

# **Floristics and vegetation structure in areas of caatinga savannas in the Coreaú basin, Ceará, Brazil**

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**Abstract:** Although the Brazilian Cerrado occupies a large continuous area in central Brazil, it also occurs in disjunct patches across other regions. In the semi-arid zone, some of these patches have shown greater floristic and ecological affinity with the Caatinga and are thus referred to as caatinga savannas. These areas exhibit diverse vegetation types, with varying densities depending on the degree of arboreal cover. We identified the flora and characterized the natural vegetation of four sites located in two municipalities in the state of Ceará: Granja (Fazenda Quilómetro 35, Papagaios, and Vereda dos Tomás) and Martinópolis (Bom Princípio), within the Coreaú River Basin. The classical sigmatist method of Braun-Blanquet was applied for vegetation survey, followed by a classificatory analysis (Modified Twinspan) to distinguish plant communities. Botanical expeditions and phytosociological inventories were conducted unsystematically in 2018, 2023, and 2024. A total of 73 phytosociological inventories were carried out, allowing the identification and proposal of 10 plant communities, classified as arboreal, arboreal-shrub, shrub, and herbaceous. The synphytosociological analysis led to the proposal of two edaphophilous vegetation series.

**Keywords:** Northeast, Cerrado, Braun-Blanquet, plant communities, vegetation series.

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**Estrutura e classificação da vegetação de quatro áreas de savana da caatinga na bacia do Coreaú, Ceará, Brasil**

**Resumo:** O Cerrado brasileiro, embora ocupando uma grande área contínua no Brasil central, ocorre de forma disjunta em outras regiões. No semiárido, algumas dessas áreas revelaram-se mais próximas florístico e ecologicamente com a Caatinga, recebendo a denominação de savanas da caatinga. Estas apresentam fitofisionomias diversificadas, cujas densidades variam de acordo com o grau de cobertura do estrato arbóreo. Caracterizou-se a estrutura e classificou-se a vegetação natural de quatro áreas de savana da caatinga em dois municípios do Ceará, Granja (Fazenda Quilómetro 35, Papagaios e Vereda dos Tomás) e Martinópolis (Bom Princípio), na bacia hidrográfica do rio Coreaú. No estudo da vegetação aplicou-se o método clássico sigmatista de Braun-Blanquet e efetuou-se uma análise classificativa (Modified Twinspan) na separação das comunidades vegetais. As expedições de campo e a realização de inventários fitossociológicos ocorreram de maneira assistemática, nos anos de 2018, 2023 e 2024. Efetuaram-se 73 inventários fitossociológicos que permitiram identificar e propor 10 comunidades classificadas em arbórea, arbóreo-arbustivas, arbustivas e herbáceas. Na análise sinfitossociológica propõem-se duas séries edafófilas de vegetação.

**Palavras-Chave:** Nordeste, Cerrado, Braun-Blanquet, comunidades vegetais, séries de vegetação.

## Introduction

The Brazilian Cerrado, which spans a vast continuous area in central Brazil, is the country's second-largest vegetation formation, second only to the Amazonian Rainforest (RIBEIRO & WALTER, 1998; MEIRA-NETO & JUNIOR, 2002). It comprises a complex mosaic of vegetation types, ranging from open grasslands to dense forests, with varying degrees of tree cover (EITEN, 1972; RIBEIRO *et al.*, 1983). These forest formations (tree patches), savannas (grassy areas with scattered trees), and campo (herbaceous vegetation without trees), are shaped by the interaction of biotic and abiotic environmental factors (WALTER & RIBEIRO, 2010).

Climate is decisive in determining landscape structure, composition, and land use patterns (SILVA *et al.*, 2008). The Cerrado is characterized by a marked seasonality, with distinct dry and wet periods and an annual precipitation ranging between 600 and 2,000 mm (ASSAD, 1994; RIBEIRO & WALTER, 1998). Oxisols (Latosolos) are the dominant soil type in the Cerrado. However, other soil classes are also present in significant proportions. These, along with climatic conditions, contribute to the establishment of a highly diverse flora (REATTO *et al.*, 2008). The Cerrado's biodiversity, though remarkable, is increasingly threatened by unsustainable human activity, leading to its recognition as a global biodiversity hotspot (MYERS *et al.*, 2000).

Although mainly concentrated in the Central Plateau, the Cerrado also occurs disjunct in isolated patches within the Amazon and Caatinga domains (DEVECCHI *et al.*, 2020; NEPOMUCENO *et al.*, 2021; PORTELA *et al.*, 2024). This pattern is thought to result from a historically broader distribution of the Cerrado in central Brazil (HENRIQUES, 2005). According to RIZZINI (1997), COLE (1986), and PRANCE (1996), a drier climatic period favoured the expansion of Cerrado vegetation and the dispersion of species adapted to such conditions. As humidity levels rose over time, these remnant patches became isolated and gradually incorporated elements from adjacent biomes, leading to the formation of hybrid communities (HENRIQUES, 2005).

Within this context, the present study aimed to characterize the vegetation structure and classify the plant communities of four savanna areas linked to the Caatinga domain, located in the municipalities of Granja and Martinópolis, within the Coreaú River Basin, in the state of Ceará, Brazil.

## Material and methods

### *Study area*

The Coreaú River watershed is in the Northwestern Mesoregion of the state of Ceará, Brazil, covering an area of approximately 4,400 km<sup>2</sup>. Its geomorphology is highly diverse, reflecting the influence of geological structures on the landscape. The highest areas are represented by the Ibiapaba Sedimentary Plateau and residual landforms such as massifs and inselbergs. In contrast, the lower surfaces include the Sertaneja Depression, the Pre-littoral Tablelands, colluvial-alluvial deposits, and fluvial and coastal plains (FIGUEIREDO, 1997).

In the study areas located in the municipalities of Granja and Martinópolis, Argisols were predominant. These soils are classified as moderately deep to deep and moderately to well-drained. Additionally, Planosols were observed in low-lying areas with flat or slightly undulating terrain (CUNHA *et al.*, 2010). Altitudes ranged from 49 m (Bom Princípio, Martinópolis) to 93 m (Vereda dos Tomás, Granja).

According to Köppen's climate classification, the prevailing climate in the state of Ceará corresponds to type BSh, a hot semi-arid climate of dry zones. This is characteristic of low-latitude and low-altitude regions in northeastern Brazil, where annual average precipitation is typically below 800 mm (ALVARES *et al.*, 2013). Generally, the climate presents a dry season from July to January, and an irregular rainy season from February to June, characterized by high-intensity and short-duration rainfall events (SOBRINHO, 2009; ALEXANDRE *et al.*, 2010).

### *Field expeditions and vegetation classification*

Field expeditions were conducted in an unsystematic manner, across two distinct periods: in 2018, in the localities of Bom Princípio (municipality of Martinópolis), Papagaios, and Vereda dos Tomás (municipality of Granja); and in 2023 and 2024, at Fazenda Quilómetro 35 (also in the municipality of Granja) (table 1). These expeditions took place during both the rainy and dry seasons, always in areas with low anthropogenic influence (Fig. 1).

The scientific nomenclature of the recorded species follows the standards established by FLORA E FUNGA DO BRASIL (2025), continuously updated). Regarding the degree of endemism, the following categories were adopted: (\*) endemic to Brazil, when occurring in more than one region; (\*\*) endemic to the

Northeast, when restricted to that region only; and (\*\*\*) endemic to the Caatinga, when restricted to Caatinga vegetation.

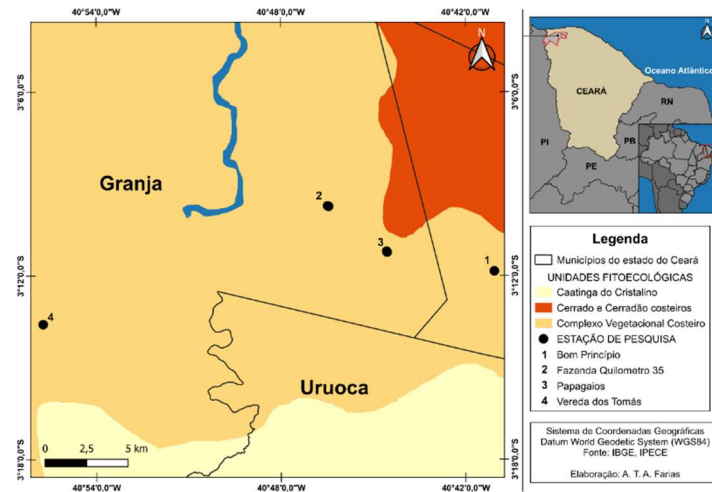
Vegetation studies were carried out according to the principles of the sigmatist school of landscape architecture of Zürich-Montpellier (BRAUN-BLANQUET, 1979; GÉHU & RIVAS-MARTÍNEZ, 1981; CAPELO, 2003; RIVAS-MARTÍNEZ, 2007; CAPELO & AGUIAR, 2021).

For each identified vegetation type, the minimum sampling area necessary for phytosociological inventories was calculated, as proposed by PEREIRA *et al.* (2018) (Tab. 2).

The inventories were selected and organized into phytosociological tables based on field observations, floristic affinities, and the physiognomic characteristics of the sampled areas. A classificatory analysis was then conducted using the Modified TWINSpan method (ROLEČEK *et al.*, 2009), aiming at the separation of plant communities. This procedure allowed for the identification of diagnostic species through the calculation of the phi coefficient, and the application of Fisher's exact test to assess the statistical significance of the observed associations.

