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**BAMBOO DOMINANCE IN AN ATLANTIC FOREST COMMUNITY: A
STRUCTURAL, FUNCTIONAL AND TAXONOMIC APPROACH**

JUIZ DE FORA
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Dissertação apresentada ao Programa de Pós-Graduação em Ecologia, da Universidade Federal de Juiz de Fora, como parte dos requisitos à obtenção do Título de Mestre em Ecologia Aplicada ao Manejo e Conservação dos Recursos Naturais.

Orientador: Prof. Dr. Fabrício Alvim Carvalho
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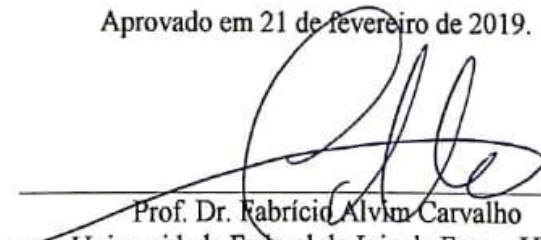
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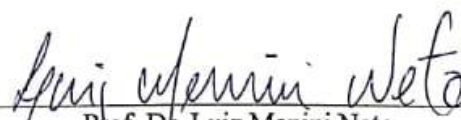
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Quando a última árvore for cortada, quando o último rio for poluído, quando o último peixe for pescado, aí sim eles verão que dinheiro não se come.

Chefe Sioux

ABSTRACT

Native species also have the potential to spread and proliferate disproportionately, causing considerable damage as much as exotic species. The increase in native species dominance is called as overabundance and it has affected communities and ecosystems in many different ways. In Brazil, many woody bamboos are typical examples of invasive native species. Their high dominance usually alters the structure and composition of forests, reducing tree density, total basal area, richness, as well as taxonomic and functional diversity of trees. *Merostachys sp.* is a common native bamboo genus in the Atlantic Forest and in certain disturbed conditions can become overabundant in forest communities. In order to understand the relationship between bamboo dominance and forest parameters we allocated 30 plots of 10x20 m in a Atlantic forest fragment, we marked and identified all the trees individuals with DAB ≥ 5 cm and we measured the basal area of all bamboo clumps within the plots. We evaluated the relationships between bamboo basal area and structural, taxonomic and functional diversity metrics in a tropical forest community, and how these relationships change among the underlying diameter classes of the community. We found that plots with higher bamboo dominance have lower tree density and higher basal area of dead trees, whereas those plots have higher functional and taxonomic diversity, considering that the *niche-filling hypothesis* plays an important role in invaded communities at local scale. In addition, we found that bamboo dominance was positively related to high dominance of acquisitive traits species and that those relationships were stronger for small trees than larger trees. Even though we have found strong evidence of the effects of the bamboo overdominance, we cannot affirm that those changes within community were the cause or consequence of invasion. In overall, this study was import to highlight the native bamboo interactions with forest parameters, also bringing new contributions for invasion studies at local scale.

Keywords: Overabundance; invasion; niche-filling hypothesis; community-weighted mean (CWM); functional diversity; average taxonomic distinctness.

RESUMO

Espécies nativas também tem o potencial de se espalhar e proliferar desproporcionalmente, causando danos consideráveis tanto quanto espécies exóticas. O aumento na dominância dessas espécies nativas é chamado de superabundância e tem afetado comunidades e ecossistemas de diferentes formas. No Brasil, muitas espécies de bambu lenhosos são típicos exemplos de espécies invasoras nativas. Sua alta dominância geralmente altera a estrutura e composição de florestas, reduzindo a densidade, área basal total, riqueza de espécies, assim como a diversidade taxonômica e funcional de árvores. *Merostachys* é um gênero comum de bambu nativo encontrado em fragmentos de Floresta Atlântica que sofreram algum tipo de perturbação, tornando-se superdominante nesses ambientes. De forma a entender as relações entre dominância de bambu e parâmetros florestais, nós alocamos 30 parcelas de 10x20 m em um fragmento de Floresta Atlântica; marcamos e identificamos todas as espécies arbóreas com DAP ≥ 5 cm e medimos a área basal de todas as touceiras de bambu por parcela. Nós avaliamos as relações entre a área basal do bambu e os parâmetros estruturais, e as métricas de diversidade taxonômica e funcional em uma comunidade de floresta tropical, e como essas relações variam entre as classes de diâmetro subjacentes da comunidade. Encontramos que parcelas com maior dominância de bambu possuem menor densidade de árvores e maior área basal de árvores mortas, enquanto que essas mesmas parcelas apresentam maior diversidade funcional e taxonômica, considerando que a hipótese de preenchimento de nicho desempenha um papel importante na comunidade invadida em escala local. Além disso, encontramos que a dominância de bambu estava positivamente relacionada à alta dominância de espécies com traços funcionais aquisitivos e que essas relações são mais fortes para árvores pequenas do que árvores maiores. Embora tenhamos encontrado fortes evidências dos efeitos da superabundância do bambu, não podemos afirmar que essas mudanças dentro da comunidade tenham sido a causa ou consequência da invasão. No geral, este estudo foi importante para destacar as interações da espécie de bambu nativo com outros parâmetros florestais, trazendo também novas contribuições para estudos de invasão em escala local.

Palavras-chave: Superabundância; invasão; hipótese de preenchimento de nicho; CWM; diversidade funcional; distinção taxonômica média.

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INTRODUCTION

Biological invasions have directly affected the worldwide biodiversity in different scales (Tilman 1999). Most of our knowledge of invasion ecology is based on studies evaluating the effect of alien species in native communities (Simberloff *et al.* 2003). These alien species are usually introduced by man into a new environment, and for many reasons, such as the lack of predators or competitors, they can become dominant (Vitousek *et al.* 1987). A central but yet understudied question is whether native species can also become invasive species. Some of them have the potential to spread and proliferate disproportionately, causing considerable damage as much as alien species (Garrott *et al.* 1993). The overabundance of native species in natural communities (Garrot *et al.* 1993) is associated to several human impacts such as land use intensification (Wiens 2009) and climate change (Pivello *et al.* 2018). When these disturbances overcome the thresholds that limit the community resilience, these superperformers species (that usually combine high growth and reproduction rates) can outcompete other species and leads to reduced productivity and to changes in ecosystem functions (Pivello *et al.* 2018).

Most studies evaluating the effect of “native invader species” in natural communities indicates that they are stronger competitors than the resident species (other native species in a community besides the invader one), and leads to a strong decrease in species richness and diversity (Hejda *et al.* 2009). Nevertheless, other studies have shown that the impacts of plant invasions are context-dependent, and not necessarily influences species diversity. In some cases, especially when the life form of the alien species is different from the other resident species most species are able to coexist with the invader (Tecco *et al.* 2009). The lack of concern among the studies is probably due to the use of species richness as the main metric to evaluate the invasion resistance of communities. Especially in high-diverse tropical forests, the number of coexisting species does not necessarily reflect the ecosystem structure, because they do not inform about species relatedness and function (Diaz & Cabido 2001). Therefore, to understand the invasive potential of a native species, and the capacity of natural communities to deal with invasion, we must evaluate the whole community diversity, including functional and phylogenetic parameters, and then infer more precisely about the differences in the niche occupation and in the competitive capacity of species (McGill *et al.* 2006; Kunstler *et al.* 2012; Kraft, Godoy, & Levine 2015).

