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# FITOFISIONOMIAS DO TRECHO DE VAZÃO REDUZIDA DA USINA HIDRELÉTRICA DE BELO MONTE, PARÁ, BRASIL

## PHYTOPHYSIOGNOMIES OF THE REDUCED FLOW STRETCH OF THE BELO MONTE HYDROELECTRIC POWER PLANT IN PARÁ, BRAZIL

## FITOFISIOGNOMÍAS DEL TRAMO DE CAUDAL REDUCIDO DE LA CENTRAL HIDROELÉCTRICA DE BELO MONTE, PARÁ, BRASIL

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**RESUMO**

A Usina Hidrelétrica de Belo Monte possui um trecho denominado de trecho de vazão reduzida (TVR). Nesse trecho o ambiente foi classificado sem critérios claros e com incongruências. Diante disso, o objetivo do trabalho delimitar e classificar as fitofisionomia e a flora presentes neste trecho. Para isso, utilizou-se o material botânico coletado no TVR no ano de 2019, os quais foram descritos e sistematizados de acordo com o sistema de classificação APG IV e para a definição das fitofisionomias foram comparados com o existente na literatura. Assim, foram identificados 514 indivíduos distribuídos em 74 famílias, 180 gêneros e 185 espécies e quanto as denominações Sarobal, Beiradão, Açaizal, Grota, Restinga, Ilha, e Golosal não correspondem as fitofisionomias distintas ou reconhecidas cientificamente.
**Palavras-chave:** Fitogeografia; Etnofitogeografia; Ambientes Amazônicos

**ABSTRACT**

The Belo Monte hydroelectric power plant has a section known as the reduced flow stretch (RFS). In this area, the environmental classification of vegetation was based on unclear criteria and various inconsistencies. In view of this, the objective of the present study is to delimit and classify the phytophysiognomy and flora of this area by analyzing the botanical material collected at the RFS in 2019 in Belo Monte Hydroelectric Power Plant, Xingu River, Brazil. This material was described and systematized according to the APG IV classification system and compared with the existing literature on the theme for the definition of phytophysiognomies. Thus, the study identified 514 individuals distributed in 74 families, 180 genera, and 185 species, while the previously used names Sarobal, Beiradão, Açaizal, Grota, Restinga, Ilha, and Golosal do not correspond to distinct or scientifically recognized phytophysiognomies. Technical reports must be adapted to the scientifically recognized phytophysiognomies

**Keywords:** Phytogeography; Ethno-phytogeography; Amazonian Environments.

**RESUMEN OU RÉSUMÉ (caixa alta, negrito, tamanho 11, Times New Roman)**

La Central Hidroeléctrica de Belo Monte tiene un tramo denominado tramo de caudal reducido (TVR). En este apartado se clasificó el medio ambiente sin criterios claros y con inconsistencias. Por tanto, el objetivo del trabajo es delimitar y clasificar la fitofisonomía y flora presente en este apartado. Para ello se utilizó el material botánico recolectado en TVR en el año 2019, los cuales fueron descritos y sistematizados según el sistema de clasificación APG IV y para la definición de fitofisonomías se compararon con lo existente en la literatura. Así, fueron identificados 514 individuos distribuidos en 74 familias, 180 géneros y 185 especies y los nombres Sarobal, Beiradão, Açaizal, Grota, Restinga, Ilha y Golosal no corresponden a fitofisonomías distintas o científicamente reconocidas.

**Palabrasclave:** Fitogeografía; Etnofitogeografía; Ambientes Amazónicos.

## INTRODUCTION

Brazil is recognized worldwide as the holder of the largest biodiversity reserve on the planet, most of which is located in the Amazon (MAGNUSSON et al., 2016), since "this region in Brazil has extremely expressive and differentiated forest landscape, highlighting the immense concentration of life in this ecosystem" (CARRARO et al., 2019). "Furthermore, recent estimates indicate that there may be more than 16,000 species of trees in the Amazon, of which less than a quarter have been scientifically described" (MAGNUSSON et al., 2016).

According to Fearnside (2009), this diversity includes not only interspecific variation, but also genetic and ecological function variations. Furthermore, understanding the distribution and relationship between species and their environment may help protect species from extinction caused by habitat loss (SANTOS JUNIOR et al., 2014).

In addition to this diversity, the country's extensive water resources are a great resource for use in hydroelectric power plants (HPPs) (BUENAGA, 2019). However, using this resource affects the environment and consequently changes the ecosystem.

"Hydroelectric plants are among the infrastructure projects in the Amazon that cause the greatest changes to the landscape" (CHOUERI et al., 2019), resulting in large-scale environmental impacts. According to Conama Resolution No. 01/86, environmental impact is considered to be any change in the physical, chemical, and biological properties of the environment, caused by any form of matter or energy resulting from human activities that have direct or indirect effects on: (i) the health, safety, and well-being of the population; (ii) social and economic activities; (iii) biota; (iv) the aesthetic and sanitary properties of the environment; and (v) the quality of environmental resources.

Furthermore, watersheds are environmental systems vulnerable to the use and occupation of their space, as they are dynamic open systems that work and depend directly on the hydrological cycle (CARRARO et al., 2019). Based on this, mention should be made of the Xingu River, where the Belo Monte hydroelectric power plant (BM HPP), the largest entirely Brazilian-owned plant, is located.

Installation of the HPP began in 2011, with an Area of Direct Influence (ADI) comprising some of the municipalities surrounding the project, namely Altamira, Anapu, Brasil Novo, Senador José Porfírio, and Vitória do Xingu (CARRARO, 2019), in addition to a reduced flow stretch (RFS), which is the stretch of the natural river that has its flow reduced by the layout of a hydroelectric plant (BUENAGA, 2019).

For the stretch with reduced flow, the loss of floral diversity was associated with changes in the phenological patterns and floristic composition of the alluvial forest. This impact is considered a certainty, since the reduction in flow in the RFS largely eliminates the effect of the river overflowing onto the banks and alluvial islands, exposing this vegetation to a new natural condition (BUENAGA, 2019, pp. 22, 23).

