

Mauritia flexuosa L.f. (Buriti) Forest Description: Hydro-edaphic Effects on Tree Species Distribution in Western Amazon

Karoline A.F. Ribeiro

karolfr@usal.es

Mamirauá Institute for Sustainable Development: Instituto de Desenvolvimento Sustentavel Mamiraua <https://orcid.org/0000-0001-5931-4336>

Leonardo P. Reis

Mamirauá Institute for Sustainable Development: Instituto de Desenvolvimento Sustentavel Mamiraua

Pâmella L.S. Assis

Mamirauá Institute for Sustainable Development: Instituto de Desenvolvimento Sustentavel Mamiraua

Mário J.L. Castro

Mamirauá Institute for Sustainable Development: Instituto de Desenvolvimento Sustentavel Mamiraua

Paulo J.F.P. Nascimento

Mamirauá Institute for Sustainable Development: Instituto de Desenvolvimento Sustentavel Mamiraua

Bruna M. Naissinger

Mamirauá Institute for Sustainable Development: Instituto de Desenvolvimento Sustentavel Mamiraua

Gabriela O. Souza

Mamirauá Institute for Sustainable Development: Instituto de Desenvolvimento Sustentavel Mamiraua

Darlene Gris

Mamirauá Institute for Sustainable Development: Instituto de Desenvolvimento Sustentavel Mamiraua

Research Article

Keywords: Flooded forests, Vegetation-environment interrelationships, Edaphic parameters, Phytosociology, Buriti Palm

Posted Date: June 12th, 2024

DOI: <https://doi.org/10.21203/rs.3.rs-4420570/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

This study addresses the lack of knowledge about the *Buritizais* of the Western Brazilian Amazon, trying to fill important gaps for the conservation and management of these unique ecosystems. The study was conducted in the Javari-Buriti Area of Relevant Ecological Interest, with the aim of characterizing the forest communities in different phytophysiognomies, identifying species distribution patterns and the factors that influence the abundance of *Mauritia flexuosa* L.f. A floristic inventory was carried out in areas of *várzea alta* (T1), *várzea alta* with transition to *buritizal* (T2) and *buritizal* (T3). Phytosociological analysis was carried out and environmental variables (soil and flooding) were related to vegetation composition using statistical tests and Canonical Correspondence Analysis (CCA). 112 species were recorded and there was a significant variation in richness between areas, with T2 having the highest number (84 species) and T3 (*Buritizal*) the lowest (28 species). The CCA showed an association between floristic composition and environmental characteristics, especially organic matter. The regression tree showed a preference of *M. flexuosa* for areas with high organic matter and phosphorus. Ordination revealed a clear differentiation in floristic composition between the areas of *várzea alta* and *buritizal*, with the marked presence of species such as *M. flexuosa* and *Chromolucuma rubriflora* in the *buritizal*, correlated positively with organic matter and negatively with copper and aluminum. Our results highlight the influence of environmental conditions on the distribution of plant species in the ARIE Javari-Buriti. Understanding these interactions is crucial for guiding conservation and sustainable management strategies in the Amazon.

1. Introduction

The high species diversity in the Amazon rainforest is attributed to the stable conditions and variety of habitats in the region (Ab'saber 2003; Wittmann et al. 2010), with more than 14,000 tree species estimated (Cardoso et al. 2017; Luize et al. 2018; Ter Steege et al. 2020). These habitats include non-flooded forests, such as *terra firme*, and flooded forests, such as *igapós* and *várzeas*, which can be flooded by black or crystalline water (*igapós*) and by white water (*várzeas*) (Ayres 1995; Junk et al. 2011). The presence and dynamics of water have a significant influence on the distribution of plant species in different aspects (Casanova and Brock 2000; Engelbrecht et al. 2007; Junk et al. 2011). In the wetlands of the Amazon Basin, which occupy up to one third of the total area, water bodies play a fundamental role in creating a heterogeneous landscape, promoting endemism and harboring the most diverse wetland flora in the world (Kubitzki 1989; Wittmann et al. 2006, 2013; Hess 2003; Hamilton et al. 2007; Householder et al. 2012).

Scientific research has mainly focused on periodically flooded areas, such as *várzeas* and *igapós*, leaving a significant gap in knowledge about permanently flooded areas, such as *buritizais*. Although the importance of Amazonian wetlands is increasingly recognized due to their crucial role in the global carbon cycle (Lähteenoja et al. 2012), in the conservation of biodiversity (Brightsmith and Bravo 2006; Householder et al. 2010; Marshall et al. 2011), and in local water dynamics (Kelly et al. 2014), there is still a significant gap in basic knowledge about the plant composition and factors related to the occurrence of these areas.

The permanently flooded areas of the Amazon are often home to monodominant forests or flooded savannas characterized by the presence of the palm of the genus *Mauritia* (buriti) (Spruce 1871; Junk and Furch 1993). An extrapolated analysis of local data from the study by ter Steege et al. (2013) indicates that the permanently flooded areas with widespread *Mauritia* (*buritizais*) dominance occupy an estimated 2–3 million hectares in the Amazon basin, with an estimated *Mauritia* population of approximately 1,5 billion individuals. *Buritizais* occur in dispersed form in *terra firme* forests or periodically flooded forests (Householder et al. 2012). Despite their widespread presence, this Amazonian habitat is paradoxically one of the least studied and is often excluded from most forest inventory programs.

A large area of *Buritizal* is located in the Javari-Buriti Area of Relevant Ecological Interest (ARIE Javari-Buriti, acronym in Portuguese) in the western Amazon. The main objective of this area is to protect the Buriti palm forests (*Mauritia flexuosa* L.f.) and the fauna associated with this plant formation. Since its creation, the ARIE Javari-Buriti has remained one of the least known areas of the Brazilian Amazon. In light of this, this article presents the results of the vegetation survey of the area, carried out in response to a direct request from the Chico Mendes Institute for Biodiversity Conservation (ICMBio, acronym in Portuguese), with the aim of improving the conservation and management of the unit, as well as providing input for the future process of building the ARIE Javari-Buriti management plan.

Thus, the objectives of this work were: i) to characterize and compare the forest communities of the *várzea alta*, *várzea alta* with transition to *buritizal* and *buritizal* areas of the ARIE Javari-Buriti; ii) to correlate environmental variables (duration of flooding and physico-chemical characteristics of the soil) with the floristic composition of the different vegetation types observed in the area; iii) to correlate these same environmental parameters with the occurrence of buriti (*M. flexuosa*). Therefore, the questions we tried to answer in this study are: 1) Do the vegetation types of the ARIE Javari-Buriti differ in terms of structure and floristic composition? And what about the environmental parameters analyzed? 2) Is the distribution of buriti (*M. flexuosa*) more modulated by the duration of flooding? Is there a relationship between the physical and chemical composition of the soil and the distribution of buriti (*M. flexuosa*)?

2. Material and Methods

Study Area

The ARIE Javari-Buriti was created by Decree No. 91.886 of November 5, 1985 (Brasil 1985). It is located in the *Solimões* River Basin, in the municipality of *Santo Antônio do Içá*, Amazonas State, Brazil (Fig. 1). It covers an area of 13,177.22 hectares, and its main objective is the protection of buriti palm forests and the fauna associated with this vegetation type. It is accessible by river on its northern boundary, on the right bank of the *Solimões* River at 02°59'S 67°49'W to 03°01'S 67°51'W upstream. The southern and eastern sides are only accessible by land through long strips of forest (Fleischmann et al. 2023). The climate of the region is classified as tropical Af according to the Köppen system, without a dry season, with annual precipitation between 2,800 and 3,100 mm per year and average annual temperatures between 24 and 26°C (Alvares et al. 2013a, 2013b).

The shapefiles for hydrography and Brazilian states were provided by the Brazilian Institute of Geography and Statistics (IBGE 2019a, 2019b). The boundary of the ARIE Javari-Buriti in georeferenced vector format was provided by ICMBio.

Floristic Structure

Forest inventory

For the floristic inventory, the selection of the areas was initially based on the establishment of three trails that were opened in three different areas according to the criteria of the three vegetation classes observed in the ARIE Javari-Buriti: *Várzea Alta* (Transect 1) - *Várzea Alta* with transition to *Buritizal* (Transect 2) - *Buritizal* (Transect 3). A stratified conglomerate sampling system was chosen. In each sampling area, a main transect (T) was established 600 m to the north, where a first conglomerate (C) was sampled 200 m to the east and a second 600 m to the west, each conglomerate 275 m long (Fig. 2). Four 25 x 25 m temporary plots (P) were established in each conglomerate, 50 m apart, giving a total sample area of 0,5 ha in each transect (8 plots) and a total area of 1,5 ha considering the entire study area (24 plots - Figs. 1 and 2).

Within each plot, all trees and palms with a diameter at breast height (DBH) ≥ 10 cm were sampled. Species were identified in the field by parobotanists. When not identified, botanical samples, fertile (flowers and fruits) or not, were collected and dried in an oven for later identification by specialists. The botanical names given were checked against the *Flora e Funga do Brasil* (Flora e Funga do Brasil 2022).

Phytosociological analysis

The phytosociological parameters estimated for each transect (T) were basal area, density, absolute frequency and dominance, as well as the Importance Value Index (IV), according to Müller-Dombois and Ellenberg (1974). Floristic diversity was assessed using the Species Richness and Shannon-Wiener (H') indices (Brower and Zar 1984; Perkins, 1982) and the Pielou Equability Index (J') according to Magurran (1988).

The species accumulation curve was generated using the rarefaction method (Gotelli and Colwell 2001) to evaluate sampling effort and compare species richness between transects. Rarefaction generates the expected number of species for the corresponding accumulation curve, which is the curve constructed from the total number of species recorded during the inventory (Gotelli and Colwell 2001). Floristic similarities between conglomerates were analyzed and estimated using quantitative (Bray-Curtis) and qualitative (Jaccard) indices (Müller-Dombois and Ellenberg 1974). Dendrograms were constructed from these cluster analyses.

All parameters and analyses were generated with the R program (R Development Core Team 2021), using the packages *ecolTest* (Salinas and Ramirez-Delgado 2021) and *Vegan* (Oksanen et al. 2022).

Environmental Variables

Soil sampling and analysis

Soil analysis was carried out using samples collected at depths of 0–20 cm in all the temporary plots installed in the ARIE Javari-Buriti. One soil sample was collected in the center of each plot from all the vegetation types inventoried. The soil chemical parameters analyzed were pH; phosphorus (P); potassium (K); sodium (Na); calcium (Ca); magnesium (Mg); aluminum (Al); potential acidity (H + Al) and calculations of the sum of bases (SB); cation exchange capacity (CTC); base saturation (V%); aluminum saturation (m%); the micronutrients iron (Fe); zinc (Zn); copper (Cu) and manganese (Mn); total carbon/total nitrogen ratio (C/N); total organic carbon and organic matter (M. O.). The physical parameters analyzed were: total sand, silt and clay (dispersant) (texture).

The physical and chemical analyses of the soil samples were performed by the Soil and Plant Laboratory (LSP) of the Brazilian Agricultural Research Corporation (*Embrapa Amazônia Oriental*), following the protocol established by Teixeira et al. (2017). For the physical analyses, sand content was determined by separation with a 0,212 mm mesh sieve, while silt and clay were determined by the pipette method, which consists of determining each fraction according to sedimentation time. For the chemical analyses, available P was determined by spectrophotometry, while the cations Ca, Mg, K, Na and Al and the micronutrients Fe, Zn, Mn and Cu were quantified by atomic absorption spectrometry (Anderson and Ingram 1993). C and N were estimated using an automatic elemental analyzer (Pella 1990) and finally, M.O. was quantified by the difference between the dry mass of the soil and the mass of the residue obtained after incineration (Pereira et al. 2006).

Flooding

The flooding was inferred from the relationship between the average historical permanence of the water surface and the altitude of the plots. This data was taken from the Santo Antônio do Içá fluviometric station (Hidroweb Code 11.500.000), and from the Digital Terrain Model Cartografia da Amazônia, with five meters of spatial resolution (Correia 2011). The measurements of the water surface were made on rulers in the local topographic plane, it was necessary to transform these values to the same vertical reference as the digital model, so the zero value of the ruler was assumed to be 43,15 m, as proposed by Moreira (2016). The number of days flooded per year was calculated by averaging the days on which the altitude of the plots was higher than the altitude of the water surface.

Statistical analysis

The soil parameters analyzed and the duration of flooding were correlated with the tree species abundance data in the installed plots. To minimize multicollinearity between the environmental variables, we first used a stepwise variance inflation factor (VIF) selection procedure (Graham 2003). From the resulting correlation matrix, we selected variables based on a minimum cut-off or threshold of 0,6. For this analysis, we used the *HH* package in the R software (Graham 2003).

In order to identify statistical differences between the three vegetation types for each of the environmental variables, the following statistical tests were employed: ANOVA tests followed by Tukey's test when the data followed a normal distribution, or the Kruskal-Wallis test followed by Dunn's test when the data did not follow a normal distribution. The analyses were conducted using the *Agricolae* (Mendiburu 2023) and *dunn.test* (Dinno 2017) packages in the R software. Boxplots were generated to visualise the results using the *ggplot2* (Wickham 2016) and *gridExtra* (Auguie 2017) packages.