Two long-standing contrasting hypotheses based on the ecological dissimilarity between resident species have been put forward to understand how alien

species influence community's attributes, and to predict the susceptibility of communities to invasion (Thuiller *et al.* 2010; Blonder 2016; Loiola *et al.* 2018). The *environmental filtering hypothesis* (Kembel & Hubbell 2006) assumes that there is a similar supply of resources for resident and alien species, and then, communities with large functional and phylogenetic diversity should use available resources more completely (Gerhold *et al.* 2011; Hejda & de Bello 2013) and be more resistant to invasion (Levine, Adler, & Yelenik 2004) than communities with low functional and phylogenetic diversity. In this sense, the impacts of invasion would be related to the competitive exclusion between alien and resident species, promote the dominance of certain groups of similar species related to greater competitive abilities against the alien species, that have higher performance under the available resources, possibly leading to decreased in functional and taxonomic diversity. Conversely, the *niche-filling hypothesis* (Thuiller *et al.* 2010) predicts that communities of native species with large functional and phylogenetic diversity would be more susceptible to invasion (Gurvich, Tecco & Díaz 2005), since high dissimilarity between species could lead to empty gaps within the phylogenetic and functional space of a community (Blonder 2016). These niches could be used by aliens to establish and enhance invasion in communities with higher functional and phylogenetic diversity. The contrasting predictions among the effects of *environmental filtering hypothesis* and *niche-filling hypothesis* seem to be scale-dependent (Götzenberger *et al.* 2012). While *environmental filtering hypothesis* is expected to be the most important driver of invasion among habitats, *niche-filling hypothesis* is expected to be more important at local scales within habitats. Evaluating how invasion change the overall diversity metrics among the resident species in invaded communities are still rare (Bennett *et al.* 2016).

In Brazil, many woody bamboos (Poaceae: Bambusoideae) are typical examples of invasive native species that have many characteristics of successful invaders (Lima *et al.* 2012). The Brazilian Atlantic forest, one of the conservation hotspots in the world, is one of the richness spots of Neotropical bamboos distribution (Clark 1991; Bystriakova *et al.* 2004). This extends to the genus *Merostachys* that has the center of endemism and diversity spot in the Atlantic domain (Judziewicz *et al.* 1999). *Merostachys* species generally inhabit both wet and shaded understories as well as forest gaps and edges of forests formations (Judziewicz *et al.* 1999; Filgueiras and Santos Goncalves 2004). Species from *Merostachys* genus are characterized by having a long life cycle (around 30 years) (Judziewicz *et al.* 1999; Guilherme *et al.*

2004), enabling the growth of their populations by great production of seeds that provides food for rodents and birds (Jaksic and Lima 2003; Cestari & Bernardi 2011; Kaminski *et al.* 2016). Flowering in *Merostachys* species is generally gregarious and the death of individuals allows the opening of clearings in the areas where they are established, which interferes in floristic composition and diversity of forests (Filgueiras 1988).

Many studies using bamboo species as model have shown that bamboos dominance alter the structure and composition of tropical forest communities, reducing tree density, total basal area, richness, seedling establishment, functional groups and functional diversity of plants (Griscom & Ashton, 2006; Rother 2006; Griscom *et al.* 2007; D'Oliveira *et al.* 2013; Montti *et al.* 2014). Furthermore, some studies with *Merostachys* species in semideciduous dry forests in southeastern Brazil found that clumps of the genus generally are associated with low density of tree species, constraining the recruitment, growth and survival of trees (Oliveira-Filho *et al.* 1994; Guilherme *et al.* 2004). However, these studies have focused on the relationships between bamboo dominance and the overall forests attributes, neglecting that the influence of bamboo can be size-dependent, e.g., the influence of bamboo on small trees can be different from the larger trees. As a species that usually occupies the understory (rarely higher than 8 m), the influence of *Merostachys sp.* should be stronger on small trees than in larger trees. Yet, to better understand the relationships between bamboo dominance and forests attributes, we need to disentangle the forest communities in its underlying vertical strata, and such a size-dependent approach is needed if we better want to understand the impacts of bamboo species in tropical forests.

Considering *Merostachys sp.* (Figure 1) as an overdominant species in the studied tropical forest community, the aim of this study was to evaluate the relationships between bamboo dominance and the resident native tree species, including the underlying different diameter classes which species belongs. Considering that the *niche-filling hypothesis* may be the stronger driver of local patterns of diversity, we addressed the two following questions: (1) How the invasive bamboo species is related to the tree community structural (e. g. species richness, basal area, species density) and diversity metrics? We hypothesize that plots with high bamboo dominance have lower tree density, but higher species richness, functional and phylogenetic diversity, since high dissimilarity between species could lead to empty gaps within the phylogenetic and functional space of a community. Moreover,

species dominance will change from conservative to acquisitive traits (e.g., species with lower wood density, higher specific leaf area, abiotic dispersal syndrome, deciduousness and with smaller seed size) with increasing bamboo dominance. 2) Do the relationships between bamboo dominance and the resident tree species differ between size (diameter) classes? We hypothesized that the relationship of bamboo (rarely higher than 8 m) and the native tree community is size-dependent, being stronger for the small trees than larger trees.



Figure 1: Clumps of the bamboo species *Merostachys sp.*

METHODS

Study area and vegetation sampling

This study was conducted in a secondary semideciduous tropical forest (21°33'9.94"S, 43°15'10.09"O; 80 ha) located in the experimental field of Embrapa Gado de Leite, southeastern region of the state of Minas Gerais, Brazil (Figure 2). The predominant climate of the region is characterized by hot and rainy summers (October to March) and cold and dry winters (April to September). Mean annual rainfall is 1501 mm (290 mm in the wettest month and 19 mm in driest month), and the mean annual temperature is 21.9 °C (Oliveira-Filho 2017). The predominant soil type is classified as red-yellow latosol (Paciullo *et al.* 2008). The study area has a historical of selective logging, where the main species extracted were *Apuleia leiocarpa*, *Ocotea sp.* and *Plathymenia sp.* No extraction of wood has been made in the last 50 years.