In this stretch, the environmental classification was provided by Sartoreli (2018) and used as a guideline by the company hired to rescue the flora. However, this categorization was inconsistent with the phytogeographic classifications for this region and is neither used nor accepted by the scientific community, classified as Sarobal, Ilha, Igapó, Beiradão, Açaizal, Restinga, Grota, Golosal and Terra Firme.

Vegetation has always been one of the parameters for characterizing and delimiting geographical spaces, whether at local, national or global level, according to IBGE (2012). It has been discussed since the foundation of Western philosophical thought by Aristotle, continuing with Schimper (1903), Tansley & Chipp (1926), Burtt-Davy (1938), Dansereau (1949), Aubréville (1956), Trochain (1955, 1957), Ellenberg & Mueller-Dombois (1967), Unesco (1973), and Di Gregorio for the FAO (2000, 2005). In Brazil, this deliberation began with Martius (1858), Gonzaga de Campos (1926), Sampaio (1940), Santos (1943), Azevedo (1950), Kuhlmann (1953), , Andrade-Lima (1966), Veloso (1966), Projeto Radambrasil (1982), Rizzini (1963), Eiten (1983), Fernandes (1998), and Morrone (2001).

According to Carraro (2019), the ADI of BM HPP still has a cover of native vegetation, where we can visualize and assess phytophysiognomic characteristics and the different successional stages they represent. According to Azevedo (2019), knowledge about plant biodiversity and community composition in such circumstances is scarce. Thus, vegetation classification studies are essential tools for expanding technical scientific knowledge in the areas of botany, ecology, and geography, in order to provide guidelines for the conservation and/or preservation of endangered or non-endangered species. In addition, these studies can provide support for the creation of public policies, since it is difficult to protect the individuals without knowing them.

In view of the above, the present study evaluated the following hypothesis: the ethno-phytophysiognomies classified Sartoreli (2018) and used by the company have different vegetation compositions, which justifies the classification used. Thus, the aim of this study was to characterize the phytophysiognomy and flora found in the RFS of the BM HPP.

## MATERIAL AND METHODS

The RFS of the BM HPP is located in the southwestern parts of Pará State, covering four municipalities: Altamira, Vitória do Xingu, Anapu, and Senador José Porfírio (Figure 1).

According to the Ministry of Mines and Energy (2009), its main forest types are dry land forest, floodplain forest, and rocky areas typical vegetation.

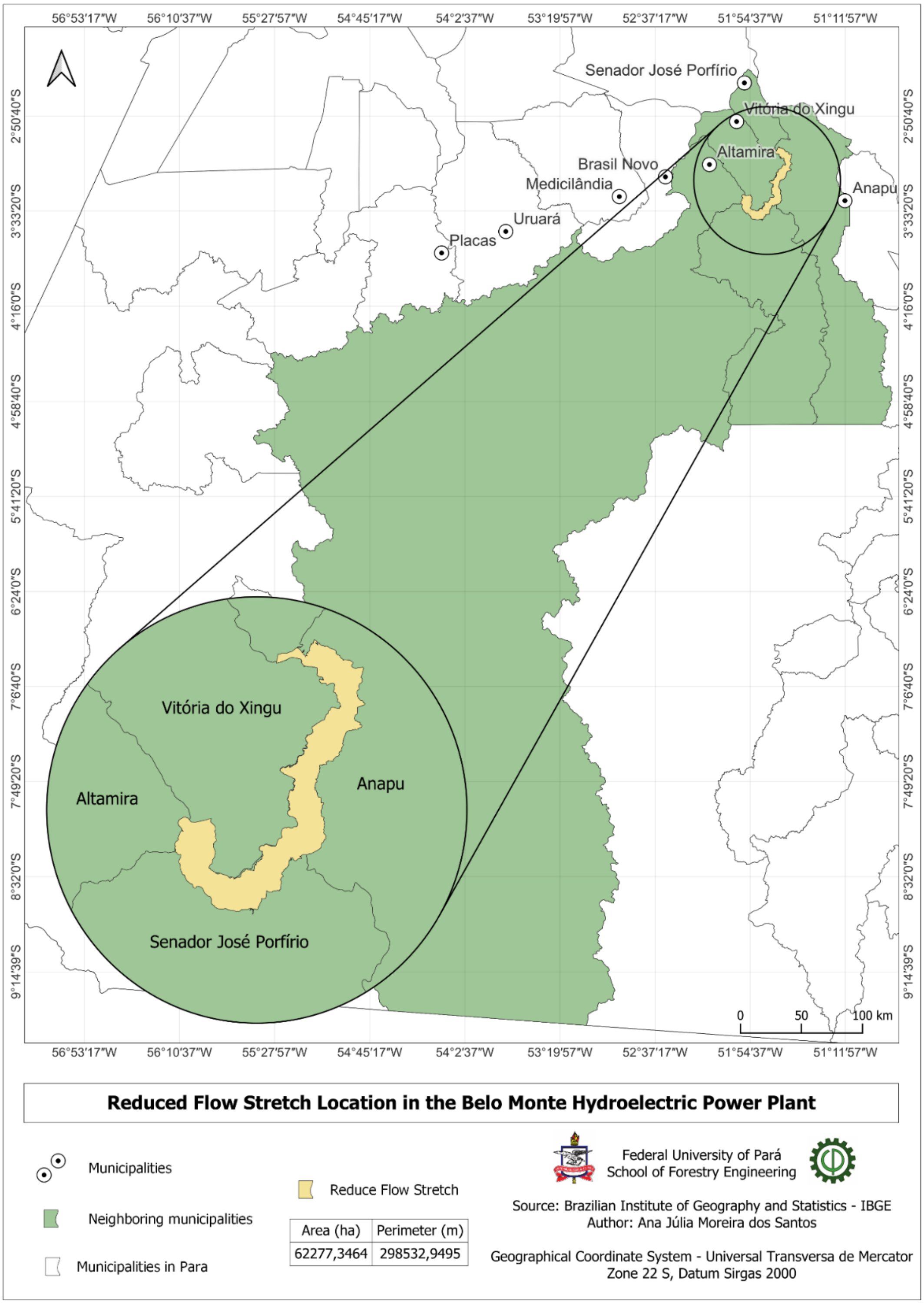


FIGURE 1 Location of the Reduced Flow Stretch of Belo Monte Hydroelectric Power Plant, *Pará* State, Brazil.

