# Structure and use of a rocky Cerrado in northeastern Brazil: Does the ecological appearancy hypothesis explain this relationship?


## ABSTRACT

The aim of this study was to characterize the vegetation structure of a low-altitude rupestrian Cerrado in the state of Piauí and to evaluate its economic exploitation by the population. The research was developed in the Castelo do Piauí. Vegetation sampling was performed by the Minimum Phytosociological Assessment Protocol (MPAP). The phytosociological parameters were obtained through the Software R. The use of the species was surveyed through interviews with the community, after which the value of use was analyzed and the hypothesis of the ecological appearancy was tested. In all 73.7% of the species found are useful for the community and the timber category was the most prominent. The hypothesis of the ecological appearancy showed a negative relation between the use and some phytosociological parameters.



*Keywords: Biodiversity, potentiality, Ethnobotany.*




## 1. INTRODUCTION

Studies have demonstrated a strong tendency to associate the utilitarian potential of plant species to their availability in nature, through the application of ecological appearancy hypothesis test, which deduces that the plants with greater dominance and frequency in a region will have the highest usage values for the population, since, they are in greater availability [1,2]. In Brazil, one of the largest floristic domains is the Cerrado, a vegetation complex with a large geographic distribution and a large phytophysiognomic variation that occupies approximately 22% of the Brazilian territory [3], however; today it presents about 50% of its primary form [4]. It is present in four of the five regions of the country and in the state of Piauí, due to its marginal position in relation to the central Cerrado, it presents a rich type and ecosystem diversity, mainly in the ecotone regions [5,6].

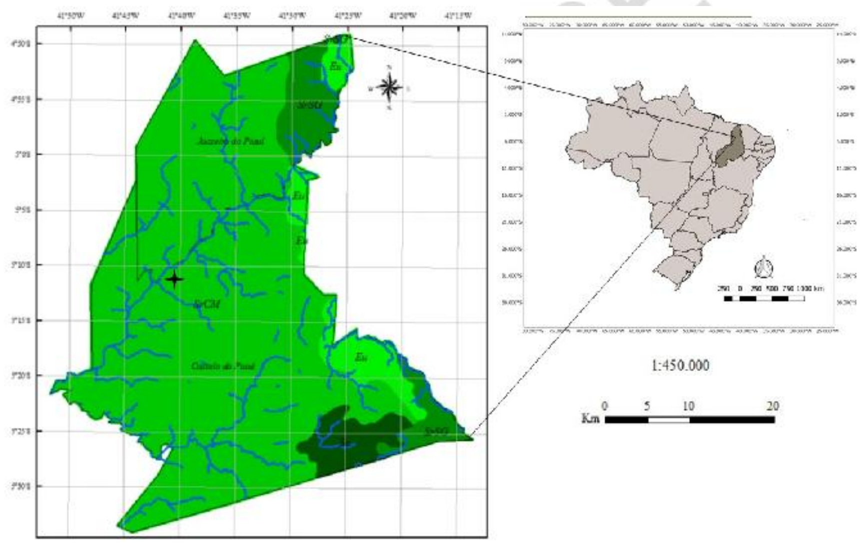
One of the types of Cerrado present in Piauí is the northern low altitude rocky of the northeast [5], which has vegetation in an insular form and is restricted to rocky outcrops of quartzite or arenite origin, usually located around 200-300 meters in sea level, mainly in the Complex of Campo Maior and region of influence of the Poti Canyon [6,7]. This vegetative complex, like the Cerrado, is full of possibilities for the use of plant resources due to its vast plant richness, considered as "plants of the future", which can play an important economic and subsistence role due to their potential use diversity, and food security in the face of climate change[8].

This large supply of resources can be used by the population to meet daily needs, and for this to occur, species are classified according to their properties of use, considering parameters such as medicinal, nutritional, quality for use in firewood or charcoal vegetables, loggers among others [1,9]. Recognizing this great plant richness of Northeast Cerrado in Brazil and its potential for use [9], this study aims to characterize the vegetation structure of the low altitude cave in the municipality of Castelo do Piauí, Brazil, evaluating the use of this vegetation by the population and applying the ecological appearancy hypothesis test.