To ascertain the variations in species composition along the environmental gradient and to identify the factors associated with each vegetation type, a Canonical Correspondence Analysis (CCA) was conducted utilising the *Vegan* package (Oksanen et al. 2018). CCA is a multivariate analysis that enables the species composition of communities to be correlated directly with variations in the environments in which they occur (Ter Braak 1986, 1987). The *envfit* function was employed to identify the variables that best explain the observed variation, and a Monte Carlo test was conducted to determine the significance of the axes (Ter Braak 1988).

In order to visualise the distribution patterns of species abundances in relation to the gradients of the selected parameters, ordination histograms were constructed. The selection of species to be included in the histograms was based on the CCA analysis, with the aim of including all species that were significant for the construction of the CCA. This analysis was conducted using the *poncho* function (Dambros 2020) within the R software.

Finally, a Classification and Regression Tree (CART) was constructed to identify the parameters that most affect the abundance of buriti (*M. flexuosa*) using the *rpart* package (Recursive Partitioning and Regression Trees, Therneau 2017) and the *part.plot* package (Milborrow 2018). This analysis was represented graphically to facilitate interpretation. This non-parametric analysis enables the explanation of variations in the response variable by successively dividing the data into more homogeneous groups, each of which is defined by the explanatory variables.

3. Results

Floristic Structure

Composition

A total of 112 morphospecies were recorded among the 816 individuals sampled in the 24 plots. Of these, 81 were determined at the specific level, 19 at the genus level, one at the family level and 11 were undetermined (Table 1). The data collected for all the individuals sampled in each plot (including DBH and estimated height – among other relevant information) can be accessed in Supplementary Material S1. The genera with the greatest floristic richness were *Inga*, with seven species (five of which were not specifically identified); *Eschweilera*, with five species, and *Ficus*, with four species. Collectively, these three genera accounted for 14,3% of the species recorded. Conversely, 54 genera were represented by just one species, accounting for 48,2% of the species identified.

The families with the highest number of species were Fabaceae (21 species), Arecaceae (eight species) and Euphorbiaceae (eight species). These three families contributed 44,6% of the local richness, suggesting that plant diversity is concentrated in a few botanical families. The most important families, in descending order of number of individuals, were: Arecaceae (287), Fabaceae (62), Euphorbiaceae (57), Lecythidaceae (28) and Malvaceae (28). Together, they accounted for 56,6% of the specimens inventoried, indicating a high relative abundance of individuals in these families (Supplementary Material S1). Of these families, Arecaceae is of particular importance, accounting for 35% of the individuals sampled. The most representative species in this family were *Mauritia flexuosa* L. f. (buriti – 135 individuals sampled) and *Euterpe precatoria* Mart. (Açaí – 87 individuals sampled). Collectively, the two species accounted for 27,2% of the individuals sampled.

Table 1
List of families and species recorded in the floristic survey of the study area. ARIE Javari-Buriti,
Amazonas State, Brazil.

Family	Species	Vernacular name
Anacardiaceae	<i>Spondias mombin</i> L.	Taperebá
Anacardiaceae	<i>Tapirira guianensis</i> Aubl.	
Annonaceae	<i>Duguetia</i> sp.1	Envira preta
Annonaceae	<i>Guatteria citriodora</i> Ducke	Envira amargosa
Annonaceae	<i>Pseudoxandra</i> sp.1	Brinco de moça
Apocynaceae	<i>Aspidosperma rigidum</i> Rusby	Carapanaúba
Apocynaceae	<i>Himatanthus articulatus</i> (Vahl) Woodson	Sucuúba
Apocynaceae	<i>Lacmellea gracilis</i> (Müll.Arg.) Markgr.	Siricutico
Apocynaceae	<i>Malouetia tamaquarina</i> (Aubl.) A.DC.	Molongó
Arecaceae	<i>Astrocaryum jauari</i> Mart.	Jauari
Arecaceae	<i>Astrocaryum murumuru</i> Mart.	Murumuru
Arecaceae	<i>Attalea phalerata</i> (Mart.) ex Spreng	Urucuri
Arecaceae	<i>Euterpe precatoria</i> Mart.	Açaí
Arecaceae	<i>Mauritia flexuosa</i> L.f.	Buriti
Arecaceae	<i>Mauritiella armata</i> (Mart.) Burret	Buritirana
Arecaceae	<i>Oenocarpus bacaba</i> Mart.	Bacaba
Arecaceae	<i>Socratea exorrhiza</i> (Mart.) H.Wendl.	Paxiúba
Burseraceae	<i>Protium</i> sp.1	Breu branco
Burseraceae	<i>Protium</i> sp.2	
Chrysobalanaceae	<i>Licania impressa</i> Prance	Uixi liso
Chrysobalanaceae	<i>Licania</i> sp.1	
Clusiaceae	<i>Garcinia brasiliensis</i> Mart.	Bacuri liso
Clusiaceae	<i>Symphonia globulifera</i> L.f.	Paxiúba amarela
Combretaceae	<i>Terminalia dichotoma</i> G.Mey.	Tanimbuca baratinha
Dichapetalaceae	<i>Tapura juruana</i> (Ule) Rizzini	Quineira
Elaeocarpaceae	<i>Sloanea guianensis</i> (Aubl.) Benth.	Urucurana vermelha
Elaeocarpaceae	<i>Sloanea</i> sp.1	Urucurana vermelha
Erythroxylaceae	<i>Erythroxylum kapplerianum</i> Peyr.	Socoró, cocarana-branca
Euphorbiaceae	<i>Alchornea discolor</i> Poepp.	Supiarana
Euphorbiaceae	<i>Anomalocalyx uleanus</i> (Pax & K.Hoffm.) Ducke	
Euphorbiaceae	<i>Conceveiba</i> sp.1	
Euphorbiaceae	<i>Hevea spruceana</i> (Benth.) Müll.Arg.	Seringa barriguda
Euphorbiaceae	<i>Hura crepitans</i> L.	Assacu
Euphorbiaceae	<i>Mabea nitida</i> Spruce ex Benth.	Seringáí
Euphorbiaceae	<i>Pinharea trifoliata</i> Baill.	Piranheira
Euphorbiaceae	<i>Sapium glandulosum</i> (L.) Morong	Murupita
Fabaceae	<i>Crudia glaberrima</i> (Steud.) J.F.Macbr.	Ingá xixica
Fabaceae	Indet2	Mututi branco
Fabaceae	<i>Inga ingoides</i> (Rich.) Willd.	Ingá do folhão
Fabaceae	<i>Inga pilosula</i> (Rich.) J.F.Macbr.	Ingá 2
Fabaceae	<i>Inga</i> sp.1	Ingá corrente

Family	Species	Vernacular name
Fabaceae	<i>Inga</i> sp.2	Ingá xixaua
Fabaceae	<i>Inga</i> sp.3	Ingá peluda
Fabaceae	<i>Inga</i> sp.4	Ingá ferro
Fabaceae	<i>Inga</i> sp.5	Ingá açú
Fabaceae	<i>Lecointea amazonica</i> Ducke	Paracuuba
Fabaceae	<i>Macrolobium bifolium</i> (Aubl.) Pers.	Cedrinho pata de vaca
Fabaceae	<i>Ormosia macrocalyx</i> Ducke	Tento vermelho
Fabaceae	<i>Ormosia towarensis</i> Pittier	Tento flamenguista
Fabaceae	<i>Pterocarpus amazonum</i> (Benth.) Amshoff	Tachi branco
Fabaceae	<i>Pterocarpus santalinoides</i> L'Hér. ex DC.	Ingá chato
Fabaceae	<i>Pterocarpus</i> sp.1	Mututi
Fabaceae	<i>Taralea oppositifolia</i> Aubl.	Cumaru-amarelo
Fabaceae	<i>Vouacapoua americana</i> Aubl.	Faveira
Fabaceae	<i>Zygia coccinea</i> (G.Don) L.Rico	Ingá
Fabaceae	<i>Zygia latifolia</i> (L.) Fawc. & Rendle	Ingá de anta
Fabaceae	<i>Zygia trunciflora</i> (Ducke) L.Rico	Ingá chato
Hypericaceae	<i>Vismia sandwithii</i> Ewan	Lacre
Lamiaceae	<i>Aegiphila</i> sp.1	Supiarana
Lauraceae	<i>Nectandra amazonum</i> Nees	Cachimbo, louro chumbo
Lauraceae	<i>Ocotea</i> sp.1	Louro chumbo
Lauraceae	<i>Ocotea splendens</i> (Meisn.) Baill.	Louro
Lecythidaceae	<i>Couropita subsessilis</i> Pilg.	Macacarecuia
Lecythidaceae	<i>Eschweilera albiflora</i> (DC.) Miers	Matá matá folha graúda
Lecythidaceae	<i>Eschweilera ovalifolia</i> (DC.) Nied.	Castanharana
Lecythidaceae	<i>Eschweilera parvifolia</i> Mart. ex DC.	Ripeira
Lecythidaceae	<i>Eschweilera rionegrense</i> S.A.Mori	
Lecythidaceae	<i>Eschweilera tenuifolia</i> (O.Berg) Miers	Matá matá
Lecythidaceae	<i>Gustavia poeppigiana</i> O.Berg	Cachimbo
Malvaceae	<i>Apeiba glabra</i> Aubl.	Bolacheira
Malvaceae	<i>Apeiba tibourbou</i> Aubl.	Caibreiro
Malvaceae	<i>Ceiba pentandra</i> (L.) Gaertn.	Samaúma
Malvaceae	<i>Pachira insignis</i> (Sw.) Sw. ex Savigny	Mungubarana
Malvaceae	<i>Pseudobombax munguba</i> (Mart.) Dugand	Munguba
Malvaceae	<i>Sterculia apetala</i> (Jacq.) H.Karst.	Tacacá
Melastomataceae	<i>Mouriri grandiflora</i> DC.	Araçapéua
Meliaceae	<i>Carapa guianensis</i> Aubl.	Andiroba
Meliaceae	<i>Carapa vasquezii</i> Kenfack	Andirobinha
Meliaceae	<i>Trichilia pallida</i> Sw.	Murici
Meliaceae	<i>Trichilia rubra</i> C.DC.	Envira fofa
Meliaceae	<i>Trichilia solitudinis</i> Harms	
Moraceae	<i>Brosimum acutifolium</i> Huber	Mururé
Moraceae	<i>Ficus adhatodifolia</i> Schott in Spreng.	Caxinguba
Moraceae	<i>Ficus maxima</i> Mill.	Caxinguba

Family	Species	Vernacular name
Moraceae	<i>Ficus paraensis</i> (Miq.) Miq.	Apuí-amarelo
Moraceae	<i>Ficus</i> sp.1	Apuí
Moraceae	<i>Maquira coriacea</i> (H.Karst.) C.C.Berg	Muiratinga
Myristicaceae	<i>Virola surinamensis</i> (Rol. ex Rottb.) Warb.	Ucuúba
Myrtaceae	<i>Eugenia</i> sp.1	Araçapéua
Olacaceae	<i>Heisteria acuminata</i> (Humb. & Bonpl.) Engl.	Brinco de moça
Olacaceae	<i>Minquartia guianensis</i> Aubl.	Acariquara
Phyllanthaceae	<i>Discocarpus essequiboensis</i> Klotzsch	Mututi
Polygonaceae	<i>Triplaris weigeltiana</i> (Rchb.) Kuntze	Tachi vermelho
Rubiaceae	<i>Sickingia tinctoria</i> (Benth.) Bremek. ex Steyerl.	Pau rosa
Sapotaceae	<i>Chromolucuma rubriflora</i> Ducke	Abiurana-grande-de-igapó
Sapotaceae	<i>Pouteria rostrata</i> (Huber) Baehni	Abiurana-seringa
Sapotaceae	<i>Pouteria</i> sp.1	
Sapotaceae	<i>Pouteria</i> sp.2	
Urticaceae	<i>Cecropia latiloba</i> Miq.	Embaúba roxa
Urticaceae	<i>Cecropia membranacea</i> Trécul	Embaúba branca
Violaceae	<i>Leonia glycyarpa</i> Ruiz & Pav.	Catoré branco
Indet	Indet	Cipó
Indet1	Indet1	Envira fofa
Indet3	Indet3	
Indet4	Indet4	
Indet5	Indet5	Canela de velho
Indet6	Indet6	
Indet7	Indet7	
Indet8	Indet8	Capitiú
Indet9	Indet9	Gitó amarelo
Indet10	Indet10	
Indet11	Indet11	

Phytosociology

A significant difference in species richness was observed between the different transects. Transect 2, which was considered to be a *várzea alta*, but with transitional characteristics between *várzea alta* and *buritizal*, had the highest number of species, with a total of 84. Transect 3, which was designated as the *buritizal* area, had the lowest richness, with 28 species recorded. Conversely, the highest total densities were observed in the *buritizal* and *várzea alta* with transition to *buritizal* (Table 2). During the course of the inventory, it was observed that the area of transect 1 (*várzea alta*) had been subject to anthropogenic interference with logging. The ease of access to this area via the *Solimões* River may contribute to the alteration processes and explain the lower total density observed in this transect (Fig. 2). The basal area did not differ significantly between the areas, being between 5,4 and 5,9 m² per hectare (Table 2).