This study was conducted with botanical material collected at nine different points in the RFS, namely Sarobal, Ilha, Igapó, Beiradão, Açaizal, Restinga, Grota, Golosal, and Terra Firme, in 2019.

This study was carried out with botanical material collected at RFS in 2019, using the RAPELD methodology described in Magnusson et al. (2005), where Modules are determined for the collection and monitoring of fauna, flora, and other relevant information.

> "(1) The Module is an area of 5 km2 where 2 transects of 5 km in length were installed, parallel to each other, 1 km apart.
>
> (2) 12 permanent plots of 250 m with variable width perpendicular to the transects were installed. The central axis of the plot follows the contour line;
>
> (3) Sampling of organisms in the plots shall cover the full extent of the plots sampled in the modules. Transect-based sampling should cover the transects in the module, exceptions are presented in the specific protocols.
>
> (4) The plots of the RAPELD Module of the Belo Monte Hydroelectric Power Plant are not square or rectangular as is generally used in inventories. On the contrary, they take into account the fact that relief is an important determinant of vegetation composition, and therefore follow contour lines (isoclines). The plot is plotted from a point with a known altitude and that altitude is kept constant along the plot as it follows the contour line."

The material was collected at nine different points in modules 4, 5, 6 and 7 of the TVR, namely: Sarobal, Ilha, Igapó, Beiradão, Açaizal, Restinga, Grota, Golosal and Terra Firme. The material was stored at the School of Forestry Engineering at the Federal University of Pará (UFPA), Altamira Campus, in the Plant Morphology/Anatomy Laboratory.

At first, the materials were observed, described, and classified correctly according to the Angiosperm Phylogeny Group IV (APG IV) classification system. Individual plants were isolated at family level in plastic bags, and subsequently classified once again, this time according to their genus, to conduct the classification. In the classification process, we examined individuals of each family, described and compared them with the existing literature, and for the final quantification, only individuals with at least one photosynthetic structure were counted.

The nomenclature used to indicate the shape and appearance of the morphological structures was based on the studies by Rizzini (1977) and Barroso (1991), as well as specialized literature for the area. For the classification of phytophysiognomies, we also considered the growth forms of the individuals.

To analyze the vegetation by calculating the Normalized Difference Vegetation Index (NDVI), images were acquired from the United States Geological Survey (USGS) from the Landsat 4-5 TM and Landsat 8 satellites at the same time of year in order to reduce variability. On Landsat 4-5 TM, the image obtained was dated 07/11/2008 for analysis in 2008, and on Landsat 8 it was dated 07/28/2020 for analysis in 2020, both with scene 225062. Qgis software 3.16.10 was used for the analysis, with the aid of the Semi-Automatic Classification (SCP) plugin.

## RESULTS

A total of 514 individual plants were identified, divided into 73 families, 197 genera, and 218 species. However, when classifying the materials based on APG IV, inconsistencies were observed regarding the identifications made, so that the 514 individuals were in fact distributed in 74 families, 180 genera, and 185 species.

Based on this, 32 orders were represented. Of these, the highest number of families belonged to Malpighiales, Caryophilales, Sapindales, Lamiales, and Zingiberales, respectively. In contrast, 18 orders were only represented by one family (Figure 2) he most representative families in terms of the number of genera were the most representative families in terms of the number of genera were Fabaceae (26), Rubiaceae (15), and Bignoniaceae (10), while all of the remaining families were represented by fewer than 10 genera (Figure 3).

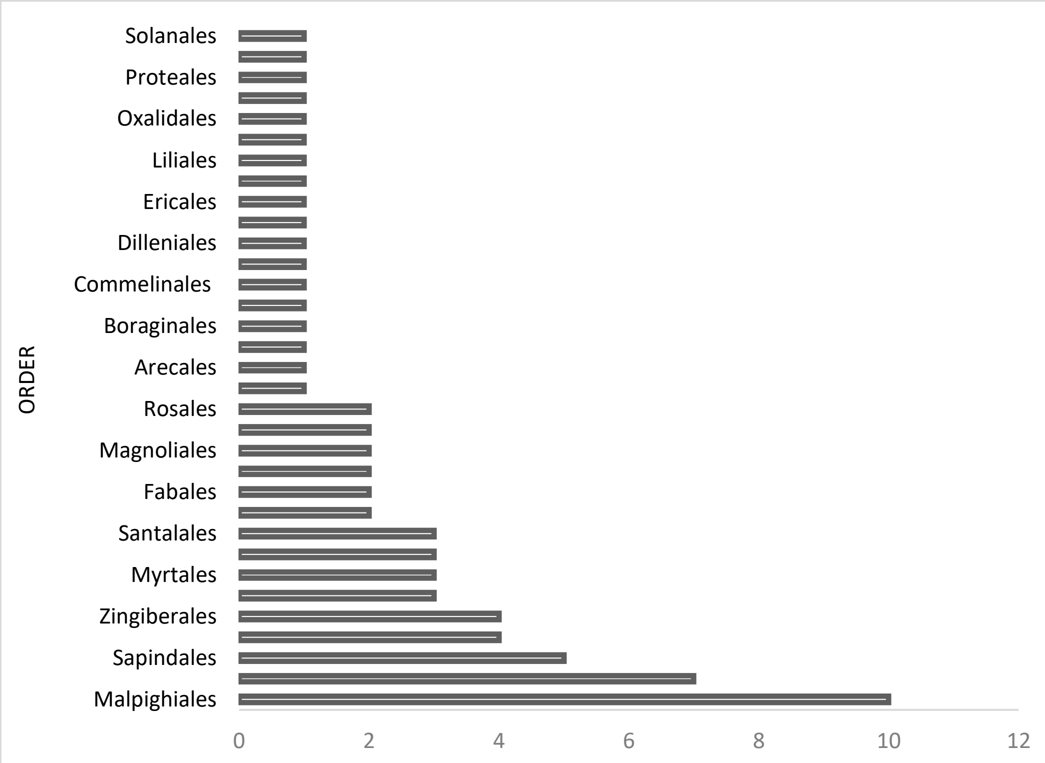


FIGURE 2 Number of plant families by order in the reduced flow stretch of the Belo Monte Hydroelectric Power Plant.