**Table 1.** Detailed location data of the study areas

Municipality	District	Coordinates	Altitude (m)
Granja	Papagaios	03°11'12"S 40°44'34"W	57-60 m
		03°11'14"S 40°44'33"W	
	Veredas dos Tomás	03°13'35"S 40°55'44"W	93 m
	Fazenda Quilômetro 35	03°09'44"S 40°46'27"W	49-53 m
03°09'43"S 40°46'29"W			
Martinópolis	Bom Princípio	03°09'44"S 40°46'27"W	60 m



**Figure 1.** Location of the study areas.

**Table 2.** Minimum sampling areas applied to the vegetation types of the studied sites

Vegetation	Vegetation types (communities)	Minimum area (m <sup>2</sup> )
Cerrado	Dense or sparse arboreal vegetation	100 a 150
	Dense or sparse tree-shrub vegetation	100 a 150
	Herbaceous vegetation	16
	Herbaceous vegetation on waterlogged soils	1

Regarding the vegetation analysis of the Caatinga savanna, and given the absence of a consolidated syntaxonomic typology for the state of Ceará, we opted to follow two classification systems widely applied to natural vegetation within the Brazilian territory. The Physiognomic-Ecological System for the Classification of Brazilian Vegetation (IBGE, 2012) organizes Brazilian vegetation types by combining phytophysiological aspects (plant density and size) with environmental drivers (climate and soil), classifying units ranging from broad classes (forest vs. non-forest) to specific formations (Amazon Rainforest, Cerrado, Caatinga, etc.). Additionally, ANDRADE-LIMA (1981) typology categorizes Caatinga formations based on phytophysiology, floristic composition, and factors such as soil and anthropogenic influence. This system captures the biome's complexity by identifying diagnostic species, distinct strata, and plant densities,

and was later updated by PRADO (2003), who integrated a new characterization unit. Both systems are grounded in extensive field observations across the Caatinga biome, prioritizing characteristic species as well as climatic, edaphic, and geological factors, thus providing a higher resolution for local floristic patterns than broader global classifications.

The concept of vegetation series, as defined by RIVAS-MARTÍNEZ (2007), refers to the natural vegetation that would potentially develop in each environment in the absence of disturbances, or as a result of the current edaphoclimatic conditions.

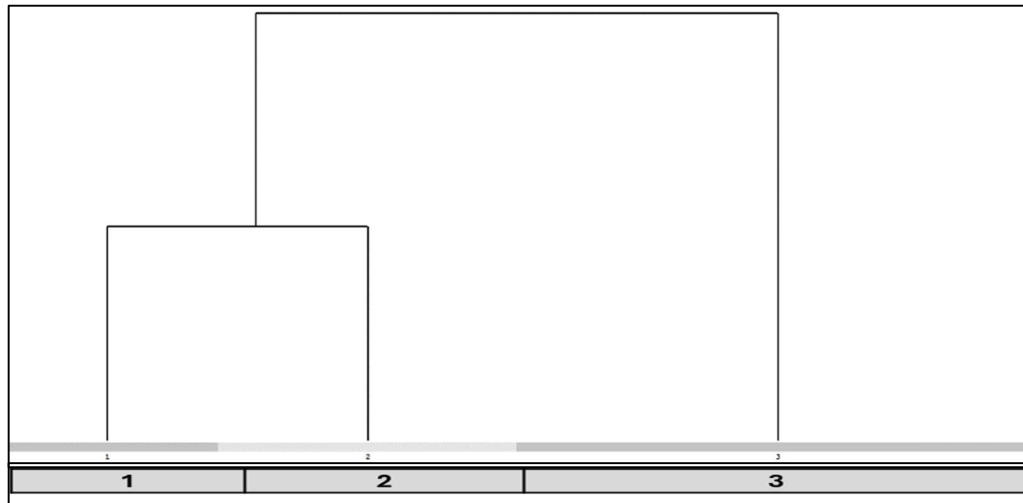
## Results and Discussion

### *An overview of the vegetation*

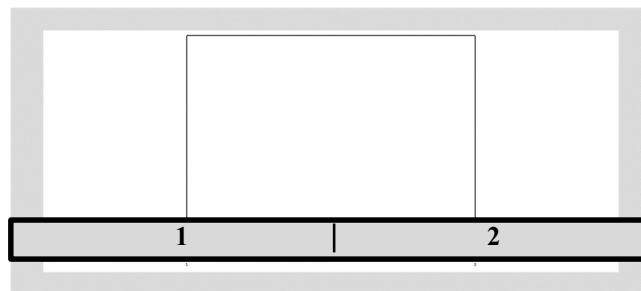
The analysis of the dendrogram shown in figure 3 allowed the distinction of three main groups (Groups 1 to 3), within which five distinct plant communities were recognized. Group 1 includes two communities with arboreal-shrub and shrub physiognomies, respectively: the *Curatella americana* and *Pityrocarpa moniliformis* community (arboreal-shrub), and the *Croton pluriglandulosus* and *Adenocalymma subsessilifolium* community (shrub).

Group 2 brings together one arboreal-shrub community, represented by *Qualea parviflora* and *Salvertia convallariodora*, and one herbaceous community, composed of *Axonopus aureus* and *Paspalum maritimum*. Group 3 corresponds to the shrubland community of *Krameria tomentosa* and *Combretum laxum*.

In the dendrogram in figure 4, two groups with three communities were differentiated: *Utricularia flaccida* and *Bacopa angulata* (1); and the communities of *Axonopus marginatus* and *Xyris savanensis*, and *Mimosa modesta* and *Chamaecrista flexuosa* (3).



**Figure 3.** Dendrogram resulting from the Modified Twinspan, with a Jaccard dissimilarity of 0.505. Communities: *Curatella americana* and *Pityrocarpa moniliformis*, and *Croton pluriglandulosus* and *Adenocalymma subsessilifolium* (1); *Qualea parviflora* and *Salvertia convallariodora*, and *Axonopus aureus* and *Paspalum maritimum* (2); *Krameria tomentosa* and *Combretum laxum* (3).



**Figure 4.** Dendrogram resulting from the Modified Twinspan, with a Jaccard dissimilarity of 0.505. Communities: *Utricularia flaccida* and *Bacopa angulata* (1); *Axonopus marginatus* and *Xyris savanensis*, and *Mimosa modesta* and *Chamaecrista flexuosa* (2).

*Fragment of the arboreal community of Cordia oncocalyx\* and Commiphora leptophloeos\*\**

At Fazenda Quilómetro 35 (Granja municipality), field observations and phytosociological inventories allowed for the identification of the arboreal community of *Cordia oncocalyx* and *Commiphora leptophloeos* within the *monchões* (small patches). This community is currently fragmented due to the absence of *pau-branco* (*Cordia oncocalyx\*\**), a species considered a structural element of this vegetation type (table 3).

Other characteristic species were consistently recorded, including *Amburana cearensis*, *Aspidosperma pyriformis*, *Cochlospermum vitifolium*, *Commiphora leptophloeos*, *Combretum laxum*, *Mimosa tenuiflora*, and *Piptadenia retusa* (PEREIRA *et al.*, 2021). The low presence of Cerrado-typical species such as *Campomanesia aromatica*, *Helicteres heptandra*, and *Rosenbergiodendron longiflorum* was a decisive factor in identifying these fragments as part of the *Cordia oncocalyx\*\** and *Commiphora leptophloeos* arboreal community of the Caatinga domain.

Originally, this community was identified at the Refúgio de Vida Silvestre Pedra da Andorinha, a Conservation Unit in Taperuaba, Sobral (PEREIRA *et al.*, 2021), where it is structured in two strata: an arboreal-shrub layer composed of micro and nanophanerophytes and lianas; and a herbaceous layer comprising chamaephytes and herbs. This formation may be classified as a Tree-Steppe Savanna, according to the typology of the *Instituto Brasileiro de Geografia e Estatística* (IBGE, 2012). The floristic composition obtained from the phytosociological inventories matched Unit VII/Type 13 of ANDRADE-LIMA (1981) and PRADO (2003).

The understory vegetation was relatively continuous, becoming denser in areas where the arboreal stratum was more open. In these zones, various shrubs were dominant, such as *Croton blanchetianus\*\**, *Croton jacobinensis*, *Krameria tomentosa*, *Lantana camara*, and *Pilosocereus cattingicola\**. Chamaephytes such as *Croton pedicellatus*, *Ipomoea subincana*, *Stylosanthes angustifolia*, and *Varronia leucomalloides* were also recorded, along with a range of herbs in the heliophilous borders, such as *Chamaecrista diphylla*, *Cuphea campestris*, *Evolvulus gypsophiloides*, *Marsypianthes chamaedrys*, and *Oxalis divaricata*. The presence of woody climbers such as *Ipomoea subincana* and *Senna splendida* may indicate a progressive successional stage, while also contributing to an increase in the coverage of the arboreal stratum (BUDOWSKI, 1963; ARAÚJO & MARTINS, 1999).

These fragments of the arboreal community also exhibited a significant number of endemics species: nine endemics to Brazil (*Bacopa cochlearia*, *Copernicia*

*prunifera*, *Croton jacobinensis*, *Dalbergia cearensis*, *Evolvulus gypsophiloides*, *Ipomoea subincana*, *Oxalis divaricata*, *Senna trachypus*, and *Varronia leucomalloides*); three endemics to the Northeast region (*Mitracarpus fernandesii*, *Pilosocereus catingicola*, and *Stachytarpheta sessilis*); and four endemics to the Caatinga domain (*Croton blanchetianus*, *Cuphea campestris*, *Fridericia pliciflora*, and *Mimosa caesalpiniifolia*).

*Arboreal-shrub community of Curatella americana and Pityrocarpa moniliformis\**

This community exhibits a two-layered structure: an arboreal-shrub layer and an herbaceous layer. Phytosociological inventories were conducted in the localities of Bom Princípio and Vereda dos Tomás, in the municipality of Granja. There was a clear dominance of megaphanerophytes such as *Curatella americana* and *Piptadenia retusa*, and mesophanerophytes such as *Byrsonima crassifolia*, *Adenocalymma candolleanum*, *Pityrocarpa moniliformis*, and *Qualea parviflora* (table 4).