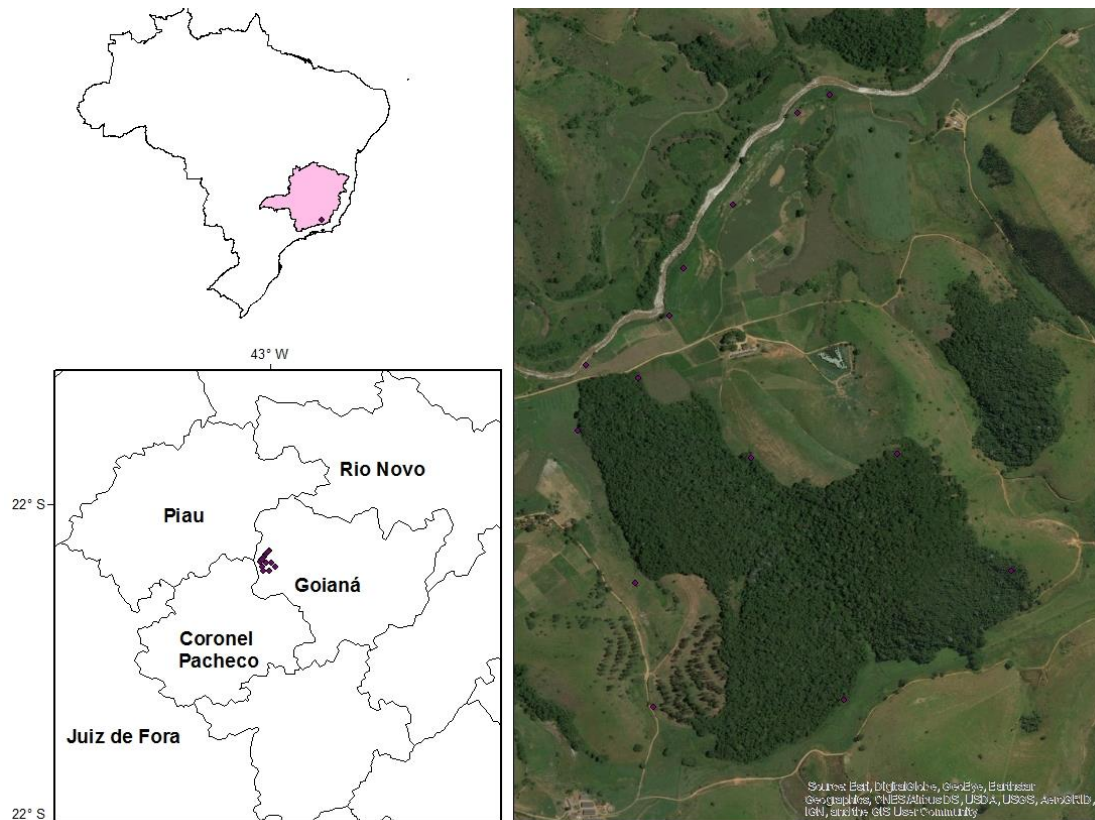


Figure 2: Study area located in the experimental field of Embrapa Gado de Leite, southeastern region of the state of Minas Gerais, Brazil.

We established 30 permanent sample plots (20×10 m) in the forest, totaling 0.6 ha. All living and standing dead trees with diameter at breast height (DBH) ≥ 5 cm (DBH, measured at 1.3 m from the ground or above the buttresses) were tagged, identified to species level and their DBH and height were measured. The samples of botanical material were collected and identified by specialists and through herbarium consultation. The species classification followed the APG IV system (2016).

Bamboo dominance estimation and tree community metrics

To quantify the bamboo dominance, we identify all the clumps inside the sample plots and we measure the diameter at the ground level of each clump to calculate the basal area of bamboo (BA). We used the basal area (BA) because this parameter may reflect the real size of the clumps, also considering the space between the culms, which arboreal individuals usually are not able to occupy.

To evaluate how the relationships between bamboo dominance and the overall vegetation metrics are related to the community underlying diameter classes, we split the community data into three diameter: small trees (DHB ≤ 10 cm), medium trees ($10 \text{ cm} < \text{DBH} < 20 \text{ cm}$), and large trees (DBH > 20 cm). All vegetation metrics

explained below were calculated for the overall community (i.e. all resident trees) and for the three diameter classes separately. Per plot for the overall community and for each diameter class (trees with DBH \leq 10 cm, DBH between 10 and 20 cm, and DBH $>$ 20 cm), we described structural metrics as tree density (number of individuals), stand basal area of trees (m²) and basal area of dead trees (m²). We described the floristic diversity using the species richness and Shannon diversity index (H').

Functional traits

We collected functional traits that are important for forest succession and competition, once bamboo invasion influences the forest establishment and compete with trees for space and resource. We sampled/compiled four vegetative traits (wood density, leaf specific area, species maximum stem diameter and deciduousness), and two reproductive traits (dispersal syndrome and seed size) (Table S1). Wood density, leaf specific area and maximum diameter were collected from species comprising at least 80% of all individuals and basal area sampled, following the methodology proposed by Perez-Harguindeguy *et al.* (2013). We collected traits for five individuals of each selected species. Wood density is an important functional trait related to the stability, defense, architecture, hydraulics, carbon accumulation, and growth potential of plants (Chave *et al.* 2009; Perez-Harguindeguy *et al.* 2013). Low wood density is related to fast growth and high hydraulic capacities, while a high wood density indicates slow growth, but high survival investments (Chave *et al.* 2009). Wood density was determined using the water-displacement method, and calculated by the ratio of dry mass of wood (g) and sample volume (cm³). Specific leaf area is positively correlated with photosynthetic rate and leaf nitrogen concentration, and negatively with leaf longevity and carbon investment in quantitatively important secondary compounds (Perez-Harguindeguy *et al.* 2013). To calculate the specific leaf area (SLA) we selected 10 leafs for individual, obtaining the ratio of the leaf area (mm², obtained with the ImageJ program after leaf scanning) and leaf dry mass (mg). Maximum diameter plays a structural and architectural role within communities; large sizes may realize faster growth rates (Hérault *et al.* 2011). The maximum diameter of the species (cm) was obtained by the 95th percentile of all the diameters of the individuals of the species sampled. Deciduousness is a trait that confers drought avoidance (Borchert 1994), and is also related to the species growth length period (Poorter & Markesteijn 2008). We classified the deciduousness of species evergreen or deciduous. Dispersal syndrome is an indicator of the distance that propagules can cover, the routes it can travel and its final destination, this trait can also be important to understand the

species separation in space and reduction on competitive exclusion (Seidler & Plotkin 2006; Perez-Harguindeguy *et al.* 2013). The dispersal syndrome was divided in biotic (zoochory) and abiotic (anemochory, barochory) categories. Seed size is an indicator of seeding survivor and trade-offs that affect forest performance; small seeds are related to colonization ability whereas fewer larger seeds enable survival under a variety of hazards (Westoby *et al.* 2002, Muller-Landau 2010; Wright *et al.* 2010). We classified the seed of the species into smaller, medium and large size. The information about dispersal syndrome, deciduousness and seed size was compiled by consulting the literature (Borges & De Assis 2014; Pyles *et al.* 2018).

Functional dominance and diversity

We used the species that comprised at least 80% of all individuals to calculate functional dominance and diversity. The functional dominance was calculated by the community-weighted mean (CWM) for each plot. The CWM was calculated for each trait, using the relative abundance of the species as weighting factor. We used species abundance rather than species basal area to equally weight small trees and big trees. Functional diversity was evaluated using functional richness (Fric) and functional dispersion (Fdis) indices, and was calculated for each plot (Villéger *et al.* 2008). Functional richness (Fric) represents the multivariate range of traits that is filled by the community and considers only species presence/absence data and their respective traits values; and the functional dispersion (Fdis) indicates how the relative abundance of the species is distributed in the multivariate space covered by the functional traits (Laliberté & Legendre 2010). The CWM values and the functional diversity indices were calculated using the "FD" package in the R (Laliberté *et al.* 2014).