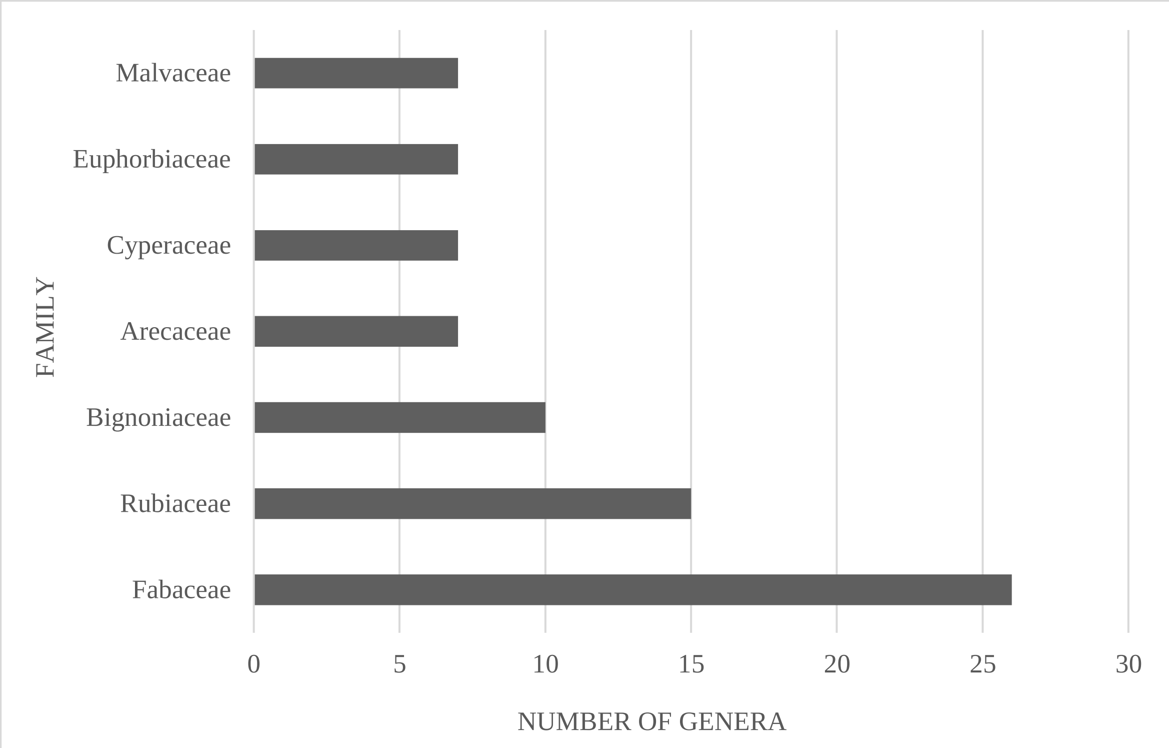


FIGURE 3 Number of genera per family for the seven most diverse plant families sampled in the reduced flow stretch of the Belo Monte Hydroelectric Power Plant.

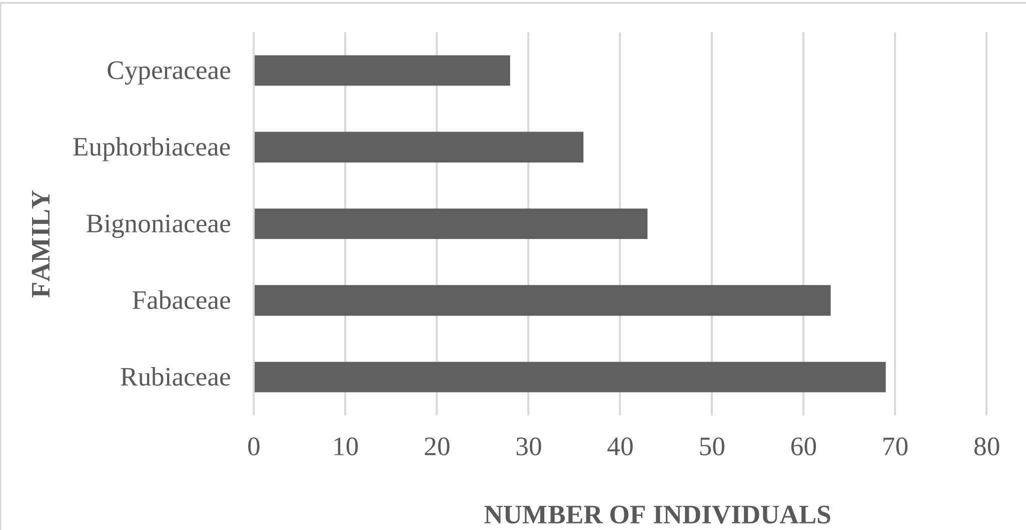


FIGURE 4 Number of individuals per family sampled in the reduced flow stretch of the Belo Monte Hydroelectric Power Plant.

Rubiaceae, Fabaceae, Bignoniaceae, Euphorbiaceae and Cyperaceae were respectively the most representative families in terms of the number of individuals detected in the sampling (Figure 4). Regarding the growth forms of the genera found, the most representative were shrubs and trees, followed by herbs and trees (Figure 5).