The individuals showed twisted trunks, irregular branching, coriaceous leaves, and suberous bark, reaching heights between 6 and 8 meters, with megaphanerophytes exceeding 10 meters. The understory vegetation was relatively continuous, dominated by herbaceous species such as *Axonopus aureus*, *Croton glandulosus*, *Hexasepalum gardneri\*\**, *Pombalia calceolaria*, *Senega boliviensis*, and *Streptostachys asperifolium*. Some nanophanerophytes were also present, such as *Adenocalymma subsessilifolium*, *Campomanesia aromatica*, *Croton pluriglandulosus\*\**, *Krameria tomentosa*, and *Senna trachypus\**, along with chamaephytes like *Allamanda blanchetii\*\**, *Amasonia campestris*, and *Cuphea impatientifolia\**, sparsely distributed.

According to ARAÚJO & MARTINS (1999) and BUDOWSKI (1963), the presence of woody climbers such as *Adenocalymma candolleanum* may indicate a progressive successional state, as well as contribute to the high canopy coverage observed (100%), due to their vigorous development among the tree crowns. Similarly, the diversity of herbaceous climbers such as *Distimake cissoides*, *Ipomoea calyptrate\**, *I. chiquitensis*, and *I. erioalyx\** may signal the region's early stages of secondary succession. If these species are shade-adapted, they could increase in both abundance and diversity over time.

**Table 3.** Fragment of the arboreal community of *Cordia oncocalyx*\* and *Commiphora leptophloeos*

Inventory n°	1	2	3	4	5	6	7	P r e s e n c e s
Mean altitude (m)	40	40	50	40	30	40	40	
Exposure	W	S	SW	SE	E	S	NE	
Minimum area (m <sup>2</sup> )	120	120	120	120	120	120	120	
Coverage degree (%)	100	100	100	100	100	100	100	
<b>Characteristic species of the community</b>								
<i>Piptadenia retusa</i>	2	2	2	1	-	3	2	6
<i>Combretum laxum</i>	2	2	1	2	2	2	2	6
<i>Mimosa caesalpiniiifolia</i> ***	-	2	2	-	-	3	2	4
<i>Cochlospermum vitifolium</i>	-	-	-	1	2	2	1	4
<i>Helicteres heptandra</i>	-	-	-	1	2	1	3	4
<i>Fridericia pliciflora</i> ***	-	-	2	-	-	3	2	3
<i>Mimosa tenuiflora</i>	2	2	-	-	-	-	-	2
<i>Rosenbergiodendron longiflorum</i>	2	-	-	1	-	-	-	2
<i>Aspidosperma pyriforme</i>	2	-	-	-	-	-	-	1
<i>Amburana cearensis</i>	-	-	-	-	2	-	-	1
<i>Campomanesia aromatica</i> *	-	-	-	-	2	-	-	1
<i>Commiphora leptophloeos</i>	-	-	-	-	-	2	-	1
<b>Other species</b>								
<i>Croton blanchetianus</i> ***	2	3	2	2	2	2	2	7
<i>Dalbergia cearensis</i> *	2	2	2	2	2	3	2	7
<i>Lantana camara</i>	1	3	1	2	2	2	1	7
<i>Ipomoea subincana</i> *	2	2	3	2	2	3	3	7
<i>Stylosanthes angustifolia</i>	-	2	2	2	2	2	3	6
<i>Marsypianthes chamaedrys</i>	-	1	1	+	1	1	1	6
<i>Oxalis divaricata</i> *	1	2	2	-	1	-	2	5
<i>Varronia leucomalloides</i> *	2	1	2	3	2	-	-	5
<i>Borreria brownii</i>	2	+	1	-	-	2	1	5
<i>Copernicia prunifera</i> *	1	-	2	1	-	2	3	5
<i>Pilosocereus cattingicola</i> **	+	-	+	-	+	+	+	5
<i>Cuphea campestris</i> ***	-	1	2	1	-	2	3	5
<i>Chamaecrista diphylla</i>	-	1	-	1	1	2	2	5
<i>Krameria tomentosa</i>	-	+	-	+	1	-	3	4
<i>Physostemon guianense</i>	-	-	+	1	-	2	3	4
<i>Senna trachypus</i> *	2	-	-	-	+	-	3	3
<i>Stachytarpheta sessilis</i> **	+	-	-	-	+	1	-	3
<i>Croton jacobinensis</i> *	-	2	-	-	-	1	1	3
<i>Borreria scabiosoides</i>	-	1	+	-	+	-	-	3
<i>Croton pedicellatus</i>	-	-	2	-	1	1	-	3
<i>Bacopa cochlearia</i> *	-	-	+	-	+	+	-	3
<i>Evolvulus gypsophiloides</i> *	-	-	-	1	-	1	1	3
<i>Hexasepalum apiculatum</i>	-	-	-	-	1	1	3	3
<i>Sida ciliaris</i>	-	-	-	+	1	-	-	2
<i>Pombalia calceolaria</i>	-	-	-	-	1	1	-	2

Species that appeared only once: inv. 1- *Senna splendida* (1); inv. 2 - *Senna obtusifolia* (1); inv. 3 - *Mimosa hirsutissima* (+); inv. 5 - *Mitracarpus fernandesii*\*\* (1). Locality: fazenda Quilómetro 35, inv. 1 e 2 - 03° 09' 39" S e 40° 46' 20" W; inv. 3 - 03° 09' 37" S e 40° 46' 20" W; inv. 4 - 03° 09' 37" S e 40° 46' 23" W, 40; inv. 5 - 03° 09' 35" S e 40° 46' 22" W, 30; inv. 6 - 03° 09' 35" S e 40° 46' 21" W; inv. 7 - 03° 09' 34" S e 40° 46' 22" W.

The community included typical Caatinga species, such as *Arachis pusilla*\*\*, *Ipomoea chiquitensis*, and *Mimosa caesalpinifolia*\*\*, as well as species shared with the Cerrado biome, such as *Allamanda blanchetii* and *Senna trachypus*. Additionally, a high number of endemics species were recorded: 10 endemics to Brazil (*Adenocalymma subsessilifolium*, *Allamanda blanchetii*, *Campomanesia aromatica*, *Cuphea impantientifolia*, *Gwilymia coriacea*, *Ipomoea calyptrata*, *I. eriocalyx*, *Ouratea glaucescens*, *Pityrocarpa moniliformis*, and *Senna trachypus*), one endemic to the Northeast region (*Hexasepalum gardneri*), and one endemic to the Caatinga biome (*Mimosa caesalpinifolia*).

Based on field observations, phytosociological inventories, the Modified Twinspan classification analysis, and vegetation typology according to IBGE (2012), it is likely that this community represents a transitional phase between Forested Savanna (Cerradão) and Wooded Savanna.

**Table 4.** Community of *Curatella americana* and *Pityrocarpa moniliformis*\*

Inventory n°	1	2	3	4	5	6	7	8	9	P r e s e n c e s
Mean altitude (m)	60	60	60	60	83	83	83	83	83	
Exposure	N	NW	SW	E	N	NE	N	NW	S	
Minimum area (m <sup>2</sup> )	150	150	150	150	150	150	150	150	150	
Coverage degree (%)	100	100	100	100	100	100	100	100	100	
<b>Characteristic species of the community</b>										
<i>Curatella americana</i>	3	2	2	3	3	3	3	2	3	9
<i>Pytirocarpa moniliformis</i> *	3	3	3	3	-	2	2	2	3	8
<i>Qualea parviflora</i>	-	3	3	3	2	3	3	3	3	8
<i>Adenocalymma candolleianum</i> **	2	2	2	-	-	1	2	2	+	7
<i>Byrsonima crassifolia</i>	-	-	2	2	3	3	3	3	-	6
<i>Combretum mellifluum</i>	-	2	-	-	3	2	3	2	3	6
<i>Rosenbergiodendron longiflorum</i>	-	1	1	-	+	-	2	2	2	6
<i>Ximenia americana</i>	2	-	-	2	-	-	2	3	3	5
<i>Gwilymia coriacea</i> *	-	-	-	2	-	-	-	3	-	2
<i>Piptadenia retusa</i>	2	-	-	-	-	-	-	-	-	1
<b>Other species</b>										
<i>Campomanesia aromatica</i> *	-	3	3	3	3	3	3	3	3	8
<i>Croton pluriglandulosus</i> **	-	3	3	3	3	2	3	-	2	7