## 2. MATERIAL AND METHODS

The research was developed in a rocky Cerrado area of low altitude located in the Canyon of Poti region, municipality of Castelo do Piauí (Figure 01), distant 175 km from capital of the state Piauí, Teresina. With a location situated under the coordinates 05°10'20 '' S and 41° 42'12 '' W, and average altitude of 200 m. The municipality is limited to the Piaui municipalities of Pedro II to the north, São Miguel do Tapuio to the south, Juazeiro do Piauí, Alto Longá and São João da Serra to the west and to the east with the litigation area between Piauí and Ceará [10]. The region presents a tropical climate alternating between wet and dry, the last with a period of five to eight months, the region has an average annual rainfall ranging from 769 mm to 1,369 mm, with a rainfall average of 996 mm and rainfall between 1,100 to 1,200 mm, with an evapotranspiration range between 1,500 and 1,600 [10].

**Fig 01. Map of the study area with vegetation (green), bodies of water (blue) and sample area (black star). Castelo do Piauí, Brazil. Adapted from Santos (2014).**




The geomorphology of the Canyon region of the Poti is characterized as disimetric relief, formed by a concave profile in steep slope and the other side by sedimentary plateau gently inclined due to the context of the Plateau of Ibiapaba. In areas with vegetation of rupestrian Cerrado prevail the Litolic Neosoils [11]. The vegetation is marked by herbaceous-arboreal and wellspaced plants. The tree physiognomy presents itself with a more dense and low to medium distribution, present between drainage lines on and between rocky outcrops in gently accented areas [7].

The quantitative study was carried out based on the Protocol of Minimum Phytosociological Assessment (PMPA) [12], with the use of 17 rectangular plots of 20x30 m (600 m²). The sample units (plots) were oriented in the same direction, determined by a precision compass. For each plot, the geographical coordinates were taken with the use of GPS (Global Position System) and altitudes, with a precision altimeter always on the first stake, relative to the initial marking point of each plot.

For the survey, it was sampled all living trees and shrubs contained in plots with stem diameter at ground level (DNS) ≥ 3 cm. For each individual selected by the inclusion criterion, the diameter of the stem and its total height was registered. Samples identification was carried out through consultations to the specific literature and comparisons to the Graziela Barroso Herbarium collection (UFPI). The botanical classification system used was the "Angiosperm Phylogeny Group" [13].

For evaluation of economic categories, structured interviews were conducted with questions directed to the exploration of the plant species found in the phytosociological survey, identifying their utilities, such as food, fuel, logging, fodder and medicinal, categorized according to the literature [1].

All residences belonging to the community were visited, for each household were interviewed two adults residing in the house. A total of nine houses were visited, comprising a sample of 18 interviewees. The study was approved by the Ethics and Research Committee (CEP) from the Federal University of Piauí (CAAE 66578317.4.0000.5214). Prior to its application, the objectives of the research were clarified and subsequently asked those who accepted to participate to sign or register their fingerprint with the Free and Informed Consent Form, according to the ethical requirements of the National Health Council through the Ethics Committee in Search (Resolution 466/12).

The phytosociological parameters (absolute density, absolute dominance, absolute frequency and Importance value). For the analysis of plant diversity, the Shannon index (H') was used with the Software R. Due to the fact that each informant was consulted only once, the use value adapted from (14), where the usage value of the species was calculated by the ratio between the sum of the citations of use for a given species and the total number of informants [2]. In order to test the hypothesis of ecological appearancy, a Pearson Linear Correlation Coefficient was performed to determine if there is a relationship between the importance value index (IV) of phytosociology and the value of use (UV), both continuous variables. All analyzes were performed in the Software R [2].

## 3. RESULTS AND DISCUSSION

In the survey, 1,560 individuals of 35 species were recorded in 15 families (Table 1). The greater representativeness of species is distributed among families: Fabaceae (11), Bignoniaceae (3), Apocynaceae (3) and Vochysiaceae (3). With the latter being the most representative (837 individuals), occupying 53.7% of the entire area, with a frequency of 100%. The area has an estimated density of 9.5 ind m² $ha^{-1}$ and the basal area of 16.6 m² $ha^{-1}$. The eight most abundant species were *Qualea parviflora* Mart. (DA=671.5), *Callisthene fasciculata* Mart. (DA=126.4), *Krameria tomentosa* A.St.-Hil (DA=110.7), *Psidium myrsinites* DC. (DA=100.9), *Curatella americana* L. (DA=87.2), *Annona leptopetala* (R.E. Fries) H. Rainer (DA=58.8), *Byrsonima correaefolia* A. Juss (DA=51.9) and *Byrsonima crassifolia* L. (DA=45.0) (Table 2).