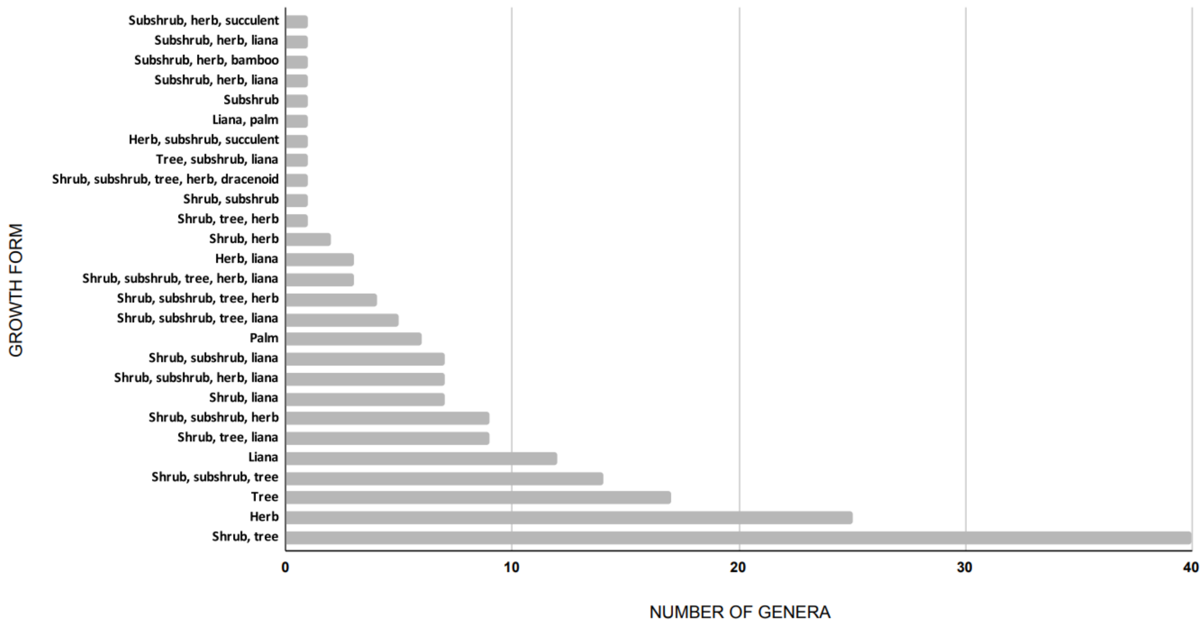


FIGURE 5 Number of genera sampled in the reduced flow stretch of the Belo Monte Hydroelectric Power Plant, classified according to their growth form.

Regarding the material collection site, of the nine different points, those with the highest number of genera collected were Sarobal, Beiradão and Igapó, followed by Açaizal and Restinga (Figure 6). Likewise, the growth forms of the genera that were collected in the sites were checked and recorded (Table 1).

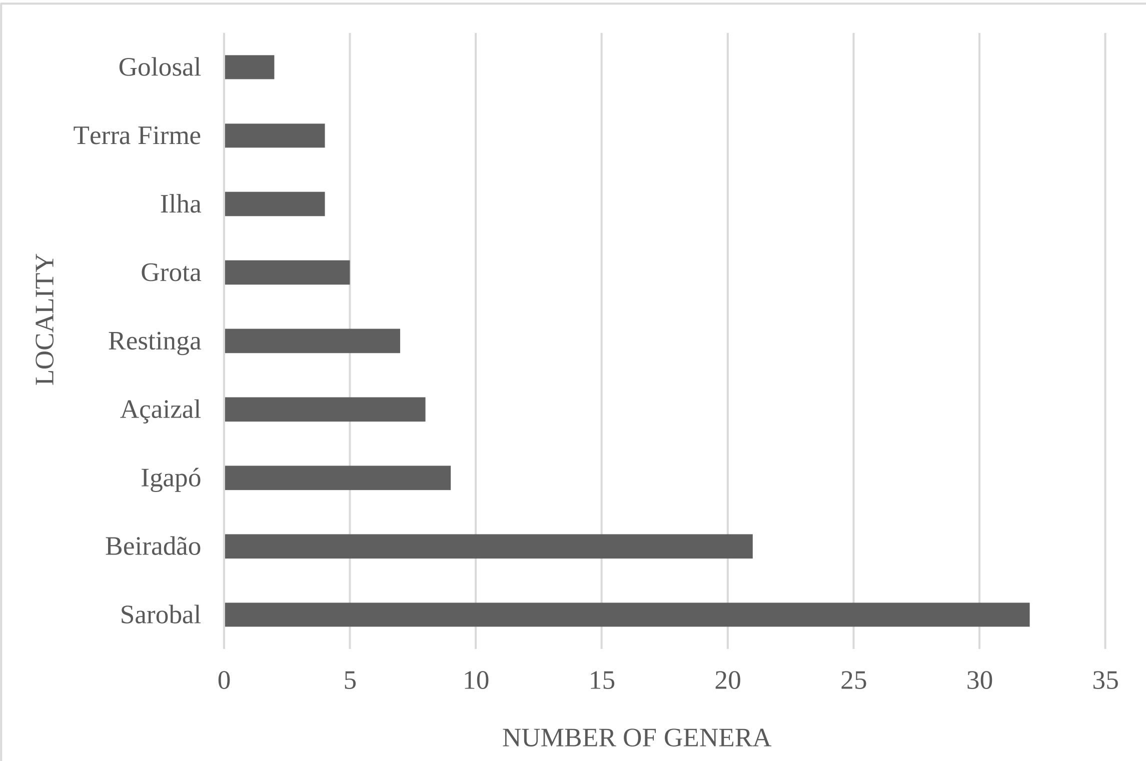

FIGURE 6 Quantification of genera sampled in the reduced flow stretch of the Belo Monte Hydroelectric Power Plant, arranged by collection site.