The values of the Shannon-Wiener diversity index and the Pielou equability index, which represents the uniformity of the distribution of individuals among the existing species, demonstrate the greatest similarity between areas T1 and T2 and a significant distinction between the *buritizal* (T3) and both (Table 2).

Table 2
Richness values and phytosociological parameters analysed for each transect (T1, T2 and T3) in the study area. ARIE Javari-Buriti, Amazonas State, Brazil.

	T1	T2	T3
Richness	50	84	28
Density*	111 ± 18,38 ind/ha	138 ± 11,31 ind/ha	140 ± 0 ind/ha
Basal Area*	5,65 ± 0,01 m ² /ha	5,44 ± 0,6 m ² /ha	5,9 ± 0,17 m ² /ha
Shannon-Wiener (H')	3,203387	3,712292	1,952309
Pielou (J)	0,8188568	0,8378347	0,5858911
* Total per area, considering the eight plots installed (= 0.5 ha)			

Species density is defined as the number of individuals per unit area. Dominance is expressed in terms of basal area, while frequency represents the occurrence of each species in the sampling units. The Importance Value Index (IV) is estimated by adding up the relative indices of density, dominance and frequency of the species sampled, and expresses the ecological relevance of the species in a community. The four species with the highest IV and most abundant (highest densities) in the *várzea alta* (T1) were: The species with the highest IV and densities in the *várzea alta* (T1) were *Hura crepitans* (Assacú), *Virola surinamensis* (Ucuúba), *Euterpe precatoria* (Açaí) and *Mauritia flexuosa* (buriti). In the *várzea alta* with transition to *buritizal* (T2), the results were similar, with the following species ranking in descending order: The species with the highest IV and densities in the *várzea alta* with transition to *buritizal* (T2) were *Carapa guianensis* (Andiroba), *Euterpe precatoria*, *Hura crepitans*, and *Virola surinamensis* (Table 3).

As anticipated, the *buritizal* (T3) exhibited highly distinctive outcomes. The four species with the highest IV included *Mauritia flexuosa* (first place) and *Euterpe precatoria* (third place) in conjunction with *Chromolucuma rubriflora* and *Anomalocalyx uleanus*, which occupied second and fourth place, respectively. Furthermore, these species, particularly *Chromolucuma rubriflora*, contributed significantly to the absolute density observed in this area, due to its high abundance (70 individuals). *Mauritia flexuosa* ranked first in absolute density and the significant number of individuals recorded, 116 (Table 3). Consequently, 41,42% of the individuals sampled in Transect 3 (*buritizal*) belong to the species *Mauritia flexuosa* (buriti).

Table 3
Species, number of individuals (N), absolute density (AD), absolute dominance (ADo), absolute frequency (AF) and importance value (IV) in the three study areas (*várzea alta*, *várzea alta* with transition to *buritizal* and *buritizal*). The table shows only the 20 species with the highest VI values per area. ARIE Javari-Buriti, Amazonas State, Brazil.

	Species	N	AD	ADo	AF	IV	T1
1	<i>Hura crepitans</i>	22	11,0	1,27	100	11,79	
2	<i>Virola surinamensis</i>	29	14,5	1,01	100	11,33	
3	<i>Euterpe precatoria</i>	28	14,0	0,35	100	7,25	
4	<i>Mauritia flexuosa</i>	15	7,5	0,60	100	6,77	
5	<i>Symphonia globulifera</i>	21	10,5	0,41	100	6,57	
6	<i>Hevea spruceana</i>	7	3,5	0,19	100	3,19	
7	<i>Astrocaryum jauari</i>	7	3,5	0,12	100	2,76	
8	<i>Sterculia apetala</i>	8	4,0	0,08	100	2,67	
9	<i>Couroupita subsessilis</i>	5	2,5	0,15	100	2,62	
10	<i>Pterocarpus amazonum</i>	7	3,5	0,08	100	2,51	
11	<i>Attalea phalerata</i>	4	2,0	0,14	100	2,44	
12	<i>Discocarpus essequiboensis</i>	6	3,0	0,14	50	2,21	
13	<i>Pseudobombax munguba</i>	1	0,5	0,20	50	1,81	
14	<i>Terminalia dichotoma</i>	4	2,0	0,03	100	1,79	
15	<i>Triplaris weigeltiana</i>	4	2,0	0,03	100	1,79	
16	<i>Eschweilera parvifolia</i>	3	1,5	0,02	100	1,56	
17	<i>Mauritiella armata</i>	5	2,5	0,05	50	1,53	
18	<i>Macrolobium bifolium</i>	2	1,0	0,03	100	1,45	
19	<i>Spondias mombin</i>	2	1,0	0,02	100	1,43	
20	<i>Socratea exorrhiza</i>	1	0,5	0,13	50	1,42	
1	<i>Carapa guianensis</i>	39	19,5	0,57	100	8,81	T2
2	<i>Euterpe precatoria</i>	38	19,0	0,56	100	8,66	
3	<i>Hura crepitans</i>	5	2,5	0,85	100	6,46	
4	<i>Virola surinamensis</i>	14	7,0	0,23	100	3,74	
5	<i>Symphonia globulifera</i>	12	6,0	0,16	50	2,72	
6	<i>Eschweilera ovalifolia</i>	6	3,0	0,19	100	2,55	
7	<i>Socratea exorrhiza</i>	10	5,0	0,07	100	2,30	
8	<i>Sterculia apetala</i>	7	3,5	0,11	100	2,18	
9	<i>Mauritia flexuosa</i>	4	2,0	0,16	50	1,80	
10	<i>Zygia latifolia</i>	6	3,0	0,06	100	1,72	
11	<i>Cecropia latiloba</i>	5	2,5	0,13	50	1,70	
12	<i>Zygia coccinea</i>	8	4,0	0,06	50	1,65	
13	<i>Indet1</i>	3	1,5	0,10	100	1,63	
14	<i>Ficus adhatodifolia</i>	2	1,0	0,12	100	1,59	
15	<i>Gustavia poeppigiana</i>	4	2,0	0,06	100	1,50	
16	<i>Couroupita subsessilis</i>	2	1,0	0,15	50	1,50	
17	<i>Attalea phalerata</i>	3	1,5	0,08	100	1,49	
18	<i>Cecropia membranacea</i>	4	2,0	0,05	100	1,44	
19	<i>Indet4</i>	1	0,5	0,15	50	1,37	

20	<i>Indet5</i>	4	2,0	0,03	100	1,32	T3
1	<i>Mauritia flexuosa</i>	116	58,0	3,81	100	37,28	
2	<i>Chromolucuma rubriflora</i>	70	35,0	0,99	100	15,90	
3	<i>Euterpe precatoria</i>	21	10,5	0,23	100	5,74	
4	<i>Anomalocalyx uleanus</i>	12	6,0	0,15	100	4,25	
5	<i>Virola surinamensis</i>	11	5,5	0,15	100	4,11	
6	<i>Himatanthus articulatus</i>	14	7,0	0,12	50	3,33	
7	<i>Sterculia apetala</i>	4	2,0	0,04	100	2,68	
8	<i>Ficus adhatodifolia</i>	5	2,5	0,18	50	2,60	
9	<i>Brosimum acutifolium</i>	3	1,5	0,07	50	1,71	
10	<i>Cecropia latiloba</i>	4	2,0	0,04	50	1,67	
11	<i>Alchornea discolor</i>	2	1,0	0,02	50	1,32	
12	<i>Vismia sandwithii</i>	2	1,0	0,01	50	1,27	
13	<i>Trichilia solitudinis</i>	1	0,5	0,01	50	1,16	
14	<i>Terminalia dichotoma</i>	1	0,5	0,01	50	1,14	
15	<i>Ormosia macrocalyx</i>	1	0,5	0,01	50	1,14	
16	<i>Crudia glaberrima</i>	1	0,5	0,01	50	1,14	
17	<i>Maclobium bifolium</i>	1	0,5	0,01	50	1,14	
18	<i>Aegiphila</i> sp.1	1	0,5	0,01	50	1,14	
19	<i>Indet11</i>	1	0,5	0,01	50	1,14	
20	<i>Spondias mombin</i>	1	0,5	0,01	50	1,14	

The rarefaction curve is generated by randomly resampling all the individuals. Each point on the curve represents the average of these resamplings (1000). The rarefaction curves in this study (Fig. 3) exhibited slight inflection points for areas T1 and T3, indicating that the sampling was sufficient and reached a satisfactory percentage of the species in the study area. Nevertheless, the curves do not reach complete stabilisation, which is most evident in T2, the area with the highest richness, with 84 species surveyed.

With regard to floristic similarity, the comparison analyses were carried out using conglomerates (a set of four plots each) established in each transect for each study area as sampling units. Each identification consisted of the transect number and conglomerate number, e.g. T1C1. The dendrograms (Jaccard and Bray-Curtis indices – Fig. 4) demonstrate a clear separation between the *várzea alta* (T1 and T2) and *buritizal* (T3), in accordance with expectations. There is a high degree of similarity between the plots set up in the same phytophysiology (T1 and T2). The conglomerates T1C1 and T1C2 exhibited the greatest degree of similarity, given that they were situated on the same transect. Conglomerate T2C1 was also highly similar to T1C1 and T1C2, followed by T2C2. However, among the four *várzea* conglomerates, the latter had the shortest distance to the conglomerates in Transect 3. The results of this study demonstrate the transitional nature of the Transect 2 area, as previously hypothesised.

Vegetation-Environment Interrelationships

The tables containing all the results of the chemical and physical soil analyses carried out, as well as the calculated inundation values, and the table containing the abundance data of the species recorded in each of the plots installed, can be accessed in the Forestplots (forestplots.net). Unfortunately, it was not possible to carry out physical analyses of the soil for all the plots in the study area, especially T3, due to insufficient material being collected. In order to address this limitation, the following approach was adopted: The clay concentrations of the 26 plots were extracted from SoilGrids 2.0 (Poggio et al. 2021). The clay correlation between the 16 plots measured in the laboratory and those extracted from SoilGrids was 0,68, so the equation of this linear regression was used to adjust the SoilGrids values of the remaining 10 plots without laboratory analysis. Consequently, only the "clay" variable was considered for the analyses presented below in terms of the soil's physical attributes.

Following the analysis of multicollinearity, the variables pH, M.O. (organic matter), P, Al, H + Al (potential acidity), V (Base Saturation Index), Zn, Mn, Cu, Clay and Flood were selected as the most appropriate for further analysis. The final VIF values achieved for the variables can be seen in Supplementary Material S2 (A). Significant differences were observed between the three phytophysiology (T1, T2 and T3) in at least one of the pairs of comparisons for the following variables: pH, M.O., P, Mn, Cu, Clay and Flood. The parameter that exhibited the most pronounced significance and differences between all the environments in the area was M.O. ($p < 0.000$), with the plots in T3 (*buritizal*) demonstrating the highest values for this parameter. Conversely, the variables Al, H + Al, V and Zn exhibited no significant differences between the three environments studied (Fig. 5 and Supplementary Material S2 (B)).

Canonical Correspondence Analysis

Canonical Correspondence Analysis (CCA) was carried out on the 112 species surveyed in this study and the 11 environmental variables selected after testing for multicollinearity. The Canonical Coordinates analysis revealed that the CCA explained 59,63% (3,0718) of the total inertia (5,1518). The remaining 40,37% of inertia can be attributed to stochastic effects or unmeasured variables. The first two CCA axes collectively explained 39,04% of the total variation in the data, with axis 1 (CCA1) contributing 22,10% and axis 2 (CCA2) 16,94%. The results demonstrate that the CCA is capable of capturing a substantial proportion of the variation in plant species in relation to the environmental variables under consideration.

The permutation tests confirmed the significance of the overall analysis and the individual axes ($p < 0,001$), further validating the results obtained. The CCA eigenvalues were: 0,6787 (axis 1) and 0,5201 (axis 2), indicating the existence of gradients, in which there is a variation in species substitution between the areas sampled in the three phytophysiognomies. Of the environmental variables, only V (Base Saturation Index) and clay did not show significant values ($p = 0,2603$ and $p = 0,2503$, respectively). As for the species, the linear regression analysis demonstrated significant values for 23 of the 112 species. The summary of all the results of the CCA analysis can be found in Supplementary Material S2 (C).

The existence of an environmental gradient in which there is a change in floristic composition and structure can be observed in the ordering of the sampling units on both axes of the CCA (Fig. 6). The plots from the *várzea alta* (P1 to P8 [T1]) and *várzea alta* with Transition to *buritizal* (P9 to P16 [T2]) environments are situated to the right of the plots referring to the *Buritizal* environment (P17 to P24 [T3]). It can be observed that the *Buritizal* sampling units constituted a coherent group, exhibiting a strong and positive correlation with the environmental variable M.O. (organic matter). Conversely, there was a negative association between this sample group and the soil variables V, Al and Mn. Furthermore, the prevalence of *M. flexuosa*, *A. uleanus* and *C. rubriflora* is evident here. These species exhibited a consistent abundance in *Buritizal*, indicating that they are species with a high density and wide distribution in this environment.