Taxonomic diversity and average taxonomic distinctness

To evaluate the phylogenetic relatedness between the sampled species, we created a taxonomic matrix, classifying all the species identified from genus to class level (Table S2), and we calculated the taxonomic diversity (delta and delta*) and the average taxonomic distinctness (delta+ or AvTD, Clarke & Warwick 1998, 2001) for each plot. These indices combine species richness and taxonomic structure to estimate the community phylogenetic diversity (Leira *et al.* 2009; Gwali *et al.* 2010). The taxonomic diversity and distinctness equations were calculated using trees abundance data, and the average taxonomic distinctness were based on presence/absence data (less sensitive to dominant species) and it is calculated as the sum of all branch lengths connecting two species averaged across all species, thus representing the

mean distance between two randomly chosen species (Warwick & Clarke 1995; Gallardo *et al.* 2011). High values of these indices indicate that species in a plot are more distinct phylogenetically (i.e., a plot with one species of Myrtaceae and one of Lauraceae have higher AvTD than a plot with one species of Myrtaceae and one of Asteraceae, see APG IV (2016). The taxonomic diversity and the average taxonomic distinctness index were calculated using the "Vegan" package in the R (Oksanen *et al.* 2010).

Statistical analysis

All the parameters compiled for the community were evaluated in relation to bamboo dominance using mixed linear models. We used bamboo basal area as fixed factor and all the parameters as response variables. Before analysis, we transformed data using log10 or square root when necessary, in order to find the assumptions of normality and homoscedasticity.

To test the spatial autocorrelation of the samples, when our variables are not independent, we used a Moran's I test. A p-value <0.05 indicates that the model residuals show spatial autocorrelation. When we found spatial correlation in our linear mixed model residuals, we used simultaneous autoregressive (SAR) models (Kissling & Carl 2008), based on the geographical coordinates of the plots. In SAR models, we need to define a minimum-weighted neighborhood structure to fit the spatial structure of the models residuals (Raymundo *et al.* 2019). We used a neighborhood distance of 10 meters because our plots are very close and it seems the smallest distance between two plots.

All analyses were performed using the software R (R-Core-Team, 2015) and the following packages: lme4 (Bates *et al.* 2014), lmerTest (Kuznetsova *et al.* 2016), MuMIn (Barton 2016), spdep (Bivand *et al.* 2005), ncf (Van Etten 2017), nlme (Pinheiro *et al.* 2014) and gstat (Pebesma 2004)

RESULTS

We sampled a total of 763 individuals, belonging to 101 species, 64 genus and 34 families (**Table S3**). The most abundant species were *Siparuna guianensis* Aubl., *Mabea fistulifera* Mart. and *Brosimum guianense* (Aubl.) Huber. We found a total basal area of 7.57 m² for bamboo and 16.45 m² for the live standing trees.

For the overall community metrics, we found that bamboo basal area was significantly negative related to tree density and CWM wood density, and positively

related to basal area of dead trees, functional dispersion and taxonomic diversity (Table 1; Figure 3). These results indicate that the dominance of bamboo is higher when plots have less trees and more dead trees, when dominant species have lower wood density, and when resident species are more diverse functionally and phylogenetically. We found no relationships between bamboo basal area and community stand basal area, species richness and diversity (H'), CWM_{SLA} , CWM_{Dmax} , CWM_{Dec} , CWM_{DS} , CWM_{SS} and functional richness, taxonomic diversity (Table 1).

When considering the three diameter classes separately (trees with $DBH \leq 10$ cm, DBH between 10 and 20 cm, and $DBH > 20$ cm), we found significant relationships between bamboo basal area and the evaluated community metrics for the first diameter class ($DBH \leq 10$ cm), and the results become non-significant for the medium and larger diameter classes (Table 1; Figure 4). Considering the first diameter class, bamboo basal area was significantly negatively related to tree density and CWM_{WD} , and positively related to CWM_{SLA} , functional dispersion, taxonomic diversity and taxonomic relatedness (Table 1). These results indicate that the relationships between bamboo basal area and the overall community metrics are size-dependent, and are more markedly for the small trees.

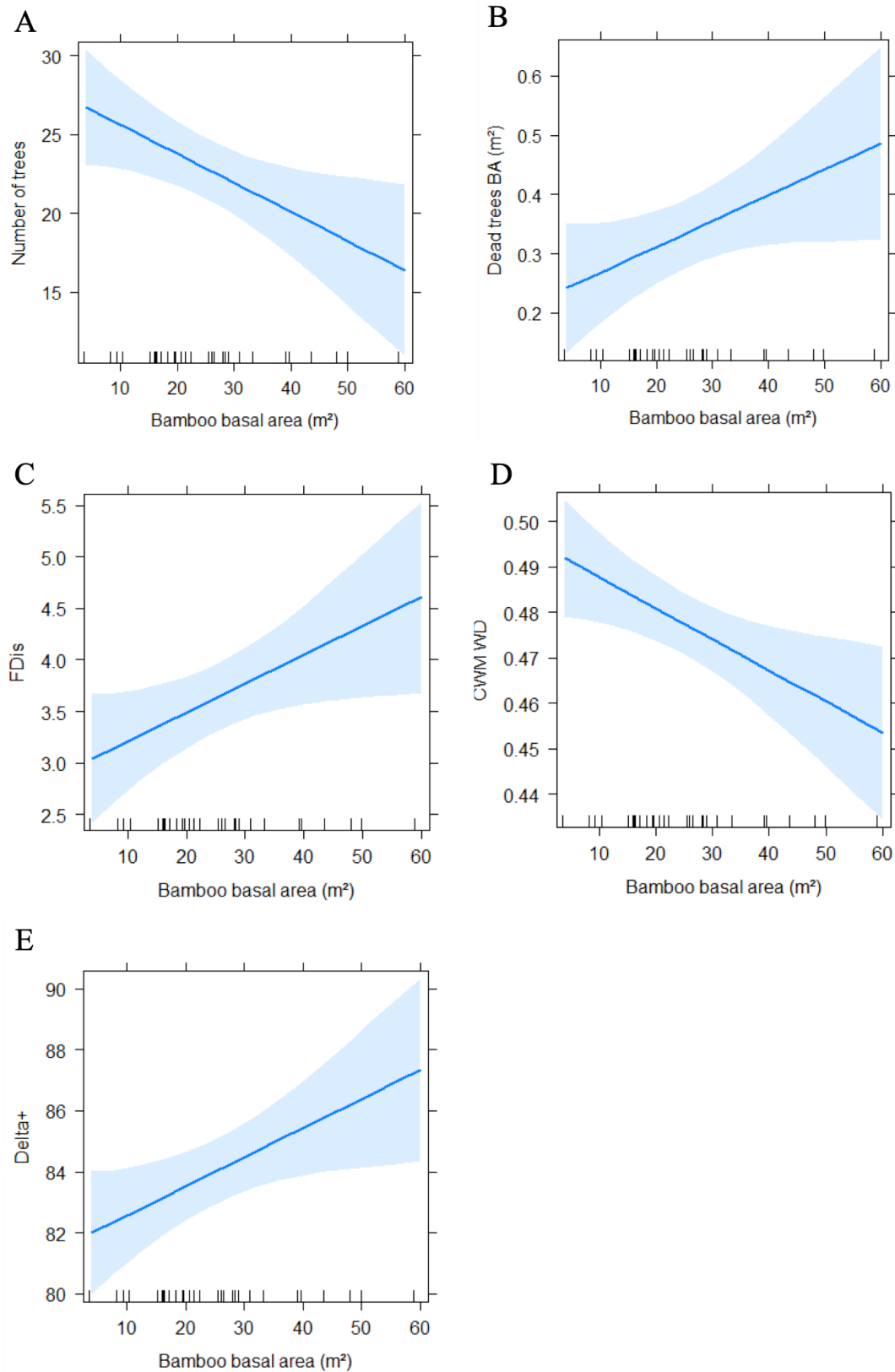


Figure 3: Bivariate relationships between bamboo basal area and number of trees (A), basal area of dead trees (B), functional diversity (FDis; C), community - weighted mean of wood density (CWM WD; D), and the average taxonomic distinctness (Delta⁺; E) for the overall community. Continuous lines represent significant relationships, and blue areas represent the 95% confidence intervals.