**Table 1. Indices of floristic diversity and vegetation structure, considering individuals with DNS ≥ 3 cm in Castelo do Piauí, Brazil.**

| Parameter | Vegetation sampled |
|---|---|
| Area (ha) | 1.2 |
| Number of Families | 15 |
| Species richness | 37 |
| Absolute density (ha-1) | 9.5 |
| Basal area (m² ha-¹) | 16.6 |
| Shannon (H') | 2.25 |

The diversity found in the area was higher than some work done in low altitude rock Cerrados in the state of Piauí [7,15] (22 species and 14 families), and lower in relation to work done in Cerrado rock areas with higher altimetric heights, such as in the survey of the Serra de Caldas Novas State Park, Goiás, which found 66 species, distributed in 53 genera and 31 families [16] and transition area of Cerrado/Amazon rainforest, with 85 species, 67 genders and 34 families [17]. This diversity variation between the Rocky Cerrado (low altitude and high altitude) can be attributed mainly to factors of climate and relief, since the Brazilian rock fields were classified as a seasonal rocky mosaic inserted in a matrix of high altitude varied vegetation, which is influenced by the annual rainfall [18]. These changes in climate and landscape influence the availability of resources and consequently the community structuring pattern in those regions [19].

In the studies carried out in Brazilian rupestrian areas [16,17,20,21], Fabaceae was also the most diverse family. This family has been distinguished in several plant phytophysiognomies in Brazil [22], showing a family very adapted to the environmental heterogeneity of the south America [23]. It is also known with the Vochysiaceae family, which is one of the most common in Cerrado areas, since some species of this family are aluminum accumulators, which favors their growth in Cerrado acid soils [24]. The value of the Shannon Diversity Index was considered high in relation to that obtained by Coutinho and Castro [7] in rocky Cerrado areas with up to 500 meters at sea level in the state of Piauí.

When analyzed the absolute frequency of species, *Qualea parviflora* Mart. presented itself as the best distributed, with FA 100.00, followed by *Luetzelburgia auriculata* (Allemão) Duck (FA=94.1), *Curatella americana* L. (FA=76.4), *Krameria tomentosa* A.St.-Hil (FA=70.5), *Byrsonima crassifolia* L. (FA=70.5), *Thiloa glaucocarpum* Mart (FA=64.7), *Byrsonima correaefolia* A. Juss (FA=64.7), *Psidium myrsinites* DC. (FA=64.71), *Terminalia fagifolia* Mart. (FA=52.9) (Table 2).

**Table2. Values of phytosociologica lparameters for the species sampled, Castelo do Piauí, Brazil, Number of individuals (N), Absolute Density (DA), Absolute Frequency (FA), Absolute Dominance (DoA) and Importance Value (VI).**