Upon examination of axis 2, the sectors on the left-hand side of the diagram, it becomes evident that the sampling units from the *várzea alta* (P1 to P8 [T1]) and *várzea alta* with transition to *buritizal* (P9 to P16 [T2]) phytophysiognomies constituted a more dispersed group with a longer gradient. The plots of transect 1 are concentrated in the upper left-hand sector, where the following species are preferentially distributed: *A. jauari*, *P. amazonum*, *H. spruceana*, *H. crepitans* and *S. globulifera*. In this transect, there is a positive relationship with Cu and Clay, and a negative one with pH. In the lower left sector of the diagram, we observe that the sample set from transect 2 (*várzea alta* with transition to *buritizal*) is even more strongly associated with the predominant floristic composition. Among the species that stand out are *A. phalerata*, *C. guianensis*, *A. murumuru* and *S. guianensis*. Furthermore, in T2, there is a negative correlation between the environmental parameters H + Al (potential acidity), P (phosphorus) and flooding.

Ordination Histograms

It has been observed that there is a significant phenomenon in plant communities whereby certain soil attributes are preferred. Figure 7 illustrates this phenomenon, showing that species such as *M. flexuosa* and *C. rubriflora* tend to thrive in soils characterised by low levels of aluminium and copper, as well as a lower proportion of clay. In contrast, other species, including *O. bacaba*, *Z. trunciflora*, *A. phalerata* and *S. guianensis*, exhibited a preference for environments with medium to high levels of these same elements. This pattern is also observed in the duration of flooding. For example, *C. guianensis*, *G. poeppigiana*, *S. guianensis*, *O. bacaba* and *Z. latifolia* are more commonly found in areas with fewer days of flooding per year, while *M. flexuosa* is more abundant in areas with a longer duration of flooding (Fig. 7).

Similarly, the influence of variables such as potential acidity (expressed as H + Al), organic matter (M.O.) and phosphorus (P) was also demonstrated to be relevant in the abundance of species (Fig. 8). Species such as *M. flexuosa*, *C. rubriflora*, *A. oleanus*, *P. amazonum*, *V. surinamensis* and *S. globulifera* were found to be more abundant in plots with medium to high levels of these elements. However, an inverse trend was observed for manganese (Mn) with regard to these same species (Fig. 8).

Figure 9 presents the results of the analysis of the base saturation (V) and pH variables. The average values did not vary significantly between plots, yet it was observed that *M. flexuosa* and *C. rubriflora* exhibited a preference for higher pH and lower V values. With regard to zinc (Zn), these species were more abundant in intermediate fractions. Finally, it is important to highlight the exclusive occurrence of the species *F. maxima*, *O. splendens* and *A. rigidum* in plots characterised by low values of these same parameters (Fig. 9).

Figure 7 Ordination histograms for the environmental variables: Al, Clau, Cu and Flood. The species analysed were based on their significance in the CCA analysis. ARIE Javari-Buriti, Amazonas State, Brazil

Figure 8 Ordination histograms for the environmental variables: H + Al, Mn, M.O. and P. The species analysed were based on their significance in the CCA analysis. ARIE Javari-Buriti, Amazonas State, Brazil

Abundance of *M. flexuosa*

Figure 10, which represents the Classification and Regression Tree, illustrates the variables with the greatest influence on the abundance of the buriti palm. It is notable that Organic Matter (M.O.) has a remarkable importance, with 107 of the 135 individuals sampled recorded in areas where M.O. values exceed 495 g/kg (C [organic carbon] x 1,724). It is also noteworthy that these individuals are concentrated in a limited number of plots (six out of a total of 24), which corroborates the phytosociological findings indicating a preponderance of these six plots in the *buritizal* environment (transect 3). For the individuals found in areas with M.O. values lower than 495 g/kg, phosphorus (P) emerged as the most significant parameter in explaining their abundance. All 28 individuals observed occurred in places where P values exceeded 9 mg/dm³. These records were identified in 11 of the 18 plots in the region considered for this group of individuals.

4. Discussion

The present study provides data on the floristic composition and structure, as well as the edaphic attributes of a *M. flexuosa* (*buritizal*) forest located in the Western Amazon, Brazil. Virapongse et al. (2017) conducted a systematic review of published information on the ecology, livelihoods and management of *M. flexuosa*. A review of the literature on the ecology of *M. flexuosa* revealed that most studies focus on natural history, population ecology and interactions with wildlife. There is a significant information gap on community and ecosystem ecology, which emphasises the relevance of our results to a greater understanding of the overall ecology and the importance of the *buritizal* as a crucial component of the Amazon ecosystem.

A comparison of the studies by Sander (2014), Sander et al. (2017), Oliveira et al. (2017, 2019) revealed similarities and differences in the floristic and phytosociological characteristics of the *buritizais*, and in the distribution of the *Mauritia flexuosa* species. Our study, conducted in the ARIE Javari-Buriti, highlights the significant presence of *Mauritia flexuosa*, corroborating the findings of Sander (2014) in a *buritizal* on the Amazon-Cerrado biological border. Both studies emphasise the ecological importance of this monodominant species in its habitat, along with other high-value species such as *Virola surinamensis* and *Euterpe precatoria*. However, our findings also indicate a high species richness, with 112 species recorded, in contrast to the lower richness observed by Sander et al. (2017) in the Jurueña-Mirim Area of Relevant Ecological Interest, located in the southern Amazon region.

A comparison of the studies by Sander (2014), Sander et al. (2017) reveals that our study highlights a lower species richness in the *buritizal* transect (T3) specifically, compared to other environments. This corroborates the observation by Oliveira et al. (2017) about the variation in species composition in different savannah habitats. Conversely, methodological aspects such as the floristic and phytosociological inventory in our study, conducted using established trails and temporary plots, can be contrasted with the methods employed by these authors. Furthermore, while our study is focused on a specific area within the ARIE Javari-Buriti, Sander's research (2014) covered a *buritizal* on the Amazon-Cerrado biological frontier, providing insights into the distribution and ecology of these environments in different regions. In conclusion, our research contributes to the understanding of the diversity and ecological importance of *buritizais* in the Amazon, emphasising their floristic richness and the significance of the *Mauritia flexuosa* species in its specific context.

The Importance Value Index (IV), calculated for plant species in undisturbed areas, is a useful indicator in management plans due to its ability to reflect the ecological importance of the most prevalent and dominant species (Oliveira and Amaral 2005). In addition to their relevance to ecological processes, such as providing shelter and food for fauna, the economic significance of certain species identified in our study is worthy of note. Species such as *Hura crepitans*, *Virola surinamensis* and *Carapa guianensis*, which showed high importance values in different transects, have multiple economic applications, from timber to medicinal use (Brito et al. 2008; Klimas et al. 2012; Oyelade et al. 2017; Silva et al. 2023; Wittmann et al. 2010). These findings highlight the area's promising potential for diversifying sources of income and products derived from biodiversity, contributing to sustainable economic development in the region. More details on this subject can be found in Supplementary Material S3.

A number of studies have been conducted with the aim of understanding the influence of environmental factors (such as climate, hydroperiod and edaphic properties) on the structure, dynamics, diversity and carbon stocks of Amazonian forests. These studies can be found in the literature, including those by Quesada et al. (2012), Durgante et al. (2023) and Assis et al. (2014, 2018). In a more detailed analysis, Quesada et al. (2012) sought to investigate the role of edaphic properties in the structure and dynamics of Amazonian forests. Their findings suggest the existence of dynamic forest feedback mechanisms initiated by edaphic conditions, which influence species composition and forest productivity in the region. This study has demonstrated that the physical and chemical properties of the soil, in particular total phosphorus and potassium, play a pivotal role in regulating forest dynamics. In their recent work focusing on the dominant species *Eschweilera coriacea*, Durgante et al. (2023) have shown that variations in tree growth over time reflect interactions between soil fertility and drought index, indicating a strong dependence on soil conditions for tree response to drought.

Conversely, Assis et al. (2014, 2018) have demonstrated that the influence of hydroperiod is the primary factor determining the diversity and composition of tree species in Amazonian floodplain forests, with substrate properties exerting a comparatively lesser effect. Furthermore, aluminium and phosphorus have been identified as the principal edaphic components influencing these stocks (Assis et al. 2018). In contrast to the aforementioned evidence, our results indicate that the importance of the flooding factor is secondary, with only a slight negative association observed between the plots in the *várzea alta* with transition to *buritizal*. No significant positive correlation was observed in the distribution of species for this parameter. This could be attributed to the potential topographical homogeneity between plots, which would result in a lack of substantial differences in the period of inundation, given the minimal variation in the number of days inundated between plots.

Amazonian forests are highly dependent on nutrient recycling to maintain metabolic activities (Vitousek 1984; Vitousek and Sanford 1986). This recycling can be illustrated by the layer of litter found on the soil of the different forest types. Our study observed that this layer of organic matter (M.O.) is positively and significantly related to the abundance of species associated with *Buritizal*. This pattern can be explained by the release of exudates by plant roots, which, in conjunction with the action of decomposers, act on the M.O. in such a way as to render the nutrients available for acquisition by the plants (Schaap et al. 2021).

This study extends the findings of Galeano et al. (2015) and Rosa et al. (2014) on vegetation-environment relationships in *M. flexuosa* forests. It highlights significant differences in soil composition and vegetation dynamics in response to environmental attributes. When comparing the studies, we observed a convergence in vegetation distribution patterns in relation to soil attributes and forest dynamics. However, specific nuances vary according to local conditions. While Galeano et al. (2015) highlighted the influence of soil organic matter on tree mortality and recruitment, Rosa et al. (2014) complemented these findings by identifying the relationship between seed mass and other aspects of *M. flexuosa* plant productivity with flooding and soil organic matter. Furthermore, we observed consistent patterns of vegetation distribution in response to variations in soil attributes, which corroborates the results of Galeano et al. (2015). This more refined understanding of the interactions between vegetation and the environment is essential for the development of effective conservation and sustainable management strategies for these ecosystems, especially in the context of climate change and anthropogenic pressures, which are increasing throughout the Amazon biome.

Conclusion

The *buritizal* differs from the *várzea alta* in terms of species composition and phytosociological structure, and is of particular biological interest and importance for the ARIE Javari-Buriti and the western Amazon region. Although there were important differences between the transects, many species occur in the three study areas and have high importance values, such as *Virola surinamensis* and *Euterpe precatoria*. Basal area and density did not differ significantly between the areas, but the with transition to *buritizal* had the highest species richness, while the *buritizal* had the lowest. The CCA analysis showed that there is an environmental gradient with clear transitions between the *várzea alta* and *buritizal* areas, where the *buritizal* environment is characterised by a positive association with organic matter and specific species, while the *várzea alta* areas show dispersal and association with different species and edaphic parameters. The Classification and Regression Tree confirmed the strong influence of organic matter on *buritizal* abundance, with most individuals found in areas with high values of this parameter. Finally, this article presents valuable data on the species *Mauritia flexuosa* and the *buritizal*, a unique formation of great interest for conservation in the Amazonian biome. The studies carried out here will contribute to the elaboration of the Area Management Plan, as well as encouraging further studies to be carried out in the ARIE Javari-Buriti and in other regions of the western Amazon that are still little known.

Declarations

Competing Interests

The authors have no relevant financial or nonfinancial interests to disclose.

Supplementary Information

The online version contains supplementary material available at ...

Funding

The authors would like to express their gratitude to *Coca-Cola* for their financial support for the field expedition to ARIE Javari-Buriti. Furthermore, they would like to acknowledge the *Mamirauá* Institute for Sustainable Development (IDSM) for awarding a scholarship to the authors, Karoline Ribeiro and Pâmella Assis (IDSM-OS-MCTI *Programa Mulheres na Ciência*). Additionally, they would like to thank IDSM for the financial resources made available to carry out the physical-chemical analyses of the soil. The authors would like to extend their gratitude to the *Fundação de Amparo à Pesquisa do Estado do Amazonas* (FAPEAM) for awarding a grant to Darlene Gris (PROFIX-IV-FAPEAM), and to Bruna Naissinger (FAPEAM-PAINTER+). Furthermore, the authors would like to acknowledge the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq/MCTI) for awarding grants to Gabriela Souza (PCI-D) and Paulo Nascimento (PCI-DD).

Author Contributions

The following authors contributed to the design of the study with original ideas and material in their areas of expertise: KAFR, LPR, PLSA, PJFPN and DG. These authors, with MJLC, were responsible for data collection on the field expedition, under the leadership of PLR. MJLC was also responsible for botanical identification. Data analysis was carried out by KAFR, PLSA, DG, GOS and BMN, under the leadership of DG. KAFR was responsible for the initial draft of the article, with the assistance of all the co-authors. All the authors (KAFR, LPR, PLSA, MJLC, PJFPN, BMN, GOS and DG) provided comments and contributions to subsequent versions of the manuscript, and read and approved the final draft.

Acknowledgements

The *Mamirauá* Institute for Sustainable Development (IDSM) and *Chico Mendes* Institute for Biodiversity Conservation, affiliated to the Brazilian Ministry of the Environment (ICMBio / MMA), for its support in carrying out the field expedition. To the assistants of the Municipality of *Santo Antônio do Içá* and other localities, who were indispensable in carrying out the field work.