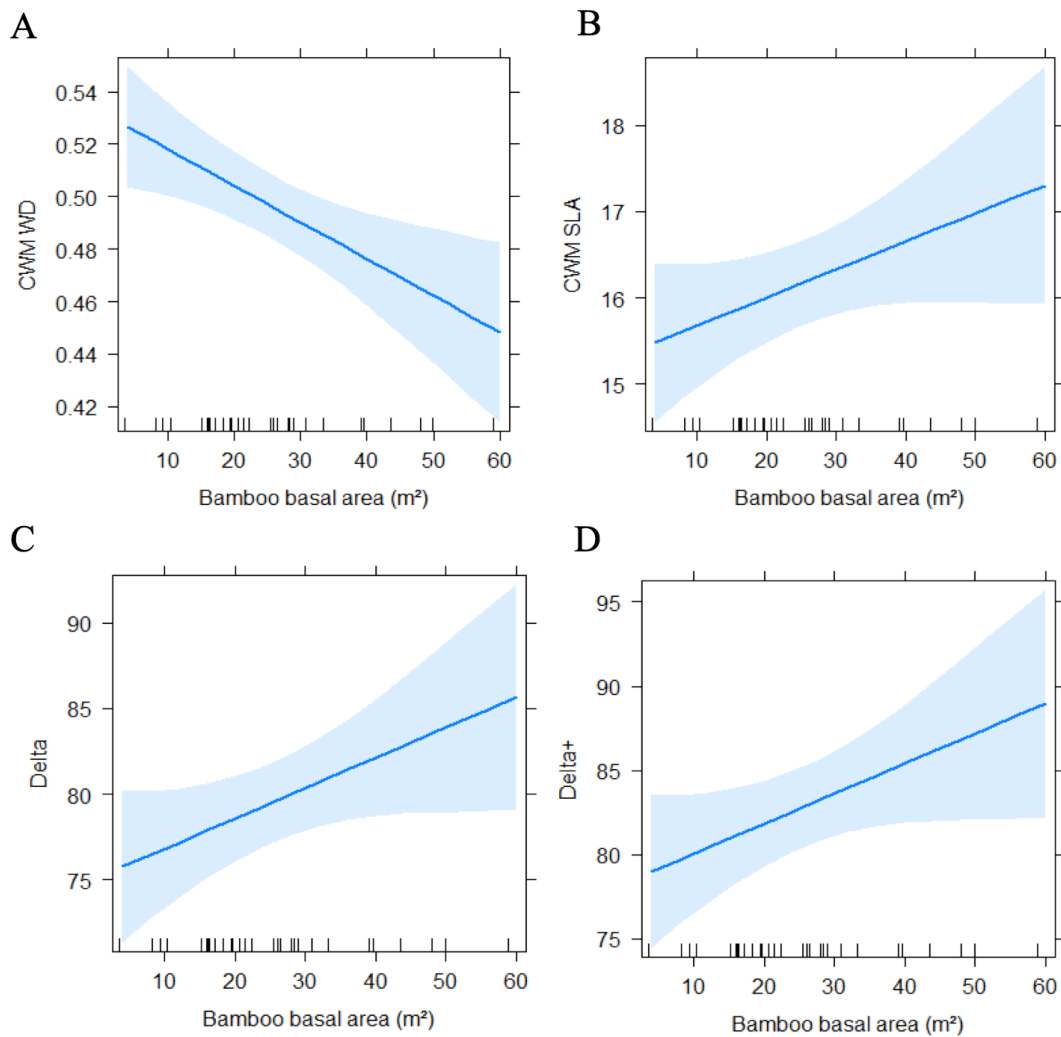


Figure 4: Bivariate relationships between community - weighted mean of wood density (CWM WD; A), community - weighted mean of specific leaf area (CWM SLA; B), taxonomic diversity (Delta; C), and the average taxonomic distinctness (Delta⁺; D) for the first diameter class (DBH ≤ 10 cm). Continuous lines represent significant relationships, and blue areas represent the 95% confidence intervals.

Table 1: Results of the mixed linear models between bamboo basal area and all the parameters analysed for the overall community, small trees ($DHB \leq 10$ cm), medium trees ($10 \text{ cm} < DBH < 20$ cm), and large trees ($DBH > 20$ cm). CWM WD (community weithghed mean of wood density), CWM SLA (community weithghed mean specific leaf area), CWM Dmax (community weithghed mean of maximum diameter), CWM AD (community weithghed mean of abiotic dispersion), CWM BD (community weithghed mean of biotic dispersion), CWM SS (community weithghed mean of small seeds), CWM MS (community weithghed mean of medium seeds), CWM LS (community weithghed mean of large seeds), CWM Dec (community weithghed mean of deciduous species), CWM Eve (community weithghed mean of evergreen species), Fric (functional richness), Fdis (functional dispersion), Delta and Delta* (taxonomic diversity) and Delta+ (average taxonomic distinctness).

BA dead trees 31.4973 0.1982 1.3550 0.0056

Parameter	Intercept	R²	β	p-value
<i>Overall communiy</i>				
Individuals number	50.7988	0.2036	-1.1229	*0.0038
BA dead trees	31.4973	0.1982	1.3550	*0.0056
Species richness (S)	41.6851	0.0755	-1.0495	0.1084
Diversity (H')	46.9599	0.0265	-8.4100	0.3553
CWM WD	180.3410	0.2168	-324.9600	*0.0030
CWM SLA	-47.3854	0.0845	4.4771	0.0953
CWM Dmax	-6.8160	0.0707	1.2171	0.1300
CWM AD	25.8084	0.0012	-3.7771	0.8835
CWM BD	22.0313	0.0012	3.7771	0.8835
CWM SS	38.3889	0.0531	-35.2836	0.1647
CWM MS	25.2638	0.0005	-0.0010	1.0000
CWM LS	19.3775	0.1154	79.6825	0.0618
CWM Dec	24.5060	0.0010	1.9596	0.8996
CWM Eve	26.4656	0.0010	-1.9596	0.8996
Fric	23.9785	0.0017	2.7604	0.8500
Fdis	4.6202	0.1582	5.6755	*0.0177
Delta	-87.3068	0.0898	1.3968	0.0751
Delta*	-88.7496	0.0692	1.3416	0.1347
Delta+	-131.8630	0.1766	1.8697	*0.0096
<i>DBH \leq 10</i>				
Individuals number	35.1635	0.0948	-0.9473	0.0658
Species richenss (S)	35.1595	0.0541	-1.1910	0.1735