TABLE 1 Growth forms found at each sampling site sampled in the reduced flow stretch of the Belo Monte Hydroelectric Power Plant.

| Site | Growth form |
|---|---|
| **Golosal** | shrub, tree |
| | herb |
| **Terra Firme** | shrub, subshrub, tree |
| | shrub, tree |
| | shrub, subshrub, tree |
| **Ilha** | shrub, tree |
| | shrub, subshrub, tree, liana |
| | herb, subshrub, succulent |
| | liana |
| **Grota** | shrub, tree |
| | shrub, subshrub, herb, liana |
| | herb, liana |
| **Restinga** | shrub, liana |
| | shrub, subshrub, herb, liana |
| | herb |
| | subshrub, herb |
| **Açaizal** | shrub, tree, liana |
| | shrub, subshrub, tree |
| | shrub, subshrub, tree, liana |
| | tree |
| | herb |
| | liana |
| **Igapó** | shrub, tree |
| | shrub, subshrub, herb |
| | tree |

| | |
|---|---|
| | herb |
| **Beiradão** | shrub, tree |
| | shrub, tree, herb |
| | shrub, tree, liana |
| | shrub, liana |
| | shrub, subshrub, tree |
| | shrub, subshrub, herb |
| | tree |
| | tree, subshrub, liana |
| | herb |
| | herb, liana |
| | liana |
| | subshrub, herb, liana |
| | subshrub, herb, succulent |
| **Sarobal** | shrub, tree |
| | shrub, subshrub |
| | shrub, subshrub, tree, herb |
| | shrub, subshrub, tree, herb, dracenoid |
| | shrub, subshrub, tree, herb, liana |
| | shrub, subshrub, herb |
| | shrub, subshrub, liana |
| | tree |
| | herb |
| | liana |
| | subshrub |
| | subshrub, herb |

The area known as Terra Firme is characterized as dense ombrophilous forest. The Aluvial, Sarobal and Beiradão sites are characterized as alluvial ombrophilous dense forest. The locality called Igapó may refer to alluvial open ombrophilous forest.

The NDVI values were subdivided into four classes, as shown in Figure 7:

Class 1: NDVI ≥ 0.7, values that can be associated with the presence of dense vegetation.

Class 2: 0.40 ≤ NDVI < 0.69, values that can be associated with growing vegetation.

Class 3: 0.20 ≤ NDVI < 0.39, values that can be associated with the presence of exposed soil.

Class 4: NDVI < 0.19, values that can be associated with the presence of water.

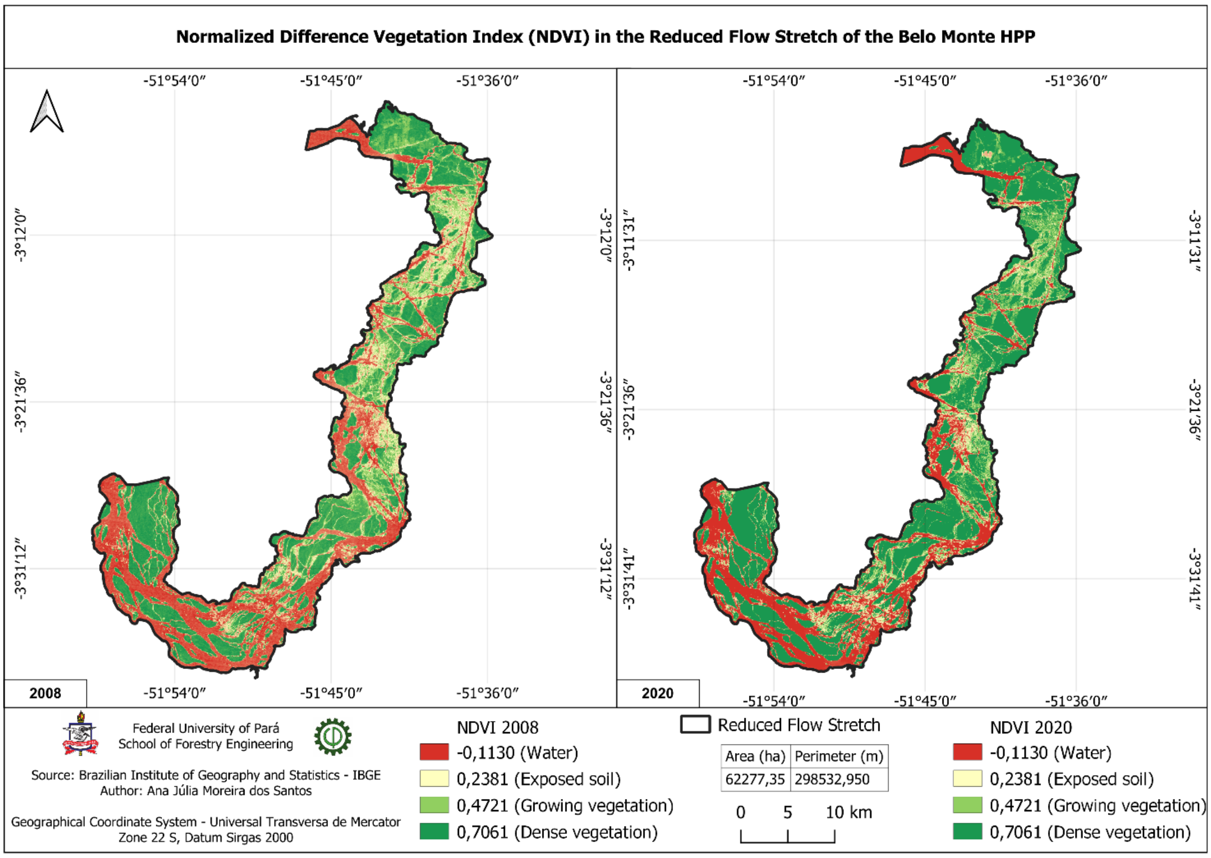


FIGURE 7 NDVI in 2008 and 2020.