Data availability

The datasets generated during and analyzed during the current study are available from the corresponding author on reasonable request, and in the additional supplemental material provided on Forestplots.net

References

1. Ab'Saber AN (2003) Os domínios da natureza no Brasil: Potencialidades paisagísticas. Ateliê editorial, São Paulo
2. Alvares CA, Stape JL, Sentelhas PC, Gonçalves JLM (2013a) Modeling monthly mean air temperature for Brazil. Theor Appl Climatol 113:407–427. <https://doi.org/10.1007/s00704-012-0796-6>

3. Alvares CA, Stape JL, Sentelhas PC, Gonçalves JLM, Sparovek G (2013b) Köppen's climate classification map for Brazil. *Meteorol Z* 22(6):711–728. <https://doi.org/10.1127/0941-2948/2013/0507>
4. Anderson JM, Ingram JSI (1993) *Tropical Soil Biology and Fertility: A Handbook of Methods*. CAB International, Wallingford, Oxford
5. Andrade TM, Assis RL, Wittmann F, Schöngart J, Piedade MTF (2008) Padrões de regeneração em clareiras de origem antrópica na Várzea da RDS Mamirauá, Amazônia Central. *Sci Magazine Uakari* 4(2):19–32
6. Assis RL, Wittmann F, Piedade MTF et al (2015) Effects of hydroperiod and substrate properties on tree alpha diversity and composition in Amazonian floodplain forests. *Plant Ecol* 216:41–54. <https://doi.org/10.1007/s11258-014-0415-y>
7. Assis RL, Wittmann F, Bredin YK et al (2019) Above-ground woody biomass distribution in Amazonian floodplain forests: Effects of hydroperiod and substrate properties. *For Ecol Manag* 432:365–375. <https://doi.org/10.1016/j.foreco.2018.09.031>
8. Augie B (2017) *_gridExtra: Miscellaneous Functions for Grid Graphics_*. R package version 2.3 <https://CRAN.R-project.org/package=gridExtra>
9. Ayres JMC (1995) *As Matas de Várzea do Mamirauá*. Brasília CNPq. Sociedade Civil Mamirauá, Tefé
10. Brasil (2024) Decreto Nº 91.886, de 05 de novembro de 1985. Diário Oficial da União. https://www.planalto.gov.br/ccivil_03/Atos/decretos/1985/D91886. Accessed 11 mar 2024
11. Brightsmith DJ, Bravo A (2006) Ecology and management of nesting blue-and-yellow macaws (*Ara ararauna*) in *Mauritia* palm swamps. *Biodivers Conserv* 15(12):4271–4287. <https://doi.org/10.1007/s10531-005-3579-x>
12. Brito JM, Wittmann F, Schongart J et al (2008) Guia de 42 Espécies Madeireiras da Reserva de Desenvolvimento Sustentável Mamirauá. Sociedade Civil Mamirauá, Tefé
13. Brower JE, Zar JH (1984) *Field and laboratory methods for general ecology*. Dubuque, WMC Brow
14. Casanova MT, Brock MA (2000) How do depth, duration and frequency of flooding influence the establishment of wetland plant communities? *Plant Ecol* 147(2):237–250. <https://doi.org/10.1023/A:1009875226637>
15. Cardoso DT, Särkinen T, Alexander S et al (2017) Amazon plant diversity revealed by a taxonomically verified species list. *Proceedings of the National Academy of Sciences* 114(40):10695–10700. <https://doi.org/10.1073/pnas.1706756114>
16. Connell JH, Lowman MD (1989) Low-density tropical rain forests: some possible mechanism for their existence. *Am Nat* 134:88–119
17. Correia AH, Do, Exército, Diretoria de Serviço Geográfico (2011) Metodologias e resultados preliminares do Projeto Radiografia da Amazônia. XV Simpósio Brasileiro de Sensoriamento Remoto-SBSR
18. Dambros CS (2020) *csdambros/R-functions: First release*. <https://github.com/csdambros/Rfunctions/tree/v1.0> 10.5281/zenodo.3784397
19. Dinno A (2017) *_dunn.test: Dunn's Test of Multiple Comparisons Using Rank Sums_*. R package version 1.3.5 <https://CRAN.R-project.org/package=dunn.test>
20. Durgante FM, Higuchi N, Ohashi S et al (2023) Soil fertility and drought interact to determine large variations in wood production for a hyperdominant Amazonian tree species. *Front Forests Global Change* 5:1–11. <https://doi.org/10.3389/ffgc.2022.1065645>
21. Engelbrecht BM, Vázquez-Rivera T, Tyree MT, Kursar TA, Chambi-Salazar A (2007) Drought effects on seedling survival in a tropical moist forest. *Trees* 21(5):389–398. <https://doi.org/10.1007/s00468-004-0393-0>
22. Fleischmann AS, Alves PC, Nascimento AZ (2023) Caracterização geográfica da Área de Relevante Interesse Ecológico Javari-Buriti. In.: Projeto Javari Buriti: Subsídios para a elaboração do Plano de Manejo da Área de Relevante Interesse Ecológico Javari-Buriti. Instituto de Desenvolvimento Sustentável Mamirauá, Tefé pp 15–48
23. Flora E, Funga Do Brasil (2022) Jardim Botânico do Rio de Janeiro. <http://floradobrasil.jbrj.gov.br>. Accessed 19 dez 2022
24. Galeano A, Urrego LE, Sánchez M et al (2015) Environmental drivers for regeneration of *Mauritia flexuosa* Lf in Colombian Amazonian swamp forest. *Aquat Bot* 123:47–53. <https://doi.org/10.1016/j.aquabot.2015.02.001>
25. Graham J (2003) *HH: Regression and Other Stories: package for R*. R package version x.y.z. <https://CRAN.R-project.org/package=HH>
26. Gotelli NJ, Colwell RK (2001) Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecol Lett* 4:379–391. <https://doi.org/10.1046/j.1461-0248.2001.00230.x>
27. Hamilton SK, Sippel SJ, Melack JM (2007) Seasonal inundation patterns in two large savanna floodplains of South America: the Llanos de Moxos (Bolivia) and the Llanos del Orinoco (Venezuela and Colombia). *Hydrol Process* 21(14):1719–1736. <https://doi.org/10.1002/hyp.5559>
28. Hart TB, Hart JA, Murphy PG (1989) Monodominant and species-rich forests of the humid tropics: causes for their co-occurrence. *Am Nat* 133(5):613–633
29. Hess LL (2003) Mapping wetlands in the Amazon Basin using SAR data: In *Proceedings of the IEEE International Geoscience and Remote Sensing Symposium (IGARSS'03)*. IEEE 2:1375–1377
30. Householder JE, Schumann DA, Hamilton SK (2010) Influence of hydrologic connectivity and environmental heterogeneity on floodplain wetland vegetation patterns in the Amazon River basin. *Wetlands* 30(6):1167–1180
31. Householder JE, Schumann DA, Hamilton SK (2012) Assessing inundation impacts in floodplain wetlands: relations between flood duration and plant community composition. *Wetlands* 32(6):1091–1103
32. IBGE Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística) (2019a) Índice de Organização do Território/ Malhas Territoriais/ Malhas Municipais/ Município2015/ Brasil ftp://geoftp.ibge.gov.br/organizacao_do_territorio/malhas_territoriais/malhas_municipais/municipio_2015/Brasil/BR/. Accessed 28 Aug 2019

33. IBGE Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística) (2019b) Index of /cartas_e_mapas/bases_cartograficas_continuas/bc250/versao2017/shapefile.http://geofp.ibge.gov.br/cartas_e_mapas/bases_cartograficas_continuas Accessed 28 Aug 2019
34. Junk WJ (1997) General aspects of floodplain ecology with special reference to Amazonian floodplains. In: Junk WJ (ed) The Central Amazon floodplain: ecology of a pulsing system. Ecological Studies 126, Berlin/Heidelberg/New York pp 3–20
35. Junk WJ, Bayley PB, Sparks RE (1989) The flood pulse concept in river-floodplain systems. Can Special Publication Fisheries Aquat Sci 106(1):110–127
36. Junk WJ, Furch K (1993) The physical and chemical limnology of Amazonian waters and their role in the carbon cycle. In: Prance GT, Lovejoy TE (eds) Amazonia. Pergamon, pp 385–404
37. Junk WJ, Piedade MTF, Schöngart J, Cohn-Haft M, Adeney JM, Wittmann F (2011) A classification of major naturally-occurring Amazonian lowland wetlands. Wetlands 31(4):623–640. <https://doi.org/10.1007/s13157-011-0190-7>
38. Kelly TJ, Baird AJ, Roucoux KH, Baker TR, Honório-Coronado EM, Ríos M, Lawson IT (2014) The high hydraulic conductivity of three wooded tropical peat swamps in northeast Peru: Measurements and implications for hydrological function. Hydrol Process 28:3373–3387. <https://doi.org/10.1002/hyp.9884>
39. Klimas CA, Kainer KA, Oliveira W, Lúcia H (2012) The economic value of sustainable seed and timber harvests of multi-use species: an example using *Carapa guianensis*. For Ecol Manag 268:81–91. <https://doi.org/10.1016/j.foreco.2011.03.006>
40. Kubitzki K (1989) The ecology of Amazonian palm swamps. In: Kubitzki K (ed) Tropical rain forest ecosystems. Biogeographical and ecological Studies, Springer, pp 227–239
41. Lähenteenoja O, Ruokolainen K, Schulman L et al (2012) Amazonian peatlands: An ignored C sink and potential source. Glob Change Biol 18(12):3366–3376. <https://doi.org/10.1111/j.1365-2486.2009.01920.x>
42. Lorenzi H (2002) Árvores Brasileiras: Manual de Identificação e Cultivo de Plantas Árboreas Nativas do Brasil. Editora Plantarum, Nova Odessa, São Paulo
43. Magurran AE (1988) Ecological Diversity and its measurement. Princeton, New Jersey
44. Marshall BG, Forsberg BR, Hess LL, Carvalho-Freitas CE (2011) Water temperature differences in interfluvial palm swamp habitats of *Paracheirodon axelrodi* and *P. simulans* (Osteichthyes: Characidae) in the middle Rio Negro, Brazil. Ichthyological Explor Freshwaters 22(4):377–383
45. Mendiburu F (2023) _agricolae: Statistical Procedures for Agricultural Research_. R package version 1.3-7, <https://CRAN.R-project.org/package=agricolae>
46. Milborrow S (2018) Package 'rpart.plot'. rpart.plot: Plot 'rpart' Models: An Enhanced Version of 'plot.rpart'. <https://CRAN.R-project.org/package=rpart.plot>. Accessed 30 jun 2023
47. Moreira DM (2016) Geodésia aplicada ao monitoramento hidrológico da bacia Amazônica. Doctoral dissertation, Universidade Federal do Rio de Janeiro, Rio de Janeiro
48. Mueller-Dombois D, Ellenberg H (1974) Aims and Methods of Vegetation Ecology. Wiley, New York
49. Oliveira RLC, Ricardo P, Veridiana S, Barbosa RI (2017) Structure and tree species composition in different habitats of savanna used by indigenous people in the Northern Brazilian Amazon. Biodivers Data J 5:1–16. <https://doi.org/10.3897/BDJ.5.e20044>
50. Oliveira RLC, Scudeller VV, Barbosa RI et al (2019) Aparência ecológica e conservação de espécies lenhosas pelos Makuxis nas Savanas de Roraima, Amazônia brasileira. Ethnoscintia-Brazilian J Ethnobiol Ethnoecology 4:1–14. <http://dx.doi.org/10.18542/ethnoscintia.v0i0.10245>
51. Oksanen J, Blanchet FG, Friendly M et al (2018) Vegan: Community Ecology Package. R package version 2.5-3. <https://CRAN.R-project.org/package=vegan> Accessed 30 jun 2023
52. Oksanen J, Blanchet FG, Friendly M et al (2022) Vegan: Community Ecology Package. R package version 2.6-4. <https://cran.r-project.org/web/packages/vegan/index.html> Accessed 30 jun 2023
53. Oliveira NA, Amaral IL (2005) Aspectos florísticos, fitossociológicos e ecológicos de um subbosque de terra firme na Amazônia central. Amazonas Brasil Acta Amazônica 35(1):1–16. <https://doi.org/10.1590/S0044-59672005000100002>
54. Oyelade JO, Idowu DO, Oniya OO, Ogunkunle DO (2017) Optimization of biodiesel production from sandbax (*Hura crepitans* L.) seed oil using two different catalysts. Energy Sour Part A Recover Utilization Environ Eff 39(12):1242–1249. <https://doi.org/10.1080/15567036.2017.1320691>
55. Pella E (1990) Elemental organic analysis. Part 2. State of the art. Am Lab 22:28–32
56. Perkins JL (1982) Shannon-Weaver or Shannon-Wiener. J Water Pollution Control Federation 54(7):1049–1050
57. Pereira MG, Valladares GS, Anjos LHC, Benites VM, Espíndula-Junior A, Ebeling AG (2006) Organic carbon determination in Histosols and soil horizons with high organic matter content from Brazil. Scientia Agricola 63(2):187–193. <https://doi.org/10.1590/S0103-90162006000200012>
58. Poggio L, De Sousa LM, Batjes NH, Heuvelink GBM, Kempen B, Ribeiro E, Rossiter D (2021) SoilGrids 2.0: producing soil information for the globe with quantified spatial uncertainty. Soil 7:217–240
59. Quesada CA, Phillips OL, Schwarz M et al (2012) Basin-wide variations in Amazon forest structure and function are mediated by both soils and climate. Biogeosciences 9(6):2203–2246. <https://doi.org/10.5194/bg-9-2203-2012>
60. R Core Team (2021) R: A language and environment for statistical computing. R Foundation for Statistical Computing. <https://www.R-project.org/> Accessed 14 may 2023
61. Resende ILM, Santos FP, Chaves LJ, Nascimento JL (2012) Estrutura etária de populações de *Mauritia flexuosa* L. (Arecaceae) de veredas da região central de goiás, Brasil. Revista árvore 36(1):103–112. <https://doi.org/10.1590/S0100-67622012000100012>