Diversity (H')	37.6072	0.0177	-6.1894	0.4440
CWM WD	116.3370	0.2606	-183.2790	*0.0011
CWM SLA	-27.8444	0.1083	3.2844	*0.0535
CWM Dmax	25.6070	0.0005	-0.0146	0.9771
CWM AD	25.6488	0.0016	-2.4601	0.8579
CWM BD	23.1887	0.0016	2.4601	0.8579
CWM SS	33.2026	0.0698	-18.3543	0.1017
CWM MS	19.9011	0.0279	10.7499	0.3144
CWM LS	23.6364	0.0290	24.0786	0.3484
CWM Dec	26.0013	0.0015	-2.3594	0.8621
CWM Eve	23.6419	0.0015	2.3594	0.8621
Fric	24.4723	0.0025	3.2690	0.8051
Fdis	21.2985	0.0160	1.3550	0.4837
Delta	-32.7904	0.1302	0.7302	*0.0343
Delta*	-19.9554	0.0816	0.5395	0.0998
Delta+	-34.2136	0.1254	0.7183	*0.0357

10 cm < DBH < 20 cm

Individuals number	30.9607	0.0338	-0.7528	0.3092
Species richness (S)	31.4973	0.0345	-0.9740	0.3035
Diversity (H')	41.2994	0.0891	-9.2781	0.0876
CWM WD	55.3910	0.0438	-64.3760	0.2348
CWM SLA	-17.1900	0.0903	2.6755	0.0847
CWM Dmax	-16.0267	0.2305	1.6938	0.0965
CWM AD	26.2583	0.0081	-7.8455	0.6294
CWM BD	18.4128	0.0081	7.8455	0.6294
CWM SS	29.1386	0.0277	-9.1570	0.3596
CWM MS	19.8614	0.0402	10.2878	0.2588
CWM LS	25.9825	0.0127	-13.8353	0.5105
CWM Dec	19.1324	0.0766	15.0048	0.1156
CWM Eve	34.1372	0.0766	-15.0048	0.1156
Fric	18.9394	0.0081	8.8535	0.8204
Fdis	13.6382	0.1270	4.1551	*0.0220
Delta	62.9713	0.0750	-0.4552	0.0911
Delta*	63.1266	0.0467	-0.4362	0.2099
Delta+	48.3451	0.0194	-0.2674	0.4350

DBH > 20 cm

Individuals number	29.8515	0.0267	-1.0369	0.3658
Species richness (S)	29.5281	0.0274	-1.1597	0.3535
Diversity (H')	28.3697	0.0130	-2.8736	0.5227
CWM WD	30.2680	0.0022	-12.2980	0.8034
CWM SLA	13.1287	0.0075	0.6761	0.6249

CWM Dmax	18.2254	0.0050	0.1920	0.7016
CWM AD	29.4356	0.0790	-29.1805	0.0849
CWM BD	0.2551	0.0790	29.1805	0.0749
CWM SS	24.1917	0.0020	3.0308	0.8122
CWM MS	29.4838	0.0143	-6.4875	0.5061
CWM LS	23.6553	0.0221	14.1532	0.4113
CWM Dec	25.9034	0.0024	-1.9309	0.8003
CWM Eve	23.9725	0.0024	1.9309	0.8003
Fric	27.4350	0.0022	12.4680	0.8034
Fdis	26.1136	0.0033	-0.5053	0.7383
Delta	30.5964	0.0071	-0.0710	0.6414
Delta*	37.6691	0.0182	-0.1518	0.4558
Delta+	40.3433	0.0242	-0.1841	0.3804

There is a significantly relationship at $p < 0.05$

DISCUSSION

We evaluated the relationships between bamboo basal area and structural, taxonomic and functional diversity metrics in a tropical forest community, and how these relationships change among the underlying diameter classes of the community. We found that plots with higher bamboo dominance have lower tree density and higher basal area of dead trees, whereas those plots have higher functional and taxonomic diversity. In addition, we found that bamboo dominance was positively related to high dominance of acquisitive traits species (lower wood density and higher specific leaf area), and that those relationships were stronger for small trees than larger trees.

Relationships between bamboo basal area and the resident species

We hypothesize that bamboo dominance would be negatively related to structural forests attributes, considering that *Merostachys sp.* has been related as a potential invasive native species. We indeed found lower tree density and higher basal area of dead trees in plots with higher dominance of bamboo. These results could be related to the competition for space and resources. Although this pattern is commonly found in natural forests (i.e., if a given species is abundant in a plot, that the rest of the species are less abundant) (Magurran 1988), we do not found the same results when considering the relationships between other two most abundant species (*Siparuna guianensis* and *Mabea fistulifera*) and the other resident species. These results highlight that bamboo competition is by far stronger than its ability to facilitate most of other resident species in our study area.

Our results differ from others studies involving different species and life forms at different scales, where invasion generally decreases species richness and diversity (Griscom 2007; Gaertner *et al.* 2009; Hedja 2009). However, Hedja *et al.* (2009, 2017) and Gaertner *et al.* (2009) found that some invaded species exhibit low impact on species richness and diversity, and invader species identity is also an important characteristic to consider, once some types of growth form have advantages related to the potential of invasion compared to others (Gaertner *et al.* 2009). The significant negative relationship between the number of trees and not on species richness may be related to the capacity of higher bamboo dominance to reduce the density of individuals within plots, but not be capable to eliminate the species from the sample unit (Hedja 2013). Besides that, bamboo dominance can eliminate or promote the occurrence of some species, qualitatively altering species composition (Hedja 2013).

We hypothesize that bamboo dominance would be positively related to species, functional and phylogenetic diversity, considering that the *niche-filling hypothesis* plays an important role in invaded communities at local scale. We indeed found that plots with more bamboo basal area are functionally and phylogenetically more diverse than plots with lower bamboo basal area, though not relationships were found for species richness or diversity. Environmental filters are generally weaker in local communities assembly, thus it is believed that less related species are able to coexist due to niche difference than closely related species (Godoy *et al.* 2014; Loiola *et al.* 2018). Studies indicate that taxonomically and functionally closer species compete more intensely than more distant species, limiting their capacity to exist (Webb *et al.* 2002; Cahill *et al.* 2008; Cavender-Bares *et al.* 2009). Therefore, plots with higher bamboo basal area have less closely related species, so competitive exclusion may be playing a local structural role (Mayfield & Levine 2010). Furthermore, at small scales, the higher FD and AvTD values found in plots with higher bamboo basal area can be due to two different coexistence mechanisms, with the invader filling niche gaps or excluding resident species (Loiola *et al.* 2018). It is also possible to infer that the invader species contribute to create such a gap in the invaded communities, increasing phylogenetic and functional dissimilarity of native plant communities by replacing some specific native species. Based on our analyses, we cannot conclude whether such increase in dissimilarity between resident species is the cause or consequence of invasion. Future studies are necessary in order to evaluate the invader species traits and their relationships with the resident tree species in the community.