| Specie | Family | N | DA | FA | DoA | VI |
|---|---|---|---|---|---|---|
| *Qualea parviflora* Mart. | Vochysiaceae | 685 | 671.5 | 100.0 | 489.8 | 83.0 |
| *Krameria tomentosa* A.St.-Hill | Krameriaceae | 113 | 110.7 | 70.5 | 172.2 | 23.9 |
| *Curatella americana* L. | Dilleniaceae | 89 | 87.2 | 76.4 | 185.2 | 23.6 |
| *Callisthene fasciculata* Mart. | Vochysiaceae | 129 | 126.4 | 47.0 | 114.9 | 19.3 |
| *Psidium myrsinites* DC. | Myrtaceae | 103 | 100.9 | 64.7 | 39.3 | 14.3 |
| *Terminalia fagifolia* Mart. | Combretaceae | 37 | 36.2 | 52.9 | 112.1 | 13.7 |
| *Luetzelburgia auriculata* Ducke | Fabaceae | 35 | 34.3 | 94.1 | 54.9 | 13.4 |
| *Byrsonima correifolia* A.Juss | Malpighiaceae | 53 | 51.9 | 64.7 | 54.4 | 12.1 |
| *Byrsonima crassifolia* L. | Malpighiaceae | 46 | 45.0 | 70.5 | 32.7 | 10.8 |
| *Thiloa glaucocarpa* (Mart.) Eichler | Combretaceae | 42 | 41.1 | 64.7 | 33.8 | 10.1 |
| *Annona leptopetala* (R.E. Fries) H. Rainer | Annonaceae | 60 | 58.8 | 35.2 | 36.0 | 9.0 |
| *Bauhinia ungulata* L. | Fabaceae | 19 | 18.6 | 35.2 | 26.3 | 5.7 |
| *Anacardium occidentale* L. | Anacardiaceae | 5 | 4.9 | 23.5 | 55.1 | 5.7 |
| *Qualea grandiflora* Mart. | Vochysiaceae | 23 | 22.5 | 41.1 | 8.9 | 5.4 |
| *Aspidosperma multiflorum* A. Dc. | Apocynaceae | 27 | 26.4 | 35.2 | 10.9 | 5.3 |
| *Simarouba versicolor* A. St.-Hill | Simaroubaceae | 9 | 8.8 | 41.1 | 18.3 | 5.1 |
| *Magonia pubescens* A. St.-Hill | Sapindaceae | 10 | 9.8 | 29.4 | 21.9 | 4.4 |
| *Senna curuensis* (Benth.) H.S.Irwin & Barnebr | Fabaceae | 16 | 15.6 | 35.2 | 6.3 | 4.3 |
| *Copaifera coriacea* Mart. | Fabaceae | 14 | 13.7 | 35.2 | 8.2 | 4.3 |
| *Vatairea macrocarpa* (Benth.) Ducke | Fabaceae | 4 | 3.9 | 17.6 | 30.3 | 3.6 |
| *Myracrodruon urundeuva* Allemão | Anacardiaceae | 7 | 6.8 | 23.5 | 11.8 | 3.1 |
| *Plathymenia reticulata* Benth. | Fabaceae | 4 | 3.9 | 23.5 | 7.2 | 2.6 |
| *Handroanthus serratifolius* (Vah) S. Grose | Bignoniaceae | 5 | 4.9 | 23.5 | 4.0 | 2.5 |
| *Mimosa caesalpiniifolia* Benth | Fabaceae | 3 | 2.9 | 17.6 | 9.9 | 2.2 |
| *Combretum leprosum* Mart. | Combretaceae | 5 | 4.9 | 17.6 | 5.9 | 2.1 |
| *Aspidosperma subincanum* Mart. | Apocynaceae | 5 | 4.9 | 11.7 | 3.9 | 1.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Clitoria fairchildiana* R. A | Fabaceae | 1 | 0.9 | 5.88 | 14.6 | 1.4 |
| *Blepharocalyx salicifolius* (Kunt) O. Berg | Myrtaceae | 2 | 1.9 | 11.7 | 4.7 | 1.3 |
| *Jacaranda brasiliana* (Lam.) pers | Bignoniaceae | 2 | 1.9 | 11.7 | 3.7 | 1.3 |
| *Arrabidaea brachypoda* Bureau | Bignoniaceae | 1 | 0.9 | 5.88 | 3.6 | 0.7 |
| *Cereus jamacaru* DC. | Cactaceae | 1 | 0.9 | 5.88 | 1.6 | 0.6 |
| *Stryphnodendron coriaceum* Benth. | Fabaceae | 2 | 1.9 | 5.88 | 0.4 | 0.6 |
| *Tocoyena formosa* (Cham. & Schltdl.) K. Schum. | Rubiaceae | 1 | 0.9 | 5.88 | 0.9 | 0.6 |
| *Machaerium cutifolium* Vogel | Fabaceae | 1 | 0.9 | 5.88 | 0.5 | 0.5 |
| *Hymenaea stigonocarpa* Mart. ex. Hayne | Fabaceae | 1 | 0.9 | 5.88 | 0.2 | 0.5 |

The ten largest importance values corresponded to 79.62% of the species sampled, accounting for 73.97% of the relative frequency, 56.74% of the relative density and 83.6% of the relative dominance. The *Q. parviflora* apart from the most dominant species, also obtained the highest importance value index (83.0) (Table 2). The maximum, average and minimum heights registered were 10.00m, 2.85m and 0.30m. Regarding the individual's distribution in the height classes, it was observed the highest concentration between 1.00 and 3.00 m, characterizing low vegetation. *Qualea parviflora* also stood out in the studies carried out in the state of Piauí [7,15], all in low-lying rock Cerrados, and in Sousa et al. [6] in a floristic and structural characterization in Cerrado areas of the Campo Maior Complex. It can be said that, besides being abundant in the areas of this type of Cerrado, this species is well distributed to the region of the Campo Maior Complex. Regarding the vegetation size, Coutinho and Castro [7] found similar values. The authors believe that the determinant factor for the low development of many species is due to the soil of these regions, which are shallow, acidic, stony and with little organic matter [7].