62. Rigueira S, Brina AE, Filho JR, Costa-Silva LV, Bedê LC, Rezende M (2002) Projeto Buriti: artesanato, natureza e sociedade. Instituto Terra Brasilis de Desenvolvimento Sócio-Ambiental, Belo Horizonte
63. Rosa R, Barbosa RI, Koptur S (2014) Which factors explain reproductive output of *Mauritia flexuosa* (Arecaceae) in forest and savanna habitats of northern Amazonia? Int J Plant Sci 175(3):307–318. <https://doi.org/10.1086/674446>
64. Salinas H, Ramirez-Delgado D (2021) *ecolTest: Community Ecology Tests*
65. Sander NL (2014) Estrutura, composição florística e etnobiologia de um buritizal na fronteira biológica Amazônia-Cerrado. Dissertation, Universidade do Estado de Mato Grosso
66. Sander NL, Ribeiro RS, Silva DR et al (2017) Floristic, phytosociology and spatial distribution of a monodominant *Mauritia flexuosa* Lf forest in an Southern Amazon in the Arc of deforestation. Natural resources in wetlands: from Pantanal to Amazonia. MPEG, Belém
67. Schaap KJ, Fuchslueger L, Hoosbeek MR, Hofhansl F, Martins NP, ValverdeBarrantes OJ, Quesada CA (2021) Litter inputs and phosphatase activity affect the temporal variability of organic phosphorus in a tropical forest soil in the Central Amazon. Plant Soil 469(1):423–441
68. Silva VP, Carvalho-Brito L, Marques AM, Cunha-Camillo F, Figueiredo RM (2023) Bioactive limonoids from *Carapa guianensis* seeds oil and the sustainable use of its by-products. Curr Res Toxicol 4:100–104. <https://doi.org/10.1016/j.crttox.2023.100104>
69. SNUC Sistema Nacional de Unidades de Conservação da Natureza (2000) Lei nº 9.985, de 18 de julho de 2000. Diário Oficial da União, Brasília, DF
70. Spruce R (1871) On the vegetation of the Amazon Valley as compared with that of the temperate zone. J Linn Soc London Bot 11(51):463–482
71. Ter Braak CJF (1986) Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. Ecology 67(5):1167–1179. <https://doi.org/10.2307/1938672>
72. Ter Braak CJF (1987) The analysis of vegetation-environment relationships by canonical correspondence analysis. Vegetation 69:69–77. <https://doi.org/10.1007/BF00038688>
73. Ter Steege H, Pitman NC, Sabatier D et al (2013) Hyperdominance in the Amazonian tree flora. Science 342(6156):1243092. <https://doi.org/10.1126/science.1243092>
74. Ter Steege H, Prado H, Lima PI et al (2020) Biased-corrected richness estimates for the Amazonian tree flora. Sci Rep 10(1):1–13. <https://doi.org/10.1038/s41598-020-66686-3>
75. Therneau T, Atkinson B, Ripley B, Ripley MB (2017) Package ‘rpart’. Published on the Internet. <https://CRAN.R-project.org/package=rpart> Accessed 30 jun 2023
76. Virapongse A, Endress BA, Gilmore MP et al (2017) Ecology, livelihoods, and management of the *Mauritia flexuosa* palm in South America. Global Ecol Conserv 10:70–92. <https://doi.org/10.1016/j.gecco.2016.12.005>
77. Vitousek P (1984) Litterfall. Nutrient Cycling. and Nutrient Limitation in Tropical Forests. Ecology 65(1):285–298
78. Vitousek P, Sanford R (1986) Nutrient Cycling in Moist Tropical Forest. Annu Rev Ecol Syst 17:137–167
79. Wickham H (2016) *ggplot2: Elegant Graphics for Data Analysis*. Springer-, New York
80. Wittmann F, Anhuf A, Junk WJ (2002) Tree species distribution and community structure of central Amazonian *várzea* forests by remote-sensing techniques. J Trop Ecol 18(6):805–820. <https://doi.org/10.1017/S0266467402002523>
81. Wittmann F, Junk WJ (2003) Sapling communities in Amazonian white-water forests. J Biogeogr 30(10):1533–1544. <https://doi.org/10.1046/j.1365-2699.2003.00966.x>
82. Wittmann F, Schöngart J, Monteiro JC, Motzer T, Junk WJ, Piedade MTF, Queiroz HL, Worbes M (2006) Tree species composition and diversity gradients in white-water forests across the Amazon Basin. J Biogeogr 33(8):1334–1347. <https://doi.org/10.1111/j.1365-2699.2006.01495.x>
83. Wittmann F, Schöngart J, Brito JM, Wittmann AO, Piedade MTF, Parolin P, Junk WJ, Guillaumet JJ (2010) Manual of trees from Central Amazonian *várzea* floodplains: taxonomy, ecology and use. Editora INPA, Manaus
84. Wittmann F, Anhuf D, Junk WJ, Piedade MTF (2013) Biogeography and biodiversity of Amazonian palm swamps. In: Junk WJ, Piedade MTF, Wittmann F, Schöngart J, Parolin P (eds) Amazonian floodplain forests: Ecophysiology, biodiversity and sustainable management. Springer, pp 355–372

Figures

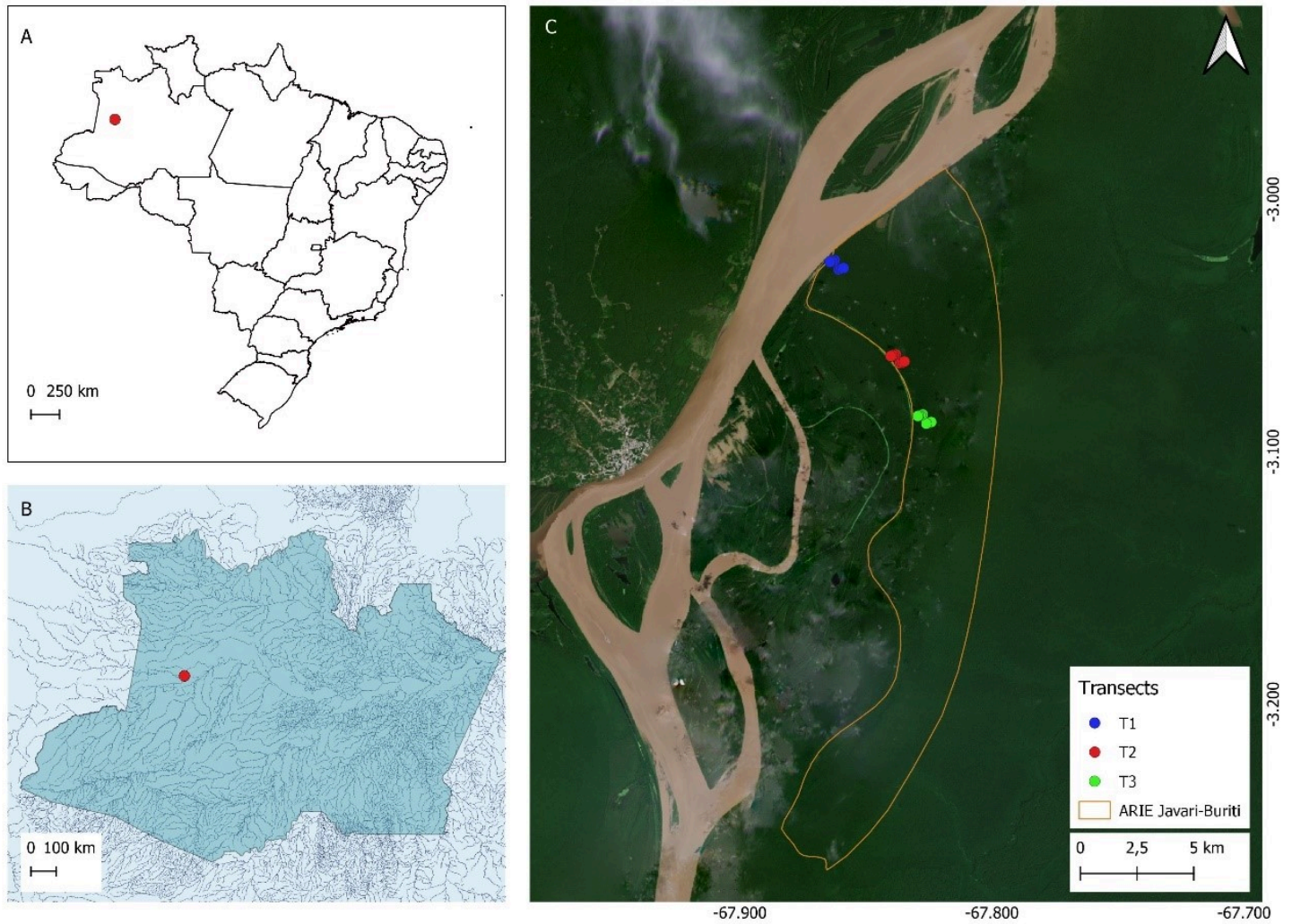


Figure 1

Cartographic representation map, highlighting the location of the ARIE Javari-Buriti in Brazil (A), in the Amazonas State, with a presentation of the hydrography (B), and a more detailed view of the polygon of the area, with the points of the transects ([C] T1, T2 and T3) used for the survey. In yellow, the boundary of the ARIE Javari-Buriti on the banks of the *Solimões* River

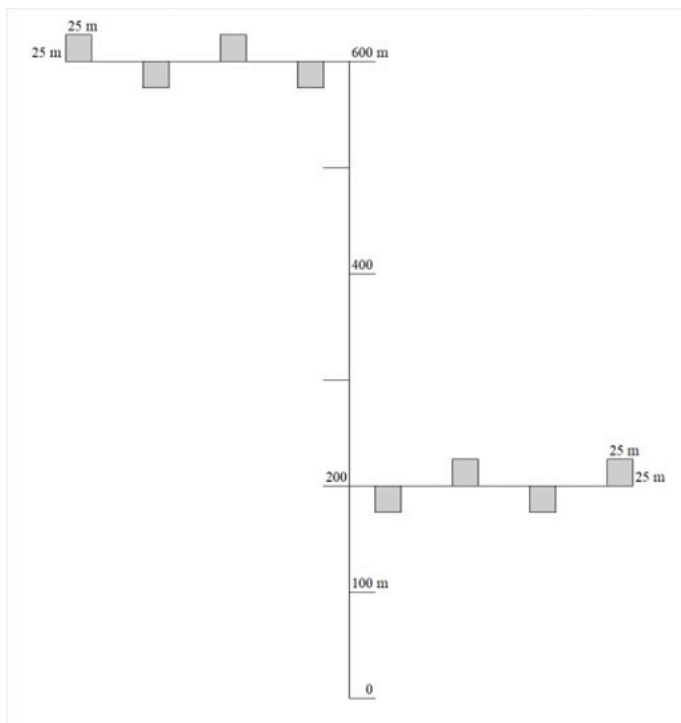


Figure 2

Scheme of transects with temporary plots forming conglomerates. 25 x 25 m plots

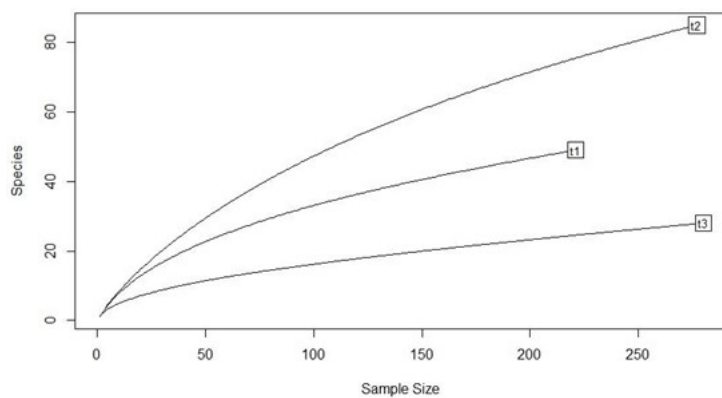


Figure 3

Species accumulation curves using the rarefaction method. *Várzea alta* (T1), *várzea alta* with transition to *buritizal* (T2) and *buritizal* (T3). ARIE Javari-Buriti, Amazonas State, Brazil