Higher bamboo dominance in plots dominated by species with acquisitive trait values
Considering that high disturbance intensities shifts the CWM trait values from conservative to acquisitive traits in forests (Van der Sande *et al.* 2016; Lodge *et al.* 2018), we expected that plots with higher dominance of bamboo would increase density of species with higher specific leaf area, abiotic dispersion, deciduousness, and lower seed mass, wood density and maximum stem diameter. We indeed found that plots with higher bamboo dominance show lower values of CWM_{WD} and higher CWM_{SLA} (for small trees only). Invasive plants usually have acquisitive traits (Reich 2014), which allow them to take advantage in disturbed environments, occupying gaps and forest edges. Bamboo species, when under disturbed environments, usually become super-dominant, competing for light with species that possess acquisitive traits, growing rapidly and occupying the niche more efficiently than resident species

(Richardson & Pysek 2006). A hypothesis to consider is that lower CWM_{WD} values in plots with more bamboo basal area may be related to the need for resident species to coexist with the invasive species. Thus, resident species should invest more in growth to overcome the bamboo height barrier (rarely higher than 8 m), where light would no longer be a limiting factor. Species with low wood density and high specific leaf areas have typically high growth rates, and can quickly surpass bamboo clumps, reaching higher light conditions, and hence, increasing their abundance compared to the species with conservative traits (Raymundo *et al.* 2018). Another plausible explanation is that species having higher values of CWM_{WD} and lower values of CWM_{SLA} generally are those that are able to live under shaded conditions. Due to a relatively slow growth and under bamboo competition, those species may be not able to survive from bamboo-mass loading (Griscom *et al.* 2007). In these circumstances, having low values of WD and SLA would be a more efficient strategy.

The impacts of bamboo in increasing the abundance of species with low WD and high SLA may have multiple effects on forests productivity. For example, these species have inherent short lifespan and can lead to high biomass mortality and lower standing biomass stocks, reducing forests carbon stocks over time (Fukushima *et al.* 2015).

The size-dependent relationships between bamboo and forests communities

We hypothesized that the relationships between bamboo (rarely higher than 8 m) and the native community is size-dependent, being stronger for the small trees than larger trees. We indeed found that the relationships between bamboo and the overall community were stronger in the smallest diameter class and become non-significant for larger trees. It could be inferred once the light competition between bamboo and resident individuals probably would be high, reducing the density of tree within these diameter classes (Tabarelli & Montavani 2000; Guilherme *et al.* 2004). Furthermore, we must highlight that the small trees in the first diameter class include not only the understory species, but also the young canopy trees. These results suggest that the relationships between bamboo and forests can lead to stronger and significant changes at longer timescales, even for the canopy composition, and that the impacts of bamboo are lasting and may become stronger over time.

CONCLUDING REMARKS

Our study can be summarized in three main results. First, dominance of the native bamboo species *Merostachys sp.* does not have significant relationships with species richness and diversity. However, higher bamboo dominance decreases the density of trees within plots, and increases functional and taxonomic diversity, considering that the *niche-filling hypothesis* plays an important role in invaded communities at local scale. Second, bamboo dominance only has significant relationship between wood density (CWM_{WD}) and specific leaf area (CWM_{SLA}), showing that the CWM trait values shift from conservative to acquisitive traits in plots with more bamboo basal area. Third, the relationships between bamboo population and the native trees community is size-dependent, being much stronger for the small trees than for medium and larger trees, due to competition abilities. Even though we have found strong evidence of the effects of the bamboo overdominance, we cannot affirm that those changes within community were the cause or consequence of invasion. In overall, this study was import to highlight the native bamboo interactions with forest parameter, also bringing new contributions for local invasion studies.

REFERENCES

- Barton K. MuMIn: Multi-Model inference. R package ver. 1.15.6. 2016.
- Bates D, Maechler M, Bolker B, Walker S. lme4: Linear mixed-effects models using Eigen and S4. R package version, 1(7), 1-23. 2014.
- Bennett JA, Riibak K, Kook E, Reier Ü, Tamme R, Guillermo Bueno C, Pärtel M. Species pools, community completeness and invasion: disentangling diversity effects on the establishment of native and alien species. *Ecology letters*. 2016. 19(12), 1496-1505. doi: 10.1111/ele.12702
- Bivand R, Bernat A, Carvalho M, Chun Y, Dormann C, Dray S, et al. The spdep package. *Comprehensive R Archive Network, Version*, 05-83. 2005.
- Blonder B. Do hypervolumes have holes? *The American Naturalist*. 2016; 187, e93–e105. <https://doi.org/10.1086/685444>
- Borchert R. Soil and stem water storage determine phenology and distribution of tropical dry forest trees. *Ecology*. 1994; 75: 1437–1449. doi: 10.2307/1937467.
- Borges MP, de Assis Prado CHB. Relationships between leaf deciduousness and flowering traits of woody species in the Brazilian neotropical savanna. *Flora-Morphology, Distribution, Functional Ecology of Plants*. 2014; 209(1), 73-80. doi: 10.1016/j.flora.2013.10.004.
- Bystriakova N, Kapos V, Lysenko I. Bamboo biodiversity. UNEP/Earthprint, United Kingdom. 2004.
- Cahill JF, Kembel SW, Lamb EG, Keddy P. Does phylogenetic relatedness influence the strength of competition among vascular plants? *Perspect. Plant Ecol. Evol. Syst.* 2008; 10, 41–50. doi: 10.1016/j.ppees.2007.10.001.
- Cavender-Bares J, Kozak KH, Fine PVA, Kembel SW. The merging of community ecology and phylogenetic biology. *Ecol. Lett.* 2009; 12, 1–23. doi: 10.1111/j.1461-0248.2009.01314.x.
- Cestari C, Bernardi CJ. Predation of the Buffy-fronted Seedeater *Sporophila frontalis* (Aves: Emberizidae) on *Merostachys neesii* (Poaceae: Babusoideae) seeds during a masting event in the Atlantic forest. *Biota Neotropica*. 2011; 11(3), 407-411. doi: 10.1590/S1676-06032011000300033
- Chave J, Coomes D, Jansen S, Lewis SL, Swenson, NG, Zanne AE. Towards a worldwide wood economics spectrum. *Ecology letters*. 2009; 12(4), 351–366. doi: 10.1111/j.1461-0248.2009.01285.x.
- Clark DB, Clark DA. The impact of physical damage on canopy tree regeneration in Tropical Rain Forest. *J. Ecol.* 1991; 79, 447–457. doi: 10.2307/2260725
- Clarke KR, Warwick RM. A further biodiversity index applicable to species lists: variation in taxonomic distinctness. *Marine ecology Progress series*. 2001; 216, 265-278. doi: 10.3354/meps216265,