Regarding families and their characteristics, five identification keys were prepared:

Keys

Simple leaves exclusively alternate or alternate/opposite......................................Key A

Simple leaves with varied phyllotaxis...........................................................Key B

Simple or compound leaves.........................................................................Key C

Ferns and lycophytes.................................................................................Key D

Palm.........................................................................................................Key E

Key A

1. Exclusively alternate simple leaves...............................................................2

1’ Simple leaves with other phyllotaxis.........................................................................3

2. Exclusively inflorescence cymose..............................................................................4

2’ Cymose or racemose inflorescence...........................................................................5

3. Exclusively inflorescence cymose..............................................................................6

3’ Cymose or racemose inflorescence............................................................................7

4. Exclusively monoclinous flowers................................................................................8

4’ Monoclinous or diclinous flowers...............................................................................9

5. Exclusively polystemone androecium........................................................................10

5’ Exclusively androecium or other forms.....................................................................11

6. Exclusively superior ovary..........................................................................................12

6’ Superior or inferior ovary............................................................................................13

7. Polystemone androecium.............................................................................................14

7' Androecium of other types...........................................................................................15

8. Oligostemone androecium...........................................................................................16

8' Androecium in other forms..........................................................................................17

9. Apocarpous or syncarpous fruit………..………………………………..Annonaceae

9’ Capsule or drupe fruit........................................................................Phyllantaceae

10. Erect placentation.....................................................................................................18

10’ Placentation of another type.....................................................................................19

11. Exclusively capsule fruit…… ......................................................Commelinaceae

11’ Achene, samara, berry, drupe, capsule or nut fruit..................................................20

12 Exclusively drupe fruit......................................................................Boraginaceae

12’ Drupe, berry or capsule fruit...........................................................Caryophylaceae

13. Berry fruit...........................................................................................................Ebenaceae

13’ Fruit of another kind.................................................................................................21

14. Exclusively capsule fruit……..........................................................Euphorbiaceae

14’ Capsule, samara, drupe or berry fruit....................................................Polygalaceae

15. Exclusively superior ovary.......................................................................................22

15’ Superior, inferior or half-inferior ovary...................................................................23

16. Capsule fruit; angular-ovoid seeds…......................................................Costaceae

16’ Capsule or berry fruit; irregular ellipsoid seeds...................................Zingiberaceae

17. Superior ovary...........................................................................................................24

17’ Inferior ovary...........................................................................................Heliconiaceae

18. Drupe fruit.........................................................................................Chrysobalanaceae

18’ Follicle or berry fruit................................................................................Myrsticaceae

19. Berry fruit..........................................................................................Dilleniaceae

19’ Fruit of another kind.................................................................................25

20. Drupe or nut fruit......................................................................Menispermaceae

20’ Fruit of another tip....................................................................................26

21. Fleshy fruit.............................................................................Melastomataceae

21’ Capsule fruit...................................................................................Celastraceae

22. Basal or lateral placentation.............................................................................27

22’ Placentation of another type...........................................................................28

23. Axial or parietal placentation...........................................................................29

23’ Placentation of another type...........................................................................30

24. Drupe fruit..............................................................................Erythproxylaceae

24’ Berry or capsule fruit........................................................................Solanaceae

25. Achene or follicle fruit.....................................................................Alismataceae

25’ Drupe fruit.........................................................................................Olacaceae

26. Central placentation......................................................................Phytolacaceae

26’ Parietal, basal or axial placentation...............................................Ochnaceae

27. Antocarp fruit.................................................................................Nyctaginaceae

27’ Achene fruit..........................................................................................Urticaceae

28. Drupe fruit...................................................................................Humiricaceae

28’ Capsule or berry fruit.......................................................................Violaceae

29. Berry, follicle, drupe or capsule fruit............................................Apocynaceae

29’ Exclusively capsule fruit..............................................................Onagraceae

30. Utricle, achene or nut fruit.........................................................Amaranthaceae

30’ Fruit of another kind........................................................................................31

31. Berry or drupe fruit...........................................................................Santalaceae

31’ Fruit of other kinds...........................................................................................32

32. Nucleoid or drupe fruit...................................................................Combretaceae

32’ Fruit of other kinds...........................................................................................33

33. Berry, drupe or samara fruit..........................................................Loranthaceae

33’ Achene or drupe fruit........................................................................Moraceae

Key B

1. Leaves with opposite, rosette or verticillate phyllotaxis……………………………2

1’ Leaves with other phyllotaxis..........................................................................................3

2. Inferior ovary; capsule, schizocarp, drupe or berry fruit...............................Rubiaceae

2’ Superior ovary………………......................................................................................4

3. Exclusively diclinous flower...........................................................................................5

3’ Monoclinous or diclinous flower...................................................................................6

4. Bilocular ovary; capsule fruit.................................................................Acanthaceae

4’ Plurilocular ovary; berry or capsule fruit…................................................Clusiaceae

5. Capsule or achene fruit..........................................................................Eriocaulaceae

5’ Berry fruit...................................................................................................Smilacaceae

6. Androecium isostemone.........................................................................Verbenaceae

6’ Androecium of another type...........................................................................................7

7. Apical placentation..................................................................................Calophylaceae

7’ Placentation of other types...............................................................................................8

8. Parietal placentation...................................................................................Verbenaceae

8’ Placentation of other types...............................................................................................9

9. Exclusively axial placentation...........................................................Molluginaceae

9’ Placentation of other types.............................................................................................10

10. Bi or tricarpellary ovary; capsule, drupe or berry fruit...............................Salicaceae

10’ Mono-, tri- or tetracarpallary ovary; drupe or berry fruit..........................Piperaceae

Key C

1. Exclusively composite leaves.........................................................................................2

1’ Simple or compound leaves...........................................................................................3

2. Alternate, rosulate or fasciculate phyllotaxis...............................................................4

2’ Alternate or opposite phyllotaxis; cymose or racemose inflorescence; superior ovary; drupe fruit...........................................................................................Burseraceae

3. Exclusively racemose inflorescence...............................................................................5

3’ Racemose or cymose inflorescence...............................................................................6

4. Racemose inflorescence; superior ovary; achene fruit…..........................Microteaceae

4’ Racemose inflorescence; follicle fruit.....................................................Connaraceae

5. Exclusively monoclinous flower.....................................................................................7

5’ Monoclinous or diclinous flower....................................................................................8