**Table 4 (cont.).** Community of *Curatella americana* and *Pityrocarpa moniliformis*\*

Inventory n°	1	2	3	4	5	6	7	8	9	P r e s e n c e s
<i>Pombalia calceolaria</i>	-	1	1	1	1	1	1	-	1	7
<i>Croton glandulosus</i>	2	2	1	2	1	1	-	-	-	6
<i>Krameria tomentosa</i>	-	2	2	2	2	2	2	-	-	6
<i>Axonopus aureus</i>	-	2	1	2	1	-	2	2	-	6
<i>Mimosa caesalpinifolia</i> ***	2	-	3	-	2	2	-	-	3	5
<i>Simarouba versicolor</i>	-	2	2	2	-	-	2	-	3	5
<i>Streptostachys asperifolium</i>	-	-	2	1	-	-	3	1	2	5
<i>Brunfelsia uniflora</i>	2	-	2	-	-	-	-	2	2	4
<i>Ipomoea chiquitensis</i>	+	-	+	-	-	-	-	+	+	4
<i>Adenocalymma subsessilifolium</i> *	-	2	2	2	-	-	2	-	-	4
<i>Ouratea glaucescens</i> *	-	2	2	-	-	-	2	-	2	4
<i>Bromelia karatas</i>	-	+	1	-	-	-	+	1	-	4
<i>Ipomoea eryocalix</i> *	-	-	1	-	+	+	-	-	+	4
<i>Guettarda viburnoides</i>	-	-	-	2	-	-	2	2	2	4
<i>Bauhinia unguolata</i>	-	-	-	-	-	2	2	2	2	4
<i>Amburana cearense</i>	2	-	2	-	-	-	-	2	-	3
<i>Hexasepalum gardneri</i> **	-	3	-	1	-	-	2	-	-	3
<i>Distimake cissoides</i>	-	-	2	-	-	-	-	2	+	3
<i>Amasonia campestris</i>	-	-	1	+	-	-	-	-	+	3
<i>Arachis pusilla</i> **	+	-	-	-	+	-	-	-	-	2
<i>Habenaria trifida</i>	+	-	-	-	+	-	-	-	-	2
<i>Ipomoea calytrapa</i> *	-	+	-	-	-	-	+	-	-	2
<i>Piptadenia retusa</i>	-	-	2	-	-	-	-	2	-	2
<i>Allamanda blanchetii</i> *	-	-	1	-	-	-	2	-	-	2
<i>Tabernaemontania cantharinensis</i>	-	-	-	+	-	-	-	+	-	2
<i>Cuphea impatiensifolia</i> *	-	-	-	-	1	-	1	-	-	2
<i>Senega boliviensis</i>	-	-	-	-	+	-	1	-	-	2

Species that appeared only once: inv. 7 - *Senna trachypus*\* (+); inv. 8 - *Fimbristylis dichothoma* (2). Localities: Bom Princípio (Martinópolis), inv. 1 a 4 - 03° 11' 51" S e 40° 41' 04" W, 60 m; Vereda dos Tomás (Granja), inv. 5 a 9 - 03° 13' 32" S e 40° 55' 47" W, 83 m.

#### **Arboreal-shrubby community of *Qualea parviflora* and *Salvertia convallariodora***

This community is dominated by *pau-terra* (*Qualea parviflora*) and *pau-de-colher* (*Salvertia convallariodora*), accompanied by other abundant mesophanerophytes (*Byrsonima crassifolia*, *Curatella americana*, *Pityrocarpa moniliformis*), with tree canopies presenting coverage ranging from 80 to 90% (Table 5). This level of

openness allowed sufficient light penetration to favor the development of the understory (RIBEIRO & WALTER, 1998).

The herbaceous layer was dominated by hemicryptophytic grasses (*Axonopus aureus*, *Paspalum maculosum*, *P. maritimum*, *Trachypogon spicatus*), forming small clumps or tussocks. These were accompanied by therophytes (*Croton glandulosus*, *Oxalis divaricata*, *Piriqueta guianensis*, *Pombalia calceolaria*, *Senega boliviensis*) and chamaephytes (*Allamanda blanchetii*, *Amasonia campestris*, *Fridericia platyphylla*, *Galactia jussiaeana*), sparsely distributed across the understory.

The inventoried vegetation showed a high number (12 species) of endemics restricted to Brazil: *Allamanda blanchetii*, *Campomanesia aromatica*, *Cuphea impantientifolia*, *Elephantopus hirtiflorus*, *Evolvulus ericifolius*, *Gwilymia coriaceum*, *Ipomoea brasiliana*, *I. eryocalix*, *Ouratea glaucescens*, *Oxalis divaricata*, *Pityrocarpa moniliformis*, and *Senna trachypus*.

Considering the presence of *murici-da-praia* (*Byrsonima crassifolia*), *lixeira* (*Curatella americana*), *pau-terra* (*Qualea parviflora*), and *pau-de-colher* (*Salvertia convallariodora*); the moderately open canopy (80 -90% cover); and the dominance of hemicryptophytic grasses, this community could be classified as a Forested Savanna (Cerradão) (RIBEIRO & WALTER, 2008; IBGE, 2012). The relatively low tree canopy density may be a consequence of anthropogenic fire management practices.

#### *Shrub community of Krameria tomentosa and Combretum laxum*

This community comprises two strata: the shrub layer (nano and microphanerophytes) and the herbaceous layer (chamaephytes, hemicryptophytes, and therophytes). It is dominated by *Campomanesia aromatica*, *Combretum laxum*, *Croton pluriglandulosus* (\*), and *Krameria tomentosa* (Table 6), and exhibits a high number of Brazilian endemics species (14 spp.): *Adenocalymma subsessilifolium*, *Allamanda blanchetii*, *Campomanesia aromatica*, *Cuphea impantientifolia*, *Elephantopus hirtifolius*, *Evolvulus ericifolius*, *Gwilymia coriacea*, *Ipomoea brasiliana*, *Ouratea cuspidata*, *Ouratea glaucescens*, *Oxalis divaricata*, *Pityrocarpa moniliformis*, *Senega trichosperma*, and *Senna trachypus*, in addition to one species endemic to the Caatinga biome: *Croton blanchetianus* (\*\*).

Field observations confirmed that this community may represent a stage of progressive regional succession, as evidenced by the abundance of seedlings and saplings of tree species such as *Byrsonima crassifolia*, *Combretum mellifluum*, *Curatella americana*, *Pityrocarpa moniliformis*, *Qualea parviflora*, and *Salvertia convallariodora*, all of which are typical of the arboreal communities of *Curatella*

*americana* and *Pityrocarpa moniliformis*, and of *Qualea parviflora* and *Salvertia convallariodora*.

**Table 5.** Community of *Qualea parviflora* and *Salvertia convallariodora*

Inventory n°	1	2	3	4	5	6	7	8	P r e s e n c e s
Mean altitude (m)	57	60	57	57	57	55	55	63	
Exposure	N	E	S	NE	NE	NW	W	NE	
Minimum area (m <sup>2</sup> )	100	100	100	100	100	100	100	100	
Coverage degree (%)	90	80	90	80	80	90	80	90	
<b>Characteristic species of the community</b>									
<i>Qualea parviflora</i>	2	3	2	2	3	2	3	3	8
<i>Pytirocarpa moniliformis</i> *	2	2	3	2	3	3	3	3	8
<i>Salvertia convallariodora</i>	1	+	3	3	1	+	2	1	8
<i>Byrsonima crassifolia</i>	2	2	2	2	-	-	2	-	5
<i>Curatella americana</i>	2	-	2	-	-	2	2	3	5
<i>Rosenbergiodendron longiflorum</i>	2	-	2	-	2	-	-	2	4
<i>Simarouba versicolor</i>	-	2	-	-	-	-	2	2	3
<i>Gwilymia coriacea</i> *	-	-	-	2	-	2	2	-	3
<i>Lutzelburgia auriculata</i>	-	-	2	-	-	2	-	-	2
<i>Ouratea glaucescens</i> *	1	-	-	-	-	-	-	-	1
<b>Other species</b>									
<i>Galactia jussiaeana</i>	3	2	2	2	3	2	2	2	8
<i>Axonopus aureus</i>	2	3	2	2	2	2	2	2	8
<i>Krameria tomentosa</i>	3	3	3	2	3	2	-	2	7
<i>Piriqueta guianensis</i>	1	+	+	1	1	1	2	-	7
<i>Cypura paludosa</i>	1	-	+	2	+	+	1	1	7
<i>Combretum laxum</i>	3	3	-	-	2	3	3	3	6
<i>Pombalia calceolaria</i>	-	+	1	1	+	-	+	1	6
<i>Senega boliviensis</i>	1	1	-	-	1	1	+	-	5
<i>Turnera coerulea</i>	1	-	+	1	1	2	-	-	5
<i>Friderichia platyphylla</i>	-	+	+	1	+	-	-	+	5
<i>Mimosa camporum</i>	1	3	-	2	-	2	-	-	4
<i>Croton glandulosus</i>	1	2	-	-	1	1	-	-	4
<i>Cuphea impatiensifolia</i> *	1	1	-	-	1	1	-	-	4
<i>Amasonia campestris</i>	-	+	+	-	-	-	+	+	4
<i>Paspalum maritimum</i>	-	-	3	3	3	-	-	2	4
<i>Chamaechrista flexuosa</i>	1	-	-	1	-	1	-	-	3
<i>Cyperus schomburgkianus</i>	-	-	1	3	-	-	-	2	3
<i>Evolvulus ericifolius</i> *	-	-	1	1	1	-	-	-	3
<i>Trachypogon spicatum</i>	-	-	-	-	-	2	3	3	3
<i>Campomanesia aromatica</i> *	-	2	-	-	-	+	-	-	2
<i>Oxalis divaricata</i> *	-	1	-	-	-	1	-	-	2
<i>Paspalum maculosum</i>	-	-	-	3	2	-	-	-	2

Species that appeared only once: inv. 2 - *Croton blanchetianus*\*\*\* (2), *Allamanda blanchetii*\* (+):

inv. 3 - *Croton pluriglandulosus*\*\* (2); inv. 5 - *Fimbristylis dichothoma* (1), *Evolvulus glomeratus* (1); *Ipomoea brasiliana*\* (+); inv. 7 - *Elephantopus hirtifolius*\* (1), *Ipomoea eryocalix*\* (1); inv. 8 - *Lantana camara* (2); *Senna trachypus*\* (2), *Senega trichosperma*\* (1). Locality: Papagaios (Granja), inv. 1 a 8 - 03°11'14''S e 40°44'33''W, 55, 57, 60, 63 m.

The community margins displayed a variety of chamaephytes, including *Allamanda blanchetii*, *Amasonia campestris*, *Chamaechrista flexuosa*, *Cuphea impantientifolia*, *Elephantopus hirtifolius*, *Galactia jussiaeana*, *Mimosa camporum*, and *Waltheria indica*, alongside a great diversity of hemicryptophytes and therophytes.