- Clarke KR, Warwick RM. A taxonomic distinctness index and its statistical properties. *Journal of applied ecology*. 1998; 35(4), 523-531. doi: 10.1046/j.1365-2664.1998.3540523.x.
- Diaz S, Cabido M. Vive la difference: plant functional diversity matters to ecosystem processes. *Trends in ecology & evolution*. 2001; 6(11), 646-655. doi: 10.1016/S0169-5347(01)02283-2
- d'Oliveira MV, Guarino EDS, Oliveira LC, Ribas LA, Acuña MH. Can forest management be sustainable in a bamboo dominated forest? A 12-year study of forest dynamics in western Amazon. *Forest Ecology and management*. 2013; 310, 672-679. doi: 10.1016/j.foreco.2013.09.008.
- Filgueiras TS, Gonçalves AS. A checklist of the basal grasses and bamboos in Brazil (Poaceae). *the journal of the American Bamboo Society*. 2004; 18(1), 7-18.
- Filgueiras TS. Bambus nativos do distrito Federal, Brasil (Gramineae: Bambusoideae).(Bamboos native to Brazil's distrito Federal-Gramineae: Bambusoideae). *Rev. Brasil. Bot.* 1988; 11(1-2), 47-66.
- Fukushima K, Usui N, Ogawa R, Tokuchi N. Impacts of moso bamboo (*Phyllostachys pubescens*) invasion on dry matter and carbon and nitrogen stocks in a broad-leaved secondary forest located in Kyoto, western Japan. *Plant Species Biology*. 2015; 30(2), 81-95. doi: 10.1111/1442-1984.12066.
- Gaertner M, Den Breeyen A, Hui C, Richardson DM. Impacts of alien plant invasions on species richness in Mediterranean-type ecosystems: a meta-analysis. *Progress in Physical Geography*. 2009; 33(3), 319-338. doi: doi.org/10.1177/0309133309341607.
- Gallardo B, Gascón S, Quintana X, Comín FA. How to choose a biodiversity indicator—Redundancy and complementarity of biodiversity metrics in a freshwater ecosystem. *Ecological indicators*. 2011; 11(5), 1177-1184. doi: 10.1016/j.ecolind.2010.12.019.
- Garrott R A, Eberhardt LL, Burn DM. Mortality of sea otters in Prince William Sound following the Exxon Valdez oil spill. *Marine Mammal Science*. 1993; 9(4), 343-359. doi: 10.1111/j.1748-7692.1993.tb00468.x
- Gerhold P, Pärtel M, Tackenberg O, Hennekens SM, Bartish I, Schaminée JH, Fergus AJ, Ozinga WA, Prinzing A. Phylogenetically poor plant communities receive more alien species, which more easily coexist with natives. *The American Naturalist*. 2011; Apr 7;177(5):668-80. doi: 10.1086/659059
- Godoy O, Kraft NJB, Levine JM. Phylogenetic relatedness and the determinants of competitive outcomes. *Ecology Letters*. 2014; 17:836–844. doi: 10.1111/ele.12289.
- Götzenberger L, de Bello F, Bråthen KA, Davison J, Dubuis A, Guisan A, Lepš J, Lindborg R, Moora M, Pärtel M, Pellissier L. Ecological assembly rules in plant communities—approaches, patterns and prospects. *Biological reviews*. 2012; Feb;87(1):111-27. doi: 10.1111/j.1469-185X.2011.00187.x

- Griscom B, Daly D, Ashton M. Floristics of Bamboo-Dominated Stands in Lowland Terra-Firma Forests of Southwestern Amazonia. *The Journal of the Torrey Botanical Society*. 2007; 134(1), 108-125. Retrieved from <http://www.jstor.org/stable/20063899>.
- Griscom BW, Ashton PMS. A self-perpetuating bamboo disturbance cycle in a neotropical forest. *Journal of Tropical Ecology*. 2006; 22(5), 587-597. doi: 10.1017/S0266467406003361.
- Gurvich DE, Tecco PA, Díaz S. Plant invasions in undisturbed ecosystems: the triggering attribute approach. *Journal of Vegetation Science*. 2005; Dec;16(6):723-8. doi: 10.1111/j.1654-1103.2005.tb02415.x
- Guilherme FA, Oliveira-Filho AT, Appolinário V, Bearzoti E. Effects of flooding regime and woody bamboos on tree community dynamics in a section of tropical semideciduous forest in South-Eastern Brazil. *Plant Ecology*. 2004; 174(1), 19. doi: 10.1023/B:VEGE.0000046051.97752.cd
- Gwali S, Okullo P, Hafashimana D, Byabashaija DM. Taxonomic diversity, distinctness, and abundance of tree and shrub species in Kasagala forest reserve in Uganda: implications for management and conservation policy decisions. *Tropical Conservation Science*. 2010; 3(3), 319-333. doi: 10.1177/194008291000300306.
- Hejda M, de Bello F. Impact of plant invasions on functional diversity in the vegetation of Central Europe. *Journal of Vegetation Science*. 2013; 24(5), 890-897. doi: 10.1111/jvs.12026
- Hejda M, Hanzelka J, Kadlec T, Štrobl M, Pyšek P, Reif J. Impacts of an invasive tree across trophic levels: Species richness, community composition and resident species' traits. *Diversity and Distributions*. 2017; 23(9), 997-1007. doi: 10.1111/ddi.12596.
- Hejda M, Pyšek P, Jarošík V. Impact of invasive plants on the species richness, diversity and composition of invaded communities. *Journal of ecology*. 2009; 97(3), 393-403. doi: 10.1111/j.1365-2745.2009.01480.x.
- Hejda M. Do species of invaded communities differ in their vulnerability to being eliminated by the dominant alien plants?. *Biological invasions*. . 2013; 15(9), 1989-1999. doi: 10.1007/s10530-013-0426-y.
- Héroult B, Bachelot B, Poorter L, Rossi V, Bongers F, Chave J, Baraloto C. Functional traits shape ontogenetic growth trajectories of rain forest tree species. *Journal of ecology*. 2011; 99(6), 1431-1440. doi: 10.1111/j.1365-2745.2011.01883.x.
- Jaksic FM., Lima M. Myths and facts on ratadas: bamboo blooms, rainfall peaks and rodent outbreaks in South America. *Austral Ecology*. 2003; 28(3), 237-251. doi: 10.1046/j.1442-9993.2003.01271.x
- Judziewicz EJ, Clark LG, Londoño X, Stern MJ. *American bamboos*. Smithsonian Institution Press. 1999.

- Kaminski S, Lawrence A, Trujillo D, Feltham I, Felipe López L. Structural use of bamboo. Part 3: Design values. *The Structural Engineer: journal of the Institution of Structural Engineer*. 2016; 94(12):42-5.
- Kembel SW, Hubbell SP. The phylogenetic structure of a neotropical forest tree community. *Ecology*. 2006; 87(sp7), S86-S99.
- Kissling WD, Carl G. Spatial autocorrelation and the selection of simultaneous autoregressive models. *Global Ecology and Biogeography*. 2008; 17(1), 59-71. doi: 10.1111/j.1466-8238.2007.00334.x.
- Kraft NJ, Godoy O, Levine JM. Plant functional traits and the multidimensional nature of species coexistence. *Proceedings of the National Academy of Sciences*. 2015; 112(3), 797-802. doi: 10.1073/pnas.1413650112
- Kunstler G, Lavergne S, Courbaud B, Thuiller W, Vieilledent G, Zimmermann NE, et al. Competitive interactions between forest trees are driven by species' trait hierarchy, not phylogenetic or functional similarity: implications for forest community assembly. *Ecology letters*. 2012; 15(8), 831-840. doi: 10.1111/j.1461-0248.2012.01803.x
- Kuznetsova A, Brockhoff PB, Christensen RHB. lmerTest package: tests in linear mixed effects models. *Journal of Statistical Software*, 82(13). 2017.
- Laliberté E, Legendre P, Shipley B, Laliberté ME. Package 'FD'. Version, 1, 12. 2014.
- Laliberté E, Legendre P. A distance-based framework for measuring functional diversity from multiple traits. *Ecology*. 2010; 91(1), 299-305. doi: 10.1890/08-2244.1.
- Leira M, Chen G, Dalton C, Irvine K, Taylor D. Patterns in freshwater diatom taxonomic distinctness along an eutrophication gradient. *Freshwater Biology*. 2009; 54(1), 1-14. doi: 10.1111/j.1365-2427.2008.02086.x.
- Levine JM, Adler PB, Yelenik SG. A meta-analysis of biotic resistance to exotic plant invasions. *Ecology letters*. 2004; Oct;7(10):975-89. doi: 10.1111/j.1461-0248.2004.00657.x
- Lima RA, Rother DC, