Fr. All.	Aroeira	7	22	100	2.1	31.8	3.2	49.06	12.2	17.47	5.8	14.23	7.1
40	Not Identified 1	Papaconha	1	1	5	0.1	4.5	0.5	0.03	< 0.1	0.56	0.2	0.10	0.1
41	Not Identified 2	Quebra-faca 1	2	10	45	0.9	9.1	0.9	1.27	0.3	2.18	0.7	1.25	0.6
42	Not Identified 3	Not identified	1	3	14	0.3	4.5	0.5	0.05	< 0.1	0.76	0.3	0.29	0.1
43	Not Identified 4	Not identified	1	10	45	0.9	4.5	0.5	0.05	< 0.1	1.41	0.5	0.95	0.5
44	Not Identified 5	Goiabinha	2	2	9	0.2	9.1	0.9	0.08	< 0.1	1.13	0.4	0.21	0.1
45	Not Identified 6	Canela de veado	1	8	36	0.8	4.5	0.5	1.45	0.4	1.57	0.5	1.11	0.6
46	Not Identified 7	Quebra-faca 2	1	13	59	1.2	4.5	0.5	0.85	0.2	1.89	0.6	1.43	0.7
47	Not Identified 8	Casca de tatu	2	10	45	0.9	9.1	0.9	0.88	0.2	2.08	0.7	1.16	0.6
48	*Parapiptadenia zehntneri* (Harms)	Angico-monjolo	2	2	9	0.2	9.1	0.9	1.99	0.5	1.61	0.5	0.68	0.3
49	*Piptadenia stipulacea* (Benth.) Ducke	Jurema branca	15	95	432	8.9	68.2	6.9	16.66	4.1	19.99	6.7	13.04	6.5
50	*Piptadenia viridiflora* (Benth.)	Amorosa branca	1	1	5	0.1	4.5	0.5	0.08	< 0.1	0.58	0.2	0.11	0.1
51	*Pisonia tomentosa* (Casar)	João mole	3	12	55	1.1	13.6	1.4	1.83	0.5	2.97	1.0	1.58	0.8
52	*Pseudobombax marginatum* (J. & C.)	Embiratanha	1	1	5	0.1	4.5	0.5	0.21	0.1	0.61	0.2	0.15	0.1
53	*Randia armata*	Espinho de judeu	1	1	5	0.1	4.5	0.5	7.28	1.8	2.36	0.8	1.90	0.9
54	*Sapium glandulatum* (Pax)	Burra leiteira	5	8	36	0.8	22.7	2.3	6.13	1.5	4.58	1.5	2.27	1.1
55	*Schinopsis brasiliensis* (Engl.)	Baraúna	5	10	45	0.9	22.7	2.3	46.34	11.5	14.74	4.9	12.43	6.2
56	*Senegalia tenuiflora* (L.) B & R.	Unha de gato	2	5	23	0.5	9.1	0.9	0.07	< 0.1	1.41	0.5	0.49	0.2

Table 3. Contd

57	*Senna trachypus* (Benth.) H.S.I. & B.	Canafístula	1	1	5	0.1	4.5	0.5	< 0.01	< 0.1	0.56	0.2	0.09	0.0
58	*Sideroxylon obtusifolium* (H. ex. R. & S.)	Quixaba	1	1	5	0.1	4.5	0.5	0.11	< 0.1	0.58	0.2	0.12	0.1
59	*Spondias tuberosa* (L.)	Umbú	1	5	23	0.5	4.5	0.5	1.29	0.3	1.25	0.4	0.79	0.4
60	*Tabebuia impetiginosa*	Ipê roxo	1	2	9	0.2	4.5	0.5	0.16	< 0.1	0.69	0.2	0.23	0.1
61	*Tocoyena brasiliensis* (Mart.)	Genipapinho	1	1	5	0.1	4.5	0.5	0.00	< 0.1	0.56	0.2	0.09	0.0
62	*Ximenia americana* (L.)	Ameixa do mato	1	1	5	0.1	4.5	0.5	0.02	< 0.1	0.56	0.2	0.10	0.0
63	*Ziziphus joazeiro* (Mart.)	Juazeiro	5	23	105	2.2	22.7	2.3	9.18	2.3	6.75	2.2	4.43	2.2
Total sum				1066	4,845	100	981.8	100	403.42	100	300	100	200	100