When local residents were interviewed regarding the use of local plant species, 100% of respondents stated that they used the local vegetation in some way in order to meet their basic needs, from food to construction of houses and furniture. When questioned about the economic exploitation, they answered that, by chance, they use firewood, coal, wood and fruits for sale. A total of 73.7% of the species found in the phytosociological survey was cited as useful for the community. Most of the species were concentrated in the timber category (39%), followed by medicinal (19.6%), food and forage (16.6% each), energy (9.8%) and oil and fat producers (2.4%) (Table 3). The ten species with the highest value in use were:

**Table 3. Shrub-tree species used by residents of the Lagoa de Barros community, Piauí Castle. Index of Importance Value (VI) and Economic Categories in Cerrado rock, Castelo do Piauí, Piauí. Value of Use (VU), Medicinal (Me), Timber (Ma), Forage (Fg), Energy (En), Food (Al) and Oil Producers (O)**

| Family / Specie | Potential of Use | | | | | | VU |
|---|---|---|---|---|---|---|---|
| | Al | Fg | En | Ma | Me | O | |
| **Anacardiaceae** | | | | | | | |
| *Anacardium occidentale* L. | x | x | | | | | 1.4 |
| *Myracrodruon urundeuva* Allemão | | | | x | x | | 1.0 |
| **Annonaceae** | | | | | | | |
| *Annona leptopetala* (R.E. Fries) H. Rainer | x | x | | x | | | 0.6 |
| **Apocynaceae** | | | | | | | |
| *Aspidosperma multiflorum* A.DC. | | | | x | | | 0.8 |
| **Bignoniaceae** | | | | | | | |
| *Jacaranda brasiliana* (lam.) pers | | | | x | | | 0.2 |
| *Handroanthus serratifolius* (Vahl) S.Grose | | | | x | | | 0.6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Cactaceae** | | | | | | | |
| *Cereus jamacaru* DC. | | x | | | | | 0.2 |
| **Combretaceae** | | | | | | | |
| *Thiloa glaucocarpa* (Mart.) Eichler. | | | | x | | | 0.2 |
| *Combretum leprosum* Mart. | | | | | x | | 1.0 |
| *Terminalia fagifolia* Mart. | | | x | x | x | | 1.8 |
| **Fabaceae** | | | | | | | |
| *Hymenaea stigonocarpa* Mart. ex Hayne | | | | x | | | 1.0 |
| *Mimosa caesalpiniifolia* Benth | | | x | x | x | | 1.0 |
| *Senna acuruensis* (Benth.) H.S.Irwin & Barneby | | | x | x | | | 0.4 |
| *Plathymenia reticulata* benth. | | | x | x | | | 1.0 |
| **Krameriaceae** | | | | | | | |
| *Krameria tomentosa* A.St.-Hil. | | | | | x | | 0.8 |
| **Malpighiaceae** | | | | | | | |
| *Byrsonima crassifolia* L. | x | x | | | | | 1.6 |
| *Byrsonima correifolia* A.Juss | x | x | | | | | 1.6 |
| **Myrtaceae** | | | | | | | |
| *Psidium myrsinites* DC. | x | | | | x | | 0.8 |
| *Blepharocalyx salicifolius* (Kunth) O. Berg. | x | x | | | | | 1.0 |
| **Sapindaceae** | | | | | | | |
| *Magonia pubescens* A. St.-Hil. | | | | x | | | 0.4 |
| **Simaroubaceae** | | | | | | | |
| *Simarouba versicolor* A.St.-Hil | | | | | | x | 0.6 |
| **Vochysiaceae** | | | | | | | |
| *Callisthene fasciculata* Mart. | | | | x | | | 0.4 |

*Terminalia fagifolia* Mart (*Rama branca*) was indicated by the community for civil construction, serving as fence, rafters in the construction of houses and in the production of energy, using it as firewood in domestic activities. This use can be attributed to its wood presenting density of 1.00 g/cm³, and hard to be cut [25].