**Table 6.** Community of *Krameria tomentosa* and *Combretum laxum*

Inventory n°	1	2	3	4	5	6	7	8	9	P r e s e n c e s
Mean altitude (m)	57	60	57	55	60	60	60	83	83	
Exposure	N	SE	S	NW	N	SW	E	N	NE	
Minimum area (m <sup>2</sup> )	100	100	100	100	150	150	150	150	150	
Coverage degree (%)	90	100	90	100	100	100	100	100	100	
<b>Characteristic species of the community</b>										
<i>Krameria tomentosa</i>	4	4	3	2	2	2	2	3	2	9
<i>Combretum laxum</i>	3	4	3	3	3	1	3	-	-	8
<i>Campomanesia aromatica</i> *	-	2	-	+	3	2	3	3	3	7
<i>Croton pluriglandulosus</i> **	-	-	2	-	3	3	3	3	2	6
<i>Bauhinia unguolata</i>	-	1	-	-	-	2	2	2	2	5
<i>Adenocalymma subsessilifolium</i> *	-	-	-	-	2	2	2	2	-	4
<i>Croton blanchetianus</i> ***	-	2	-	-	3	3	-	-	-	3
<i>Combretum mellifluum</i>	-	-	-	-	1	-	-	2	2	3
<i>Senna trachypus</i> *	-	-	2	-	-	-	-	+	-	2
<b>Other species</b>										
<i>Curatella americana</i>	2	1	1	1	1	2	1	2	3	9
<i>Qualea parviflora</i>	1	1	1	1	2	1	2	1	2	9
<i>Croton glandulosus</i>	1	3	1	1	2	2	2	2	1	9
<i>Galactia jussiaeana</i>	3	2	3	2	2	3	1	2	-	8
<i>Pityrocarpa moniliformis</i> *	1	2	2	1	1	-	3	1	2	8
<i>Pombalia calceolaria</i>	-	1	1	+	-	1	1	1	1	8
<i>Cipura paludosa</i>	1	1	2	1	+	1	+	-	-	7
<i>Rosenbergiodendron longiflorum</i>	1	1	1	-	1	1	-	+	1	7
<i>Axonopus aureus</i>	-	2	1	1	3	3	3	2	-	7
<i>Amasonia campestris</i>	-	+	+	+	-	1	+	-	+	6
<i>Piriqueta guianensis</i>	1	1	1	2	-	-	-	2	-	5
<i>Turnera coerulea</i>	1	1	1	2	-	-	1	-	-	5
<i>Senega boliviensis</i> *	1	1	1	1	-	-	-	1	-	5
<i>Cuphea impantientifolia</i> *	1	1	1	1	-	-	-	1	-	5
<i>Paspalum maculosum</i>	-	2	2	-	2	1	1	-	-	5
<i>Ipomoea brasiliana</i> *	-	-	+	-	3	2	3	+	-	5

**Table 6 (cont.).** Community of *Krameria tomentosa* and *Combretum laxum*

Inventory n°	1	2	3	4	5	6	7	8	9	P r e s e n c e s
<i>Chamaechrista flexuosa</i>	1	-	1	1	1	-	-	-	-	4
<i>Mimosa camporum</i>	1	3	2	2	-	-	-	-	-	4
<i>Gwilymia coriaceum*</i>	-	1	1	1	-	-	-	1	-	4
<i>Allamanda blanchetii*</i>	-	+	-	-	2	1	-	2	-	4
<i>Ouratea glaucescens*</i>	2	2	-	-	-	-	-	-	+	3
<i>Trachypogon spicatum</i>	-	1	2	3	-	-	-	-	-	3
<i>Cordia rigida</i>	-	-	-	-	3	2	2	-	-	3
<i>Ouratea cearensis**</i>	-	-	-	-	3	3	3	-	-	3
<i>Bromelia karatas</i>	-	-	-	-	+	+	-	1	-	3
<i>Oxalis divaricata*</i>	-	1	-	1	-	-	-	-	-	2
<i>Paspalum maritimum</i>	-	2	3	-	-	-	-	-	-	2
<i>Cyperus schomburgkianus</i>	-	1	3	-	-	-	-	-	-	2
<i>Elephantopus hirtifolius*</i>	-	1	-	1	-	-	-	-	-	2
<i>Waltheria indica</i>	-	1	-	-	-	1	-	-	-	2
<i>Salvertia convallariodora</i>	-	+	2	-	-	-	-	-	-	2
<i>Friderichia platyphylla</i>	-	+	1	-	-	-	-	-	-	2
<i>Fimbristylis dichothoma</i>	-	-	1	-	-	-	-	2	-	2

Species that appeared only once: inv. 2 - *Oxalis psoraleoides* (1); inv. 3 - *Lantana camara* (2); *Evolvulus ericifolius\** (1), *Evolvulus glomeratus* (1); *Senega trichosperma\** (1); inv. 6 - *Ouratea cuspidata\** (2). Localities: Papagaios (Granja), inv. 1 a 4 - 03° 11' 14'' S e 40° 44' 33'' W, 57, 60 m; Bom Princípio (Martinópolis), inv. 5 a 7 - 03° 11' 51'' S e 40° 41' 04'' W, 60 m; Vereda dos Tomás (Granja), inv. 8 e 9 - 03° 13' 32'' S e 40° 55' 47'', 83 m.

Shrub community of *Croton pluriglandulosus\*\** and *Adenocalymma subsessilifolium\**

Table 7 compiles the floristic inventories carried out in the understory and shrub clearings of the *Curatella americana* and *Pityrocarpa moniliformis* woodland community in the localities of Bom Princípio and Vereda dos Tomás.

In addition to the dominant shrub layer (*Adenocalymma subsessilifolium*, *Bauhinia unguolata*, *Campomanesia aromatica*, *Croton pluriglandulosus*, and *Krameria tomentosa*), the herbaceous stratum proved to be diverse, comprising several therophytes (*Croton glandulosus*, *Cuphea campestris*, *Ipomoea eriocalyx*, *Pombalia calceolaria*, *Turnera coerulea*), hemicryptophytes (*Axonopus aureus*, *Bromelia karatas*, *Pavonia cancellata*), and chamaephytes (*Allamanda blanchetii*, *Amasonia campestris*, *Galactia jussiaeana*, *Hexasepalum gardneri*).

Within this shrub-woodland formation, seven species were identified as endemics to Brazil: *Adenocalymma subsessilifolium*, *Allamanda blanchetii*, *Campomanesia aromatica*, *Ipomoea eriocalyx*, *Ouratea cuspidata*, *Pityrocarpa moniliformis*, and *Taccarum ulei*; two species were endemics to the Northeast region: *Hexasepalum gardneri* and *Ouratea cearensis*; and one species endemic to the Caatinga biome: *Croton blanchetianus*\*\*.

**Table 7.** Community of *Croton pluriglandulosus*\*\* and *Adenocalymma subsessilifolium*\*

Inventory n <sup>o</sup>	1	2	3	4	5	6	7	8	9	P r e s e n c e s
Mean altitude (m)	60	60	60	60	60	83	83	83	83	
Exposure	W	E	W	NW	E	N	N	NE	N	
Minimum area (m <sup>2</sup> )	60	60	60	60	60	60	60	60	60	
Coverage degree (%)	100	100	100	100	100	90	80	80	90	
<b>Characteristic species of the community</b>										
<i>Croton pluriglandulosus</i> **	3	2	3	3	2	2	3	3	3	9
<i>Campomanesia aromatica</i> *	2	2	2	1	-	2	-	2	2	8
<i>Bauhinia unguolata</i>	2	-	-	-	2	1	2	2	2	6
<i>Krameria tomentosa</i>	-	1	-	1	-	2	2	1	2	6
<i>Adenocalymma subsessilifolium</i> *	1	1	2	-	2	-	-	-	2	5
<i>Combretum laxum</i>	1	1	1	-	-	-	-	-	-	3
<i>Ouratea cuspidata</i> *	-	-	2	-	-	-	2	+	-	3
<i>Croton blanchetianus</i> ***	2	-	-	-	-	-	-	-	-	1
<b>Other species</b>										
<i>Axonopus aureus</i>	3	3	2	2	2	1	2	1	2	9
<i>Qualea parviflora</i>	1	1	1	1	1	1	-	2	2	8
<i>Galactia jussiaeana</i>	1	1	1	2	1	-	-	-	2	6
<i>Croton glandulosus</i>	-	2	1	-	2	1	1	-	1	6
<i>Pytirocarpa moniliformis</i> *	1	1	-	1	2	-	-	-	1	5
<i>Pombalia calceolaria</i>	1	1	-	-	1	1	1	1	-	5
<i>Curatella americana</i>	1	1	-	-	-	1	2	2	-	5
<i>Cordia rigida</i>	2	2	2	2	-	-	-	-	-	4
<i>Luetzelburgia auriculata</i>	-	2	-	2	2	-	-	-	-	4
<i>Ouratea cearensis</i> **	3	-	-	3	3	-	-	-	-	3
<i>Amazonia campestris</i>	1	+	-	-	+	-	-	-	-	3
<i>Bromelia karatas</i>	+	-	-	+	-	-	+	-	-	3
<i>Hexasepalum gardneri</i> **	-	1	-	1	-	-	-	-	2	3
<i>Turnera coerulea</i>	-	1	-	+	-	-	-	-	2	3
<i>Ipomoea eryocalix</i> *	-	-	1	-	-	+	-	+	-	3
<i>Pavonia cancelata</i>	-	-	+	-	-	-	1	-	2	3
<i>Paspalum maculosum</i>	1	1	-	-	-	-	-	-	-	2
<i>Allamanda blanchetii</i> *	1	-	-	-	-	-	-	-	+	2
<i>Cuphea campestris</i>	-	1	-	-	-	+	-	-	-	2
<i>Cypura paludosa</i>	-	+	-	-	-	+	-	-	-	2
<i>Mesosphaerum suaveolens</i>	-	-	-	-	1	-	-	-	2	2

Species that appeared only once: inv. 3 - *Waltheria indica* (1), *Taccarum ulei*\*\* (+); inv. 5 - *Guettarda viburnoides* (2). Localities: Bom Princípio (Martinópolis), inv. 1 a 6 - 03° 11' 51" S e 40° 41' 04" W, 60 m; Vereda dos Tomás (Granja), inv. 7 a 10 - 03° 13' 32" S e 40° 55' 47" , 83 m.