6. Exclusively cymose inflorescence..................................................................................9

6’ Racemose or cymose inflorescence...............................................................................10

7. Androecium with single stamen............................................................Maranthaceae

7’ Androecium with other characteristics......................................................................11

8. Unicarpellate superior ovary......................................................................Proteaceae

8’ Bi-, tri- or plurilocular ovary.......................................................................................12

9. Inferior ovary, axial placentation.................................................................Cactaceae

9’ Superior ovary..............................................................................................................13

10. Isostemone, diplostemone or polystemone androecium..........................................14

10’ Dialistemone androecium; inferior ovary; basal placentation...................Asteraceae

11. Axial or parietal placentation.....................................................................................15

11’ Marginal or basal placentation; legume fruit..............................................Fabaceae

12. Aquene fruit..............................................................................................Cyperaceae

12’ Fruit with another characteristic...............................................................................16

13. Axial placentation.......................................................................................................17

13’ Parietal or axial placentation....................................................................Caricaceae

14. Drupe, berry, follicle or capsule fruit..........................................................Rutaceae

14’ Fruit with other characteristics..................................................................................18

15. Capsule or schizocarp fruit.........................................................................................19

15’. Fruit with other characteristics.................................................................................20

16. Drupe, schizocarp fruit...............................................................................Lamiaceae

16’ Drupe, berry or samara fruit; axial placentation................................Simaroubaceae

17. Capsule, drupe or berry fruit; dried seeds..................................................Meliaceae

17’ Samara, capsule or berry fruit; exalbuminous seeds...............................Sapindaceae

18. Inferior ovary..............................................................................................................21

18’ Superior ovary...........................................................................................Malvaceae

19. Polystemone androecium; uni-, tri- or plurilocular ovary............................Bixaceae

19’ Anisostemone androecium; uni- or bilocular ovary................................Cleomaceae

20. Bilocular ovary; bivalved capsule fruit.................................................Bignoniaceae

20’ Unilocular ovary; amphisarc capsule, berry or peponidium fruit...........Capparaceae

21. Trilocular ovary.....................................................................................Dioscoreaceae

21’ Unilocular ovary...................................................................................Cucurbitaceae

Key D

1. Monomorphic or dimorphic simple lamina..........................................Polypodiaceae

1’ Monomorphic or dimorphic frond…...........................................................................2

2 Monomorphic frond......................................................................................3

2’ Monomorphic or dimorphic frond…...........................................................................4

3. Terminal sori on veins, circular to slightly elongated........................Nephrolepidaceae

3’ Sessile or subsessile sporangia; trilete spores................................Hymenophyllaceae

4. Trilete, globose to tetrahedral-globose or monolete spore..........................Pteridaceae

Key E

1. Slender or stout stipe; covered by the sheaths of fallen leaves; simple, pinnate, palmate or costapalmate leaves; inter-, intra- or supra-leaf, spiciform or panicle inflorescence; superior ovary, axial placentation; ovoid drupe, ellipsoid, fusiform or globose fruit....Arecaceae

## DISCUSSION

The identity of a plant can provide detailed scientific information about it. Thus, discussing its conservation status (PROCÓPIO & SECCO, 2008) and determining the flora of the areas in which it occurs may expose any misidentifications in the materials studied.

Although the APG IV was already in use during the period in which the collections and consequent identifications were made, we observed that the identifications were not based on this classification system. In the classification using the APG IV, some families were mistakenly identified as genera belonging to other families, such as Adiantaceae, who became part of Pteridaceae. In addition, there were identifications of genera and species that do not occur in Brazil, in the northern region or in the state of Pará, such as Parinari excelsa Sabine, Mikania cardiophylla B.L.Rob, and Dioscorea ceratandra R.Knuth. Thus, of the 185 species identified, 26, equivalent to 14%, showed some inconsistency. In view of this, the accuracy of botanical identifications in the field is the first issue requiring debate and improvement.

The NDVI calculation presented an increase in areas with dense vegetation, showing that the area is in a more advanced successional stage compared to 2008. The decrease in class 4, showing evidence of water, can be explained by the fact that the water flow in the stretch has been reduced. In terms of the RFS floristic composition, we observed a pronounced occurrence of Fabaceae and Rubiaceae, both in terms of the number of individuals and diversity of genera.

Regarding the Fabaceae, the family’s strong representation can be explained by the fact that this is the third largest plant family in the world, and can be found as shrub, subshrub, tree, herb, or liana, which favors its adaptability to different phytophysiognomies. Likewise, the Rubiaceae is a highly diverse family, and according to Fonseca et al. (2020, p. 2), it is frequently among the most representative groups in floristic surveys conducted in various plant formations throughout the Brazilian territory, corroborating the findings of the present study.

Furthermore, a large part of the vegetation richness of the RFS was found among woody genera, such as shrubs, subshrubs, trees, and lianas, together representing almost 64% of the vegetation present, in line with the NDVI result, which showed an increase in the densest vegetation class between the years 2008 and 2020. Analogous to this, according to Araújo et al. (2005), the first years of succession are marked by rapid colonization of the environment by herbaceous species, later leading to the predominance of short-lived woody pioneer species.

As for the phytophysiognomy identified as dry land, it is distinct for the exclusive presence of woody individuals. such as shrubs, subshrubs, and trees, as Açaizal, Grota, Golosal, Ilha, Sarobal, and Beiradão. Regarding the collection sites, no phytophysionomy was identified as restinga, since this plant formation is directly influenced by the ocean, which is not the case in the Xingu River Basin.

## CONCLUSION

Given the vegetation found in these locations, the names Sarobal, Beiradão, Açaizal, Grota, Restinga, Ilha and Golosal do not correspond to distinct or scientifically recognized phytophysiognomies. The results of the NDVI calculation showed a densification of the vegetation between 2008 and 2020, so new collections are needed to verify the diversity and establishment of species at the sites. Technical reports must be adapted to the scientifically recognized phytophysiognomies, since the nomenclatures identified by Sartoreli (2018) do not correspond to the actual phytophysiognomies.

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