The species was also indicated in the medicinal category that is being used to combat influenza and infections. This property is justified by the fact that the genus is rich in secondary metabolites, which isolated showed very interesting medicinal activities such as hypoglycemic, anti-inflammatory, anthelmintic, antiulcerogenic, antiulcerogenic, antidepressant, trypanocidal, molluscicidal, immunomodulatory and cardioprotective, among others [26,28].

*Byrsonima correifolia* A. Juss. (*Murici de porco*), and *B. crassifolia* L. (*Murici*) were cited by the community for human and animal feed purposes. Species of this genus have a great economic potential due to their sweet taste and yield of their pulp (75.99%), key factors for the choice of raw material by the food industry [29].

*Anacardium occidentale* L. (*Cajuí*) cited as a source of animal and human food, serving as an economic apparatus in the sale of its derivatives in the harvest period. Its economic potential occurs mainly because of its two products: the chestnut, the true fruit, and of a hypocarpo, hypertrophied peduncle with enlarged and succulent pedicel, the pseudofruit [30]. This has its potential in the production of sweets and beverages, such as juices, soft drinks, liqueurs, wines and cashews [31].

*Blepharocalyx salicifolius* (*Kunth*) O. Berg (*Maria preta*), was indicated for human and animal feeding. This use is due to its fleshy and succulent fruits, in addition to being quite suitable for consumption, due to the presence of secondary phytotherapeutic compounds and antioxidants, which make the species of this family present a high food potential[32,33].

*Myracrodruon urundeuva* Allemão (*Aroeira*), is used for medicinal purposes in fighting infections. Its hydroalcoholic extract presents bactericidal and bacteriostatic activity on some species of the genus *Streptococcus* and antifungal to the genus *Candida*, showing, therefore, a great drug potential [34]. Another category of use of this species was the wood, using the trunk for the construction of fences. This species is widely marketed by industry due to the high density of its wood [35].

*Hymenaea stigonocarpa* Mart. ex Hayne, (*Jabotá*) was cited for the construction of house roofs, serving as slats and rafters. This is because species of this genus are considered highly resistant to termites and fungi of white and brown rot, the apparent specific mass of this genus 960 kg/m³[25].

*Plathymenia reticulata* Benth (*Candéia*) was also cited as raw material for civil construction and furniture, as well as being used for firewood and making coal. This species has a great acceptance of the market, being used for the construction of furniture, panels, doors, shipbuilding, internal finishes, barrels, poles, carcasses, stakes, supports and *mourões* [36].

*Mimosa caesalpiniifolia* Benth (*Sabiá*) used for medicinal purposes in the fight against infections, has demonstrated in phytochemical studies a high antifungal and bactericidal activity [27,37]. It is also used in civil construction, for ceiling frames and as firewood in the energy category [36].

*Combretum leprosum* Math (*Mufumbo*) useful in the alternative medicine. This species is rich in secondary metabolites, with great pharmacological applicability, being a promise in the chemical and pharmacological market [33,38].

There were no significant correlations of UV of the species with the phytosociological parameters (IV). This result of the ecological appearancy hypothesis was divergent from the results obtained in forest formations [39], vegetation of Caatinga [2] and Cerrado area [9]. Some authors state that the proximity of the community to vegetation may be one of the criteria for the use of plant resources [2,40], which did not happen in our area of study, because although the population interviewed is very close to vegetation, this was a criterion used by them for the use and exploitation of resources. We believe that other attributes have provided this, as taxonomic, nutritional and functional characteristics of these species [1,41].

## 4. CONCLUSION

These rupestrian Cerrados generally occur in gently undulating relief areas, distinguishing themselves from rocky terrain of steep slopes or slopes in high altimetric areas in the Central Plateau region. This is expressed in its vegetation structure, which diverged a great deal from the results of some studies in the high altitude altitudinal rocky Cerrados, evidencing that the Piaui marginal rocky Cerrados present very different characteristics from the other vegetation parameters observed in other Brazilian Cerrados. This study also demonstrated that this phytophysiognomy for the state of Piauí is very important due to its utilitarian potential, being a total of 73.7% of the species found in the survey useful for the human population as a form of a subsistence economy, prevailing the lumber category.

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## DEFINITIONS, ACRONYMS, ABBREVIATIONS

Here is the Definitions section. This is an optional section.
**Term**: Definition for the term