The trees were sparsely distributed, and seedlings and juvenile individuals of upper-stratum species (*Curatella americana*, *Pityrocarpa moniliformis*, and *Qualea parviflora*) were frequently observed. These elements indicate that the formation may be undergoing a progressive successional stage towards a woodland community. This community typically occurs in shaded areas and forms a mosaic with the *Krameria tomentosa* and *Combretum laxum* shrubland, which is more common in open areas exposed to greater light intensity and environmental dryness.

#### *Shrub community of Croton blanchetianus\* and Combretum leprosum*

This community presents well-differentiated shrub (nano- and microphanerophytes) and herbaceous (chamaephytes) strata, allowing it to be classified as an Arboreal Steppe Savanna (IBGE, 2012) in a state of progressive development (PEREIRA *et al.*, 2021). Table 8 compiles the phytosociological inventories carried out in the understory of *monchões* (popular name for the "vegetation patches" in the cerrado) at Fazenda Quilómetro 35, conducted in clearings with low tree cover and along heliophilous edges.

In addition to the dominant shrub stratum (*Combretum laxum*, *Croton blanchetianus*\*\*, *Croton jacobinensis*, *Krameria tomentosa*, and *Pilosocereus cattingicola*), a lower layer composed of chamaephytes (*Stylosanthes angustifolia*, *Varronia leucomalloides*, among others) and a high diversity of herbaceous species (*Borreria scabiosoides*, *Chamaecrista diphylla*, *Cuphea campestris*, *Marsypianthes chamaedrys*, *Physostemon guianense*, *Stachytarpheta sessilis*, among others) was also recorded.

A total of 14 endemics species were identified, distributed as follows: nine species endemics to Brazil (*Bacopa cochlearia*, *Croton jacobinensis*, *Cuphea campestris*, *Dioscorea trisecta*, *Evolvulus gypsophiloides*, *Oxalis divaricata*, *Senega glochidata*, *Senna trachypus*, and *Varronia leucomalloides*); three species endemics to the Northeast (*Mitracarpus fernandesii*, *Pilosocereus cattingicola*, and *Stachytarpheta sessilis*); and two species endemics to the Caatinga domain (*Borreria savannicola* and *Croton blanchetianus*).

**Table 8.** Community of *Croton blanchetianus* and *Combretum leprosum*

Inventory n°	1	2	3	4	5	6	7	P r e s e n c e s
Mean altitude (m)	40	40	50	40	30	40	40	
Exposure	W	SE	SW	SE	E	S	NE	
Minimum area (m <sup>2</sup> )	60	60	80	60	80	80	60	
Coverage degree (%)	80	90	90	70	70	90	100	
<b>Characteristic species of the community</b>								
<i>Croton blanchetianus</i> ***	3	4	3	3	3	3	3	7
<i>Combretum laxum</i>	3	3	2	3	3	3	3	7
<i>Pilosocereus catingicola</i> **	+	-	+	-	+	+	+	5
<i>Krameria tomentosa</i>	-	+	-	+	1	-	3	4
<i>Croton jacobinensis</i> *	-	2	-	-	-	1	1	3
<i>Guapira opposita</i>	+	-	-	-	-	-	-	1
<i>Commiphora leptophloeos</i>	-	-	-	-	-	2	-	1
<b>Other species</b>								
<i>Lantana camara</i>	2	4	2	3	3	3	2	7
<i>Stylosanthes angustifolia</i>	-	3	3	3	4	3	4	6
<i>Marsypianthes chamaedrys</i>	-	1	1	+	1	1	1	6
<i>Oxalis divaricata</i> *	2	3	2	-	1	-	2	5
<i>Varronia leucomalloides</i> *	2	1	2	3	2	-	-	5
<i>Borreria brownii</i>	2	+	1	-	-	2	1	5
<i>Cuphea campestris</i>	-	1	2	1	-	2	3	5
<i>Chamaecrista diphylla</i>	-	1	-	1	1	2	2	5
<i>Mesosphaerum suaveolens</i>	2	3	-	-	1	-	3	4
<i>Physostemon guianense</i>	-	-	+	1	-	2	3	4
<i>Senna trachypus</i> *	2	-	-	-	+	-	3	3
<i>Stachytarpheta sessilis</i> **	+	-	-	-	+	1	-	3
<i>Borreria scabiosoides</i>	-	1	+	-	+	-	-	3
<i>Croton pedicellatus</i> Kunth	-	-	2	-	1	1	-	3
<i>Bacopa cochlearia</i> *	-	-	+	-	+	+	-	3
<i>Evolvulus gypsophiloides</i> *	-	-	-	1	-	1	1	3
<i>Hexasepalum apiculatum</i>	-	-	-	-	1	1	3	3
<i>Alternanthera tenella</i>	-	-	-	-	+	1	1	3
<i>Centrosema brasilianum</i>	+	+	-	-	-	-	-	2
<i>Spigelia anthelmia</i>	-	+	+	-	-	-	-	2
<i>Dioscorea trisecta</i> *	-	-	+	+	-	-	-	2
<i>Sida ciliaris</i>	-	-	-	+	1	-	-	2
<i>Axonopus marginatus</i>	-	-	-	-	2	3	-	2
<i>Pombalia calceolaria</i>	-	-	-	-	1	1	-	2
<i>Senega trichosperma</i> *	-	-	-	-	-	1	1	2

Species that appeared only once: inv. 2 - *Senna obtusifolia* (1), *Trimezia martinicensis* (+); inv. 3 - *Mimosa hirsutissima* (+); inv.5 - *Mitracarpus fernandesii*\*\* (1), *Chamaecrista flexuosa* (+), *Lantana fucata* (+); inv. 7: *Senega glochidata*\* (+), *Callisia filiformis* (+), *Borreria savannicola*\*\*\* (+). Locality: fazenda Quilómetro 35, inv. 1 e 2 - 03° 09' 39" S e 40° 46' 20" W; inv. 3 - 03° 09' 37" S e 40° 46' 20" W; inv. 4 - 03° 09' 37" S e 40° 46' 23" W; inv. 5 - 03° 09' 35" S e 40° 46' 22" W; inv. 6 - 03° 09' 35" S e 40° 46' 21" W; inv. 7 - 03° 09' 34" S e 40° 46' 22" W.

*Herbaceous community of Axonopus aureus and Paspalum maritimum*

This community is characterized by an herbaceous stratum, with three synusia: therophytes, hemicryptophytes, and chamaephytes. It was recorded in clearings and edges of the shrub communities (*Krameria tomentosa* and *Combretum laxum*; *Croton pluriglandulosus* and *Adenocalymma subsessilifolium*) in the localities of Papagaios and Bom Princípio. Had the phytosociological inventories compiled in table 9 been conducted over larger and more consistently herbaceous areas, this community could likely be classified as a Woody-Grassy Steppe (*Campo Limpo*), according to IBGE's classification (2012).

The vegetation was dominated by *Axonopus aureus*, accompanied by other hemicryptophytic and therophytic grasses such as *Mesosetum annuum*, *Paspalum maculosum*, *Streptostachys asperifolium*, and *Trachypogon spicatus*. Eight species endemics to Brazil were identified: *Cuphea impatiensifolia*, *Elephantopus hirtifolius*, *Evolvulus ericifolius*, *Hexasepalum gardneri*, *Marsypianthes montana*, *Oxalis divaricata*, *Senega longicaulis*, and *Senega trichosperma*.

Scattered randomly across the grassy patches were therophytes (*Oxalis divaricata*, *Piriqueta guianensis*, *Senega boliviensis*, *Turnera coerulea*, *Waltheria operculata*), hemicryptophytes (*Elephantopus hirtifolius*, *Marsypianthes montana*, *Pavonia cancellata*), and chamaephytes (*Amasonia campestris*, *Cuphea impatiensifolia*, *Hexasepalum gardneri*, *Waltheria indica*). The Cyperaceae species *Cyperus amabilis*, *C. schomburgkianus*, *C. sellowianus*, *Fimbristylis dichotoma*, and *Rhynchospora holoschoenoides* serve as bioindicators of edaphic moisture.

*Herbaceous community of Mimosa modesta and Chamaecrista flexuosa*

This community colonized moist sandy surfaces, which are periodically flooded and moderately nitrified due to sheep grazing and may dry out during the hottest and driest periods. The phytosociological inventories carried out at Fazenda Quilómetro 35, in the municipality of Granja, are compiled in table 10.

The vegetation was dominated by small chamaephytes such as *Chamaecrista flexuosa*, and *Mimosa modesta*; hemicryptophytes like *Axonopus marginatus*, *Cyperus schomburgkianus*, *Cyperus sesquiflorus*, and *Fimbristylis dichotoma*; as well as therophytes such as *Paepalanthus tortilis* and *Xyris savanensis*. Five endemics species were identified: two endemics to Brazil (*Mimosa misera* and *Mimosa modesta*) and three endemics to the Northeast (*Evolvulus gypsophiloides*, *Senega longicaulis*, and *Utricularia flaccida*).