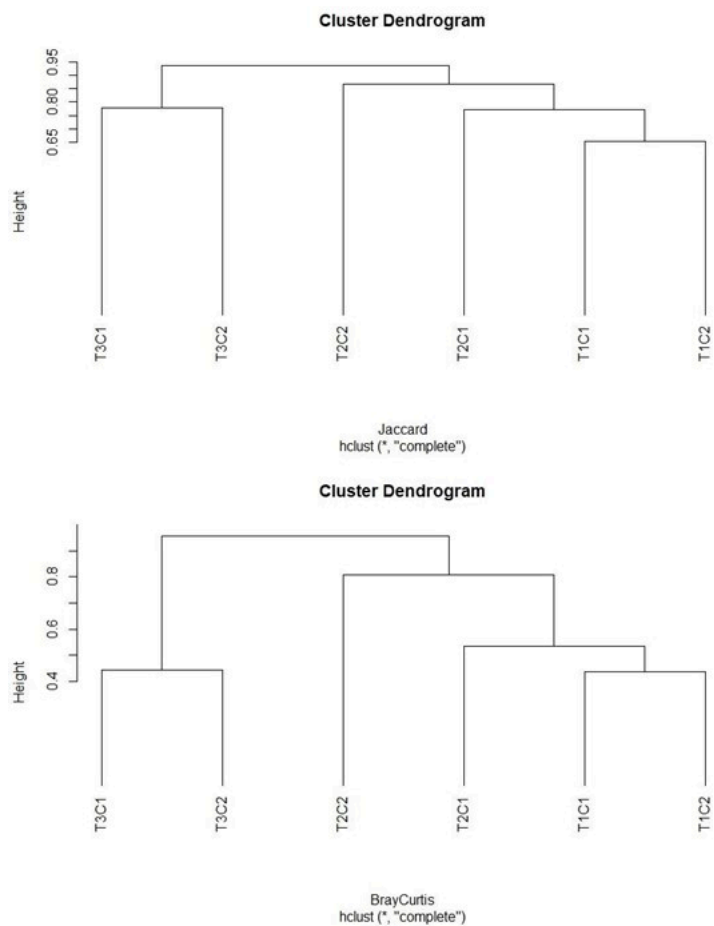


Figure 4

Floristic similarity dendrograms based on presence/absence (Jaccard's similarity index) and density data (Bray-Curtis dissimilarity index) of the species for the plots between each conglomerate (C1 and C2) in the *várzea alta* (T1), *várzea alta* with transition to *buritizal* (T2) and *buritizal* (T3) areas. ARIE Javari-Buriti, Amazonas State, Brazil

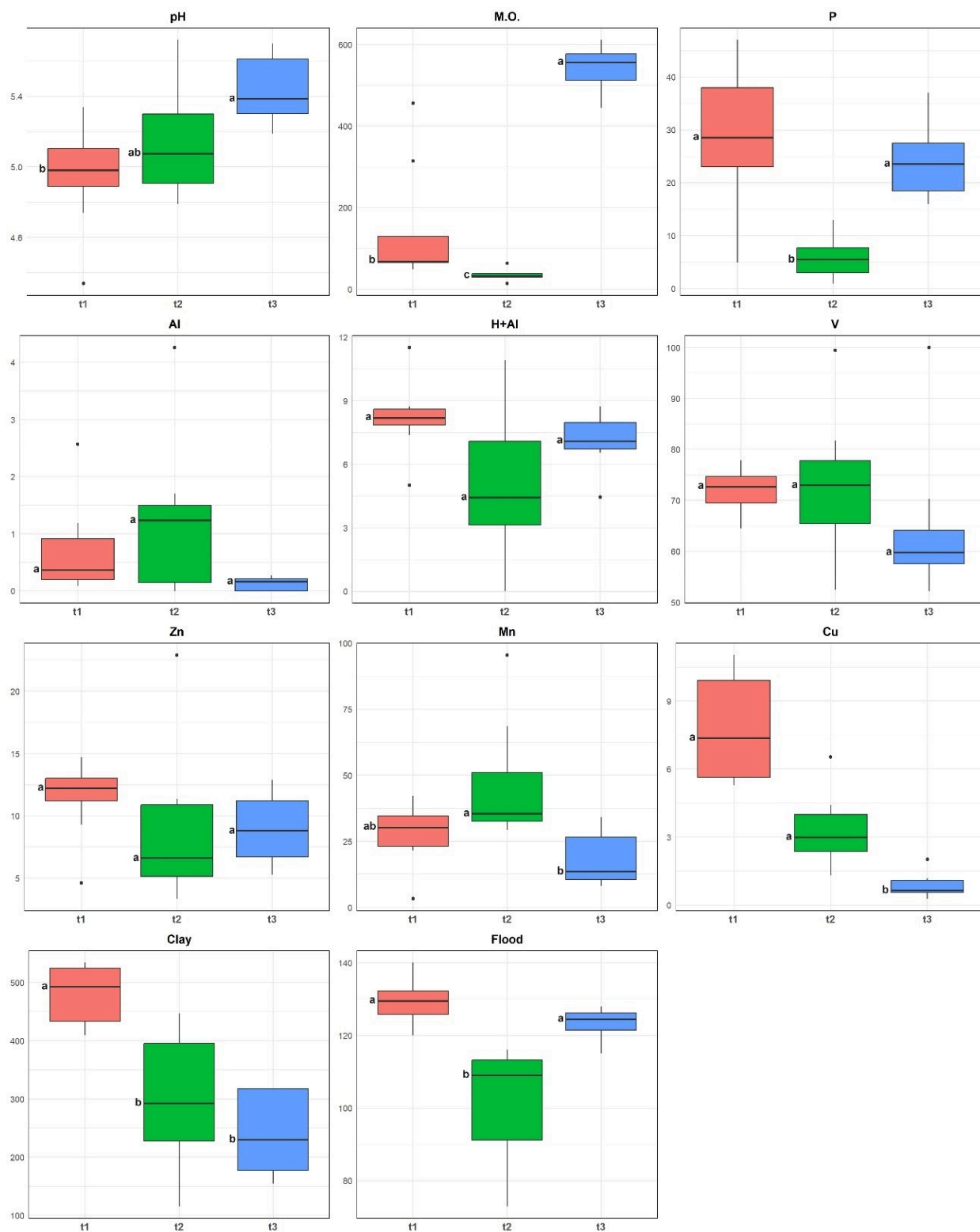


Figure 5

Boxplots comparing the environmental variables selected after testing for multicollinearity between the study areas: *várzea alta* (T1), *várzea alta* with transition to *buritizal* (T2) and *buritizal* (T3). Each boxplot represents the distribution of data for a specific parameter in each environment, highlighting the differences observed between them with different letters. ARIE Javari-Buriti, Amazonas State, Brazil

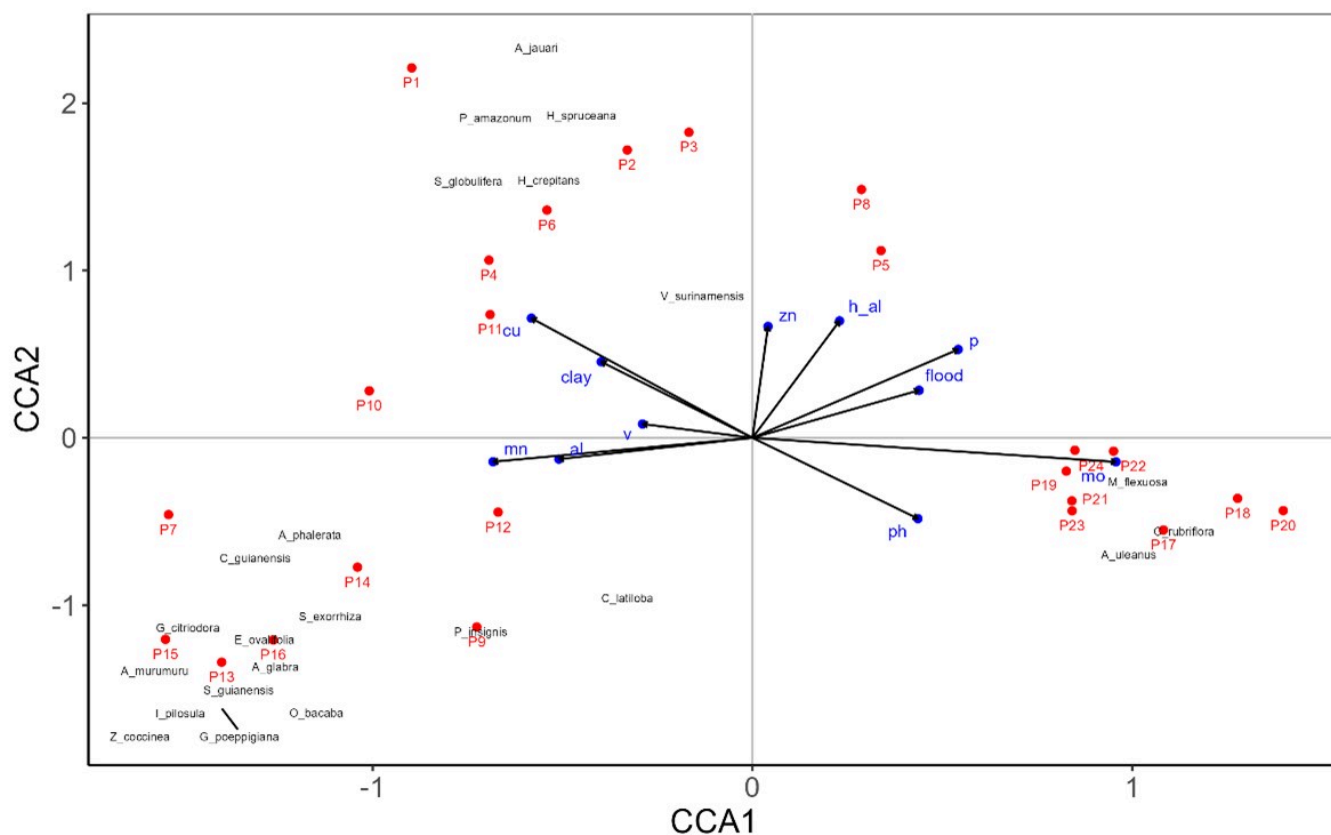


Figure 6

Canonical Correspondence Analysis (CCA): Ordination diagram of the plots (in red), based on the distribution of the species that demonstrated statistical significance and their relationship with the environmental variables employed (in blue). P1-P8 = T1 (*várzea alta*); P9-P16 = T2 (*várzea alta* with transition to *buritiza*); P17-P24 = T3 (*Buritiza*). ARIE Javari-Buriti, Amazonas State, Brazil. Copper (cu), Manganese (mn), Base Saturation Index (v), Aluminium (al), Zinc (zn), Potential acidity (h_{al}), Phosphorus (p), Flood duration (flood) and Organic matter (mo)

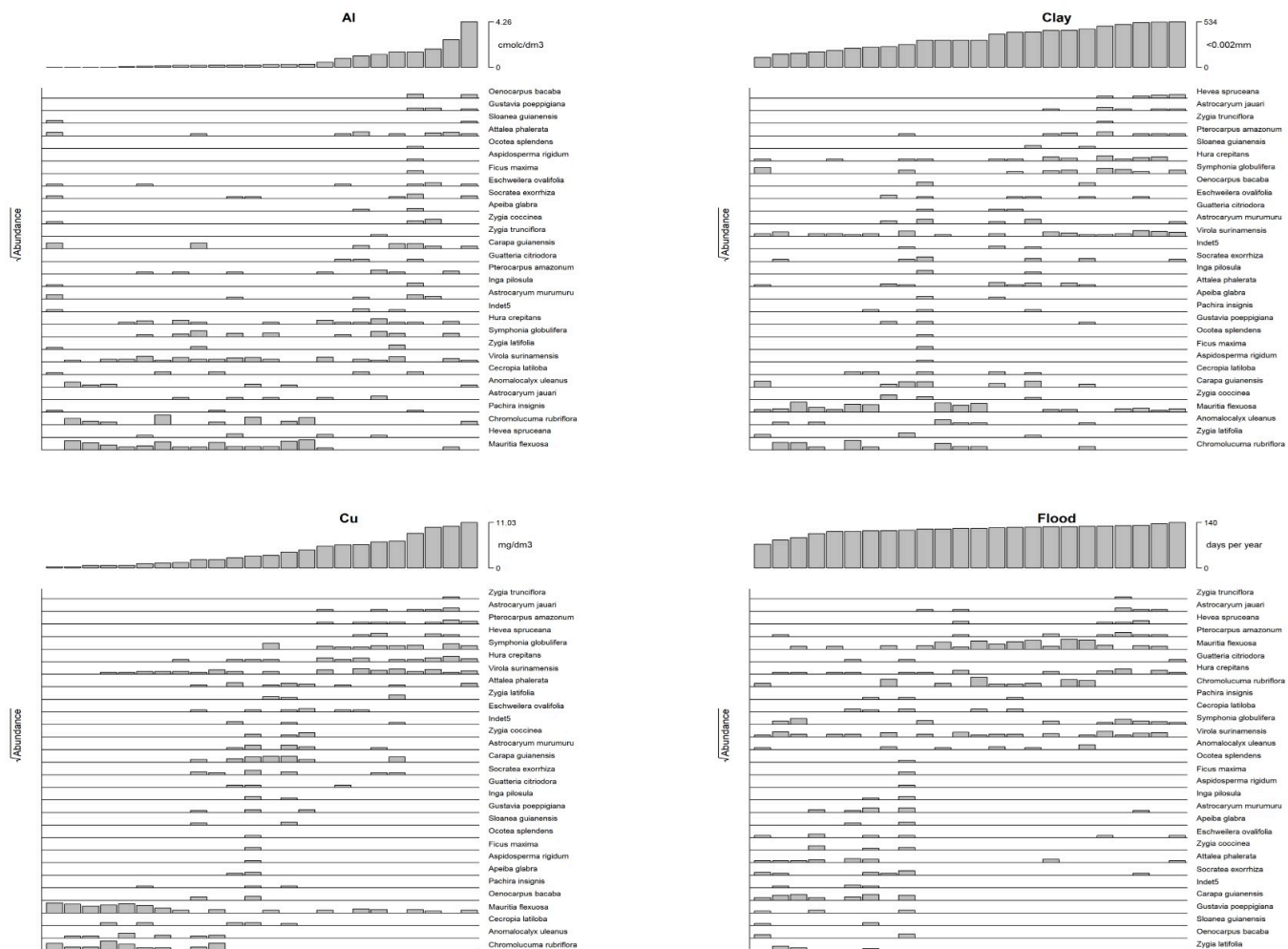


Figure 7

Ordination histograms for the environmental variables: Al, Clay, Cu and Flood. The species analysed were based on their significance in the CCA analysis.