NPIS = number of plots with the species; NPS = number of plants of the species i; AD = absolute density; RD = relative density; AF = absolute frequency; RF= relative frequency; ADo = absolute dominance; RDo = relative dominance; VI = value of importance; VI % = value of importance in percentage and VC = value of coverage; Total plot assessed= 22.

Table 4. Phytosociological survey of tree species in the conserved areas of the semi-arid region of Paraíba, Brazil.

No.	Scientific Name	Common Name	NPIS	NPS	AD (I ha^{-1})	RD (%)	AF (%)	RF (%)	ADo (m^2 ha^{-1})	RDo (%)	IVI	IVI (%)	CVI	CVI (%)
1	*Aspidosperma pyrifolium* (Mart.)	Pereiro	4	7	32	3.55	18.2	8.5	2.52	12.1	24.18	8.1	15.67	7.8
2	*Caesalpinia pyramidalis* (Tul.)	Catingueira	7	26	118	13.20	31.8	14.9	4.05	19.5	47.57	15.9	32.67	16.3
3	*Croton sonderianus* (Muell. Arg.)	Marmeleiro	7	38	173	19.29	31.8	14.9	0.73	3.5	37.69	12.6	22.79	11.4
4	*Jatropha mollissima* (Muell. Arg.)	Pinhão bravo	7	18	82	9.14	31.8	14.9	0.92	4.4	28.43	9.5	13.54	6.8
5	*Libidibia ferrea* (Mart. ex Tul.) L.P.Q.	Pau Ferro	2	3	14	1.52	9.1	4.3	0.16	0.8	6.53	2.2	2.27	1.1
6	*Mimosa tenuiflora* (Wild.) Poir	Jurema preta	15	91	414	46.19	68.2	31.9	9.87	47.5	125.59	41.9	93.68	46.8
7	*Piptadenia viridiflora* (Benth.)	Amorosa branca	1	8	36	4.06	4.5	2.1	0.12	0.6	6.76	2.3	4.63	2.3
8	*Prosopis juliflora* (Sw.) DC.	Algaroba	3	5	23	2.54	13.6	6.4	2.43	11.7	20.62	6.9	14.23	7.1
9	*Solanum paniculatum*	Jurubeba	1	1	5	0.51	4.5	2.1	< 0.01	< 0.1	2.64	0.9	0.51	0.3
Total sum				197	895	100	214	100	20.78	100	300	100	200	100

NPI = number of plots with the species; NPS = number of plants of the species i; AD = absolute density; RD = relative density; AF = absolute frequency; RF = relative frequency; ADo = absolute dominance; RDo = relative dominance; VI = value of importance; VI% = value of importance in percentage and VC = value of coverage; Total plot = 22.

C. pyramidalis (72.56 m^2 ha^{-1}) > *Anadenanthera colubrina* (69.06 m^2 ha^{-1}) > *Myracrodruon urundeuva* (49.06 m^2 ha^{-1}) in the conserved areas, and *Mimosa tenuiflora* (9.87 m^2 ha^{-1}) > *C. pyramidalis* (4.05 m^2 ha^{-1}) > and *A. pyrifolium* (2.52 m^2 ha^{-1}) in the desertified areas.

The highest importance value index (IVI) and coverage value index (CVI) were observed for *C. sonderianus* (13.7 and 16.6%) and *M. tenuiflora* (41.9 and 46.8%), in the conserved and desertified areas, respectively, indicating a more balanced importance between the species in the conserved areas.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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