**Table 9.** Community of *Axonopus aureus* and *Paspalum maritimum*

Inventory n°	1	2	3	4	5	6	7	8	9	P r e s e n c e s	
Mean altitude (m)	57	60	60	57	55	60	60	60	60		
Exposure	N	SE	E	NE	NW	N	NW	SW	E		
Minimum area (m <sup>2</sup> )	20	20	20	20	20	16	16	16	16		
Coverage degree (%)	90	100	100	100	100	80	70	80	80		
<b>Characteristic species of the community</b>											
<i>Axonopus aureus</i>	3	4	4	4	4	3	2	3	3	9	
<i>Paspalum maritimum</i>	2	1	3	3	2	+	1	2	1	9	
<i>Trachypogon spicatus</i>	1	1	2	2	3	-	-	-	-	5	
<i>Paspalum maculosum</i>	-	-	2	3	-	-	2	2	1	5	
<i>Mesosetum annuum</i>	-	-	-	-	-	2	1	2	1	4	
<i>Streptostachys asperifolium</i>	-	-	-	-	-	1	2	2	1	4	
<b>Other species</b>											
<i>Croton glandulosus</i>	1	3	2	1	1	2	2	1	2	9	
<i>Cipura paludosa</i>	1	1	1	2	1	+	-	+	-	8	
<i>Amasonia campestris</i>	-	+	+	+	+	+	-	+	+	8	
<i>Pombalia calceolaria</i>	-	1	1	1	+	-	1	1	1	7	
<i>Turnera coerulea</i>	1	1	1	1	2	-	+	-	-	6	
<i>Piriqueta guianensis</i>	1	1	1	1	2	-	-	-	-	5	
<i>Senega boliviensis*</i>	1	1	1	1	1	-	-	-	-	5	
<i>Cuphea impatiensifolia*</i>	1	1	1	1	1	-	-	-	-	5	
<i>Oxalis divaricata*</i>	-	1	1	-	1	-	-	-	-	3	
<i>Cyperus amabilis</i>	-	-	-	-	-	2	1	+	-	3	
<i>Rhynchospora holoschoenoides*</i>	-	-	-	-	-	1	+	1	-	3	
<i>Waltheria operculata</i>	-	-	-	-	-	1	-	2	1	3	
<i>Whaltheria indica</i>	-	1	-	-	-	-	-	1	-	2	
<i>Cyperus schomburgkianus</i>	-	-	1	3	-	-	-	-	-	2	
<i>Evolvulus ericifolius*</i>	-	-	1	1	-	-	-	-	-	2	
<i>Elephantopus hirtifolius*</i>	-	-	1	-	1	-	-	-	-	2	
<i>Friderichia platyphylla</i>	-	-	+	1	-	-	-	-	-	2	
<i>Marsypianthes montana*</i>	-	-	-	-	-	1	-	1	-	2	
<i>Cuphea campestris</i>	-	-	-	-	-	1	-	-	1	2	
<i>Hexasepalum gardneri**</i>	-	-	-	-	-	-	2	-	1	2	
<i>Senega longicaulis*</i>	-	-	-	-	-	-	1	1	-	2	
<i>Pavonia cancelata</i>	-	-	-	-	-	-	+	+	-	2	

Species that appeared only once: inv. 3 - *Oxalis psolarioides* (1); inv. 4 - *Fimbristylis dichothoma* (1); *Evolvulus glomeratus* (1), *Senega trichosperma\** (1); inv. 6 - *Cyperus sellowianus* (1). Localities: Papagaios (Granja), inv. 1 a 5 - 03° 11' 14'' S e 40° 44' 33'' W, 55, 57, 60, 63 m; Bom Princípio (Martinópolis), inv. 6 a 9 - 03° 11' 51'' S e 40° 41' 04'' W, 60 m.

**Table 10.** Community of *Mimosa modesta* and *Chamaecrista flexuosa*

Inventory n°	1	2	3	4	5	6	P r e s e n c e
Mean altitude (m)	49	49	49	49	49	49	
Exposure	N	SW	W	W	N	N	
Minimum area (m <sup>2</sup> )	8	8	8	8	8	8	
Coverage degree (%)	90	80	90	80	90	90	
<b>Characteristic species of the community</b>							
<i>Mimosa modesta</i> *	2	3	2	2	3	2	6
<i>Chamaecrista flexuosa</i>	1	2	2	-	2	2	5
<i>Borreria savannicola</i> ***	1	2	2	-	1	1	5
<i>Krameria tomentosa</i>	+	+	1	-	+	+	5
<i>Mimosa pigra</i>	-	+	+	+	+	+	5
<i>Mimosa misera</i> **	1	1	+	-	-	-	3
<i>Zornia reticulata</i>	-	-	-	1	+	+	3
<i>Gomphrena virgata</i>	+	-	-	-	-	-	1
<i>Hypsis lanceolata</i>	+	-	-	-	-	-	1
<i>Evolvulus gypsophiloides</i> *	-	-	-	1	-	-	1
<b>Other species</b>							
<i>Axonopus marginatus</i>	1	2	1	2	1	1	6
<i>Xyris savanensis</i>	1	2	1	1	2	2	6
<i>Chamaecrista diphylla</i>	+	+	+	+	+	+	6
<i>Fimbristylis dichotoma</i>	+	-	+	+	+	+	5
<i>Evolvulus ovatus</i>	+	+	-	+	+	+	5
<i>Hexasepalum apiculatum</i>	+	+	-	+	+	1	5
<i>Cyperus sesquiflorus</i>	1	+	+	+	-	-	4
<i>Senega longicaulis</i> *	+	-	+	+	+	-	4
<i>Physostemon guianensis</i>	-	+	+	-	+	-	2
<i>Alternanthera tenella</i>	-	+	-	-	-	+	2
<i>Evolvulus glomeratus</i>	-	-	-	-	2	+	2

Species that appeared only once: inv. 3 - *Cyperus schomburgkianus* (2); inv. 4 - *Asemeia violacea* (+); *Paepalanthus tortilis*\* (+); inv. 5 - *Utricularia flaccida*\*\* (+), *Pombalia calceolaria* (+), *Trimezia martinicensis* (+). Locality: fazenda Quilómetro 35 (Granja), inv. 1 a 6 - 03° 09' 42.5" S e 40° 46' 29.0" W, 49 m.

#### Herbaceous community of *Axonopus marginatus* and *Borreria savannicola*

This community, identified at Fazenda Quilómetro 35 in the municipality of Granja, is dominated by the grass *Axonopus marginatus* (hemicryptophyte) and *Borreria savannicola* (therophyte) (Table 11), occurring on sandy soils with surface runoff. Six endemics species were recorded in this community: two endemics to Brazil (*Mimosa modesta* and *Senega longicaulis*), one endemic to the Northeast (*Utricularia flaccida*), and two endemics to the Caatinga domain (*Borreria savannicola* and *Mimosa misera*). This formation occurs in a mosaic with the *Mimosa*

*modesta* and *Chamaecrista flexuosa* community, particularly in areas with lower edaphic moisture content.

**Table 11.** Community of *Axonopus marginatus* e *Borreria savannicola*\*\*\*

Inventory n°	1	2	3	4	5	6	7	8	P r e s e n c e s	
Mean altitude (m)	49	49	49	49	49	49	49	49		
Exposure	SW	SW	N	SW	W	W	N	N		
Minimum area (m <sup>2</sup> )	16	16	16	16	16	16	16	16		
Coverage degree (%)	90	80	90	90	90	90	90	90		
<b>Characteristic species of the community</b>										
<i>Axonopus marginatus</i>	3	3	3	3	3	3	3	3	8	
<i>Xyris savanensis</i>	2	2	2	3	2	3	2	2	8	
<i>Borreria savannicola</i> ***	+	1	1	2	2	+	1	1	8	
<i>Physostemon guianensis</i>	+	+	+	+	+	+	+	+	8	
<i>Chamaecrista diphylla</i>	-	+	+	+	+	+	+	+	7	
<i>Paepalanthus tortilis</i> *	1	+	1	-	1	+	-	-	5	
<i>Asemeia violacea</i>	-	-	+	-	-	+	+	+	4	
<b>Other species</b>										
<i>Krameria tomentosa</i>	+	1	+	+	1	+	+	+	8	
<i>Evolvulus ovatus</i>	+	+	+	+	-	+	+	+	8	
<i>Hexasepalum apiculatum</i>	+	1	+	+	-	+	+	1	7	
<i>Chamaecrista flexuosa</i>	+	-	+	1	1	-	1	1	6	
<i>Cyperus sesquiflorus</i>	+	-	1	+	+	+	-	+	6	
<i>Fimbristylis dichotoma</i>	+	-	+	-	+	+	+	+	6	
<i>Zornia reticulata</i>	1	+	-	-	-	1	+	+	5	
<i>Mimosa misera</i> ***	+	1	1	1	+	-	-	-	5	
<i>Senega longicaulis</i> *	-	-	+	-	+	2	+	2	5	
<i>Mimosa pigra</i>	-	-	-	+	+	+	+	+	5	
<i>Pombalia calceolaria</i>	+	-	+	+	-	-	+	-	4	
<i>Trimezia martinicensis</i>	-	+	-	+	-	-	+	+	4	
<i>Evolvulus glomeratus</i>	-	+	-	-	-	-	2	+	4	
<i>Cyperus schomburgkianus</i>	-	-	1	-	1	-	1	1	4	
<i>Evolvulus gypsophiloides</i> *	1	+	-	-	-	1	-	-	3	
<i>Marsypianthes chamaedrys</i>	+	+	-	+	-	-	-	-	3	
<i>Gomphrena virgata</i>	+	-	+	-	-	-	-	+	3	
<i>Mimosa modesta</i> *	-	-	-	-	-	1	1	1	3	
<i>Alternanthera tenella</i>	-	-	-	+	-	-	-	+	2	
<i>Utricularia flaccida</i> **	-	-	-	-	-	-	+	1	2	

Locality: Fazenda Quilômetro 35 (Granja), inv. 1 a 8 - 03° 09' 07'' S e 40° 46' 05'' W, 49 m.