ARIE Javari-Buriti, Amazonas State, Brazil

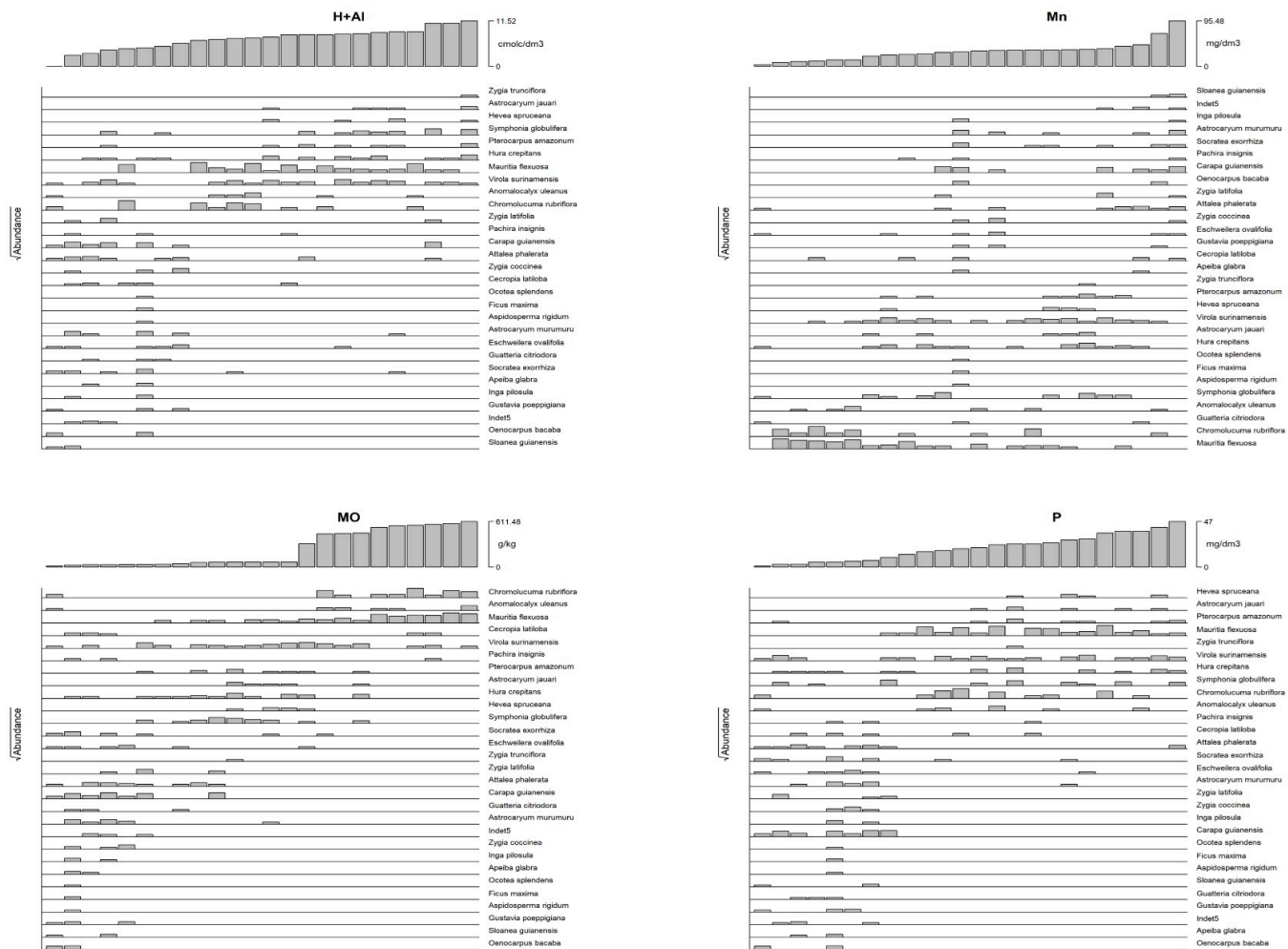


Figure 8

Ordination histograms for the environmental variables: H+Al, Mn, M.O. and P. The species analysed were based on their significance in the CCA analysis. ARIE Javari-Buriti, Amazonas State, Brazil

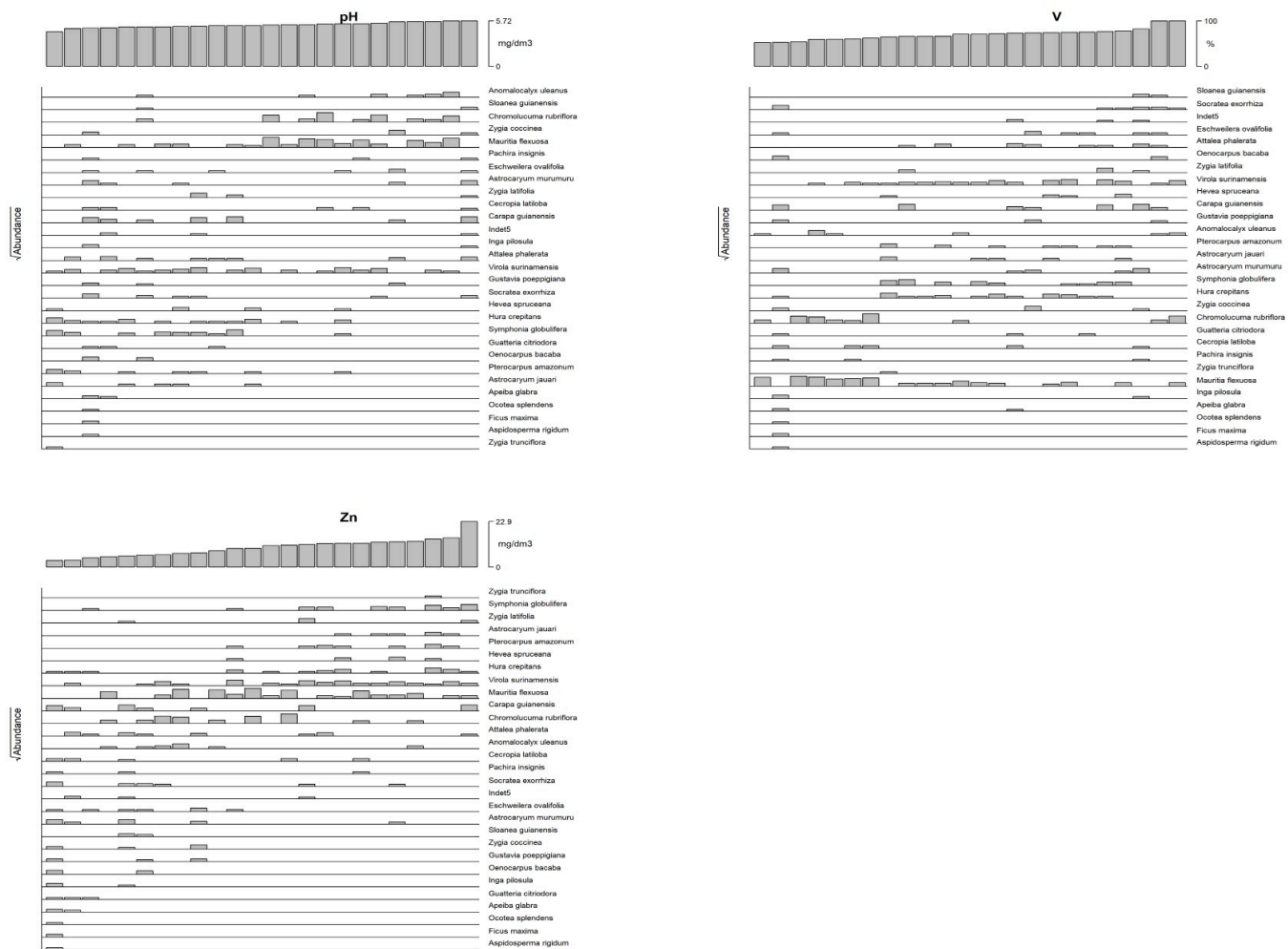


Figure 9

Ordination histograms for the environmental variables: pH, V and Zn. The species analysed were based on their significance in the CCA analysis. ARIE Javari-Buriti, Amazonas State, Brazil

Mauritia flexuosa

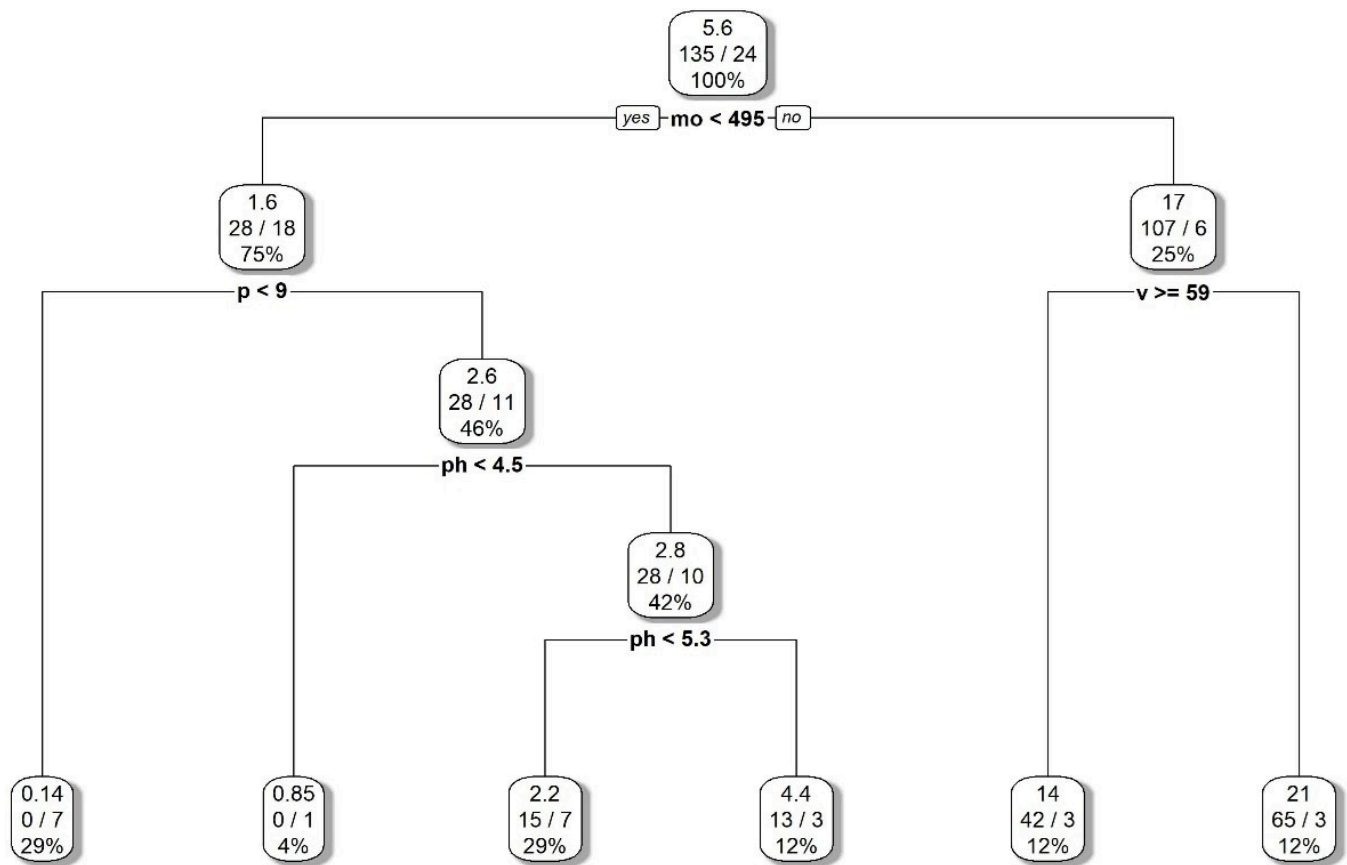


Figure 10

Classification and Regression Tree for the species *Mauritia flexuosa*. ARIE Javari-Buriti, Amazonas State, Brazil. Organic matter (mo), Phosphorus (p), Base Saturation Index (v)

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryMaterialS1.docx](#)
- [SupplementaryMaterialS2.xlsx](#)
- [SupplementaryMaterialS3.docx](#)