#### Community of *Utricularia flaccida*\*

This insectivorous community, dominated by *Utricularia flaccida*, an species endemic to Brazil, colonized small shallow water pools and runoff zones. It was associated with *Bacopa angulata*, *Cyperus schomburgkianus*, *Cyperus sesquiflorus*,

*Fimbristylis dichotoma*, and *Paepalanthus tortilis* (Table 12), especially along the margins of these moist environments. Four species endemics to Brazil (*Evolvulus gypsophiloides*, *Senega longicaulis*), one endemic to the Northeast (*Utricularia flaccida*), and one endemic to the Caatinga domain (*Mimosa misera*) were recorded. This community occurred in a mosaic with the herbaceous community of *Axonopus marginatus* and *Xyris savanensis*, found in low-lying areas subject to waterlogging.

**Table 12.** Community of *Utricularia flaccida*\*\*

Inventory n°	1	2	3	4	5	6	7	8	9	P r e s e n c e s
Mean altitude (m)	53	53	53	53	53	53	53	53	53	
Exposure	N	NE	N	N	NW	NE	W	W	SW	
Minimum area (m <sup>2</sup> )	1	1	1	1	1	1	1	1	1	
Coverage degree (%)	60	50	60	80	60	60	50	60	60	
<b>Characteristic species of the community</b>										
<i>Utricularia flaccida</i> **	3	3	3	3	3	3	3	3	2	9
<i>Cyperus schomburgkianus</i>	+	+	1	1	2	1	1	1	2	9
<i>Fimbristylis dichotoma</i>	+	2	1	2	2	-	+	1	1	8
<i>Paepalanthus tortilis</i> *	3	2	2	2	+	+	-	-	-	6
<i>Bacopa angulata</i> *	1	2	-	1	-	2	-	2	+	6
<i>Cyperus sesquiflorus</i>	-	-	-	-	-	-	1	+	+	3
<b>Other species</b>										
<i>Axonopus marginatus</i>	2	+	1	2	1	2	1	1	+	9
<i>Senega longicaulis</i> *	+	-	+	+	+	1	+	+	+	8
<i>Mimosa misera</i> ***	+	2	1	+	-	+	-	+	-	6
<i>Chamaecrista diphylla</i>	+	+	1	2	+	2	-	-	-	6
<i>Gomphrena virgata</i>	+	-	+	+	-	1	+	+	-	6
<i>Xyris savanensis</i>	+	-	-	-	1	+	1	+	+	6
<i>Evolvulus gypsophiloides</i> *	-	+	1	+	2	+	-	-	+	6
<i>Borreria savannicola</i> ***	-	-	+	-	1	+	-	-	-	3
<i>Cuphea campestris</i>	-	-	-	+	-	-	-	-	+	2
<i>Chamaecrista flexuosa</i>	-	-	-	-	-	2	-	+	-	2
<i>Hexasepalum apiculatum</i>	-	-	-	-	-	1	-	-	+	2

Species that appeared only once: inv. 3 - *Zornia reticulata* (+); inv. 5 - *Physostemon guianensis* (+). Locality: fazenda Quilómetro 35 (Granja), inv. 1 a 9 - 03° 09' 07'' S e 40° 46' 05'' W, 53 m.

#### Proposed Vegetation Series

The analysis of phytosociological tables (floristic composition and community delimitation), combined with field observations (physiognomy, presence of seedlings and juvenile individuals), allowed the proposal of vegetation series for the studied areas. In each series, the "head of the series" represents the potential

natural vegetation of the region, typically, a mature or climax-like community. From this stage, possible substitution phases are proposed, including shrub and herbaceous formations that may arise under degradation, regeneration, or environmental change scenarios.

Two edaphophilous series were identified, associated with the type of soil and topography where they occur:

Edaphophilous series of the *Curatella americana* (lixeira) and *Pityrocarpa moniliformis* (angico-de-bezerro) community

In the Bom Princípio and Vereda dos Tomás areas (municipality of Granja), this community appears as the most structurally developed formation, possibly representing a transition phase between Forested Savanna (Cerradão) and Wooded Savanna. The dominant species, *Curatella americana* and *Pityrocarpa moniliformis*, were accompanied by *Qualea parviflora*, *Byrsonima crassifolia* (murici-da-praia), *Combretum mellifluum* (mofumbo), and *Rosenbergiodendron longiflorum* (estrela-do-norte) (Table 13).

The following successional stages may represent intermediate or simplified formations derived from this community:

**Table 13.** Regressive stages and territorial characteristic (bioindicator) species of the *Curatella americana* and *Pityrocarpa moniliformis* community.

Vegetation type	Community	Characteristic species (bioindicators)
Arboreal	<i>Curatella americana</i> e <i>Pityrocarpa moniliformis</i> *	<i>Byrsonima crassifolia</i> <i>Curatella americana</i> <i>Adenocalymma candolleianum</i> ** <i>Pityrocarpa moniliformis</i> * <i>Qualea parviflora</i>
Shrub	<i>Croton pluriglandulosus</i> ** e <i>Adenocalymma subsessilifolium</i> *	<i>Adenocalymma subsessilifolium</i> * <i>Bauhinia unguolata</i> <i>Krameria tomentosa</i> <i>Campomanesia aromatica</i> * <i>Croton pluriglandulosus</i> **
Herbaceous	<i>Axonopus aureus</i> e <i>Paspalum maritimum</i>	<i>Axonopus aureus</i> <i>Mesosetum annuum</i> <i>Paspalum maculosum</i> <i>Paspalum maritimum</i> <i>Streptostachys asperifolia</i> <i>Trachypogon spicatum</i>

- a) The shrub community of *Croton pluriglandulosus* and *Adenocalymma subsessilifolium*, characterized by a high frequency of seedlings and saplings of arboreal species in the understory.
- b) The herbaceous community of *Axonopus aureus* and *Paspalum maritimum*, marked by broad hemicryptophyte cover, especially *Axonopus aureus*.

Edaphophilous series of the *Qualea parviflora* (pau-terra) and *Salvertia convallariodora* (pau-de-colher) community

This arboreal formation was identified in the locality of Papagaios (municipality of Granja), characterized by the dominance of *Qualea parviflora* (pau-terra) and *Salvertia convallariodora* (pau-de-colher). These species give the community its name. This formation also included other mesophanerophytes, such as *Byrsonima crassifolia* (murici-da-praia), *Curatella americana* (lixeira), and *Pityrocarpa moniliformis* (angico-de-bezerra) (Table 14), and its canopy exhibited a variable arboreal cover ranging from 80% to 90%.

Given this structural pattern, in the event of environmental degradation, this tree-shrub formation could undergo a regressive successional process, giving way to the shrub community of *Krameria tomentosa* and *Combretum laxum*. This hypothesis is supported by juvenile shrub individuals in the understory, particularly *Combretum laxum*, *Croton glandulosus*, and *Krameria tomentosa*.

The most advanced stage of a potential regressive trajectory would likely be represented by the herbaceous community of *Axonopus aureus* and *Paspalum maritimum*, due to the high abundance of the former grass species.

**Table 14.** Regressive stages and territorial characteristic (bioindicator) species of the *Qualea parviflora* and *Salvertia convallariodora* community.

Vegetation type	Community	Characteristic species (bioindicators)
Arboreal	<i>Qualea parviflora</i> e <i>Salvertia convallariodora</i>	<i>Byrsonima crassifolia</i> <i>Gwilymia coriacea</i> <i>Qualea parviflora</i> <i>Simarouba versicolor</i> <i>Salvertia convallariodora</i>
Shrub	<i>Krameria tomentosa</i> e <i>Combretum laxum</i>	<i>Campomanesia aromática*</i> <i>Combretum laxum</i> <i>Galactia jussiaeana</i> <i>Krameria tomentosa</i> <i>Mimosa camporum</i>
Herbaceous	<i>Axonopus aureus</i> e <i>Paspalum maritimum</i>	<i>Axonopus aureus</i> <i>Mesosetum annuum</i> <i>Paspalum maculosum</i> <i>Paspalum maritimum</i> <i>Streptostachys asperifolia</i> <i>Trachypogon spicatum</i>

### Final considerations

Based on the phytosociological inventories following the sigmatist school of Braun-Blanquet, the classificatory analyses using the Twinspan method, and the application of the Juice 7.0.33 software, it was possible to obtain results that allowed the delimitation of the ten plant communities previously described. These findings contribute to the advancement of scientific knowledge and may support the development of conservation strategies and sustainable management practices, promoting the protection of these natural landscapes for future generations. To expand the scope of this study and establish it as a reference for other regions with similar natural vegetation, it is essential to deepen our understanding of the local flora and community structure through systematic and continuous sampling.

Although the phytosociological surveys were carried out during different periods (2018, 2023, and 2024), a consistent composition of species groups was observed whenever edaphoclimatic conditions were similar. However, herbaceous communities showed greater variation, being either enriched or

replaced by other species in response to fluctuations in soil moisture and temperature during the various sampling periods.

Understanding the dynamics of arboreal, shrubby, and herbaceous communities is essential for guiding environmental protection and conservation initiatives. A balanced approach to natural resource management must consider the ecological potential of each region to preserve biodiversity, a key component of natural heritage and a foundation for sustainable development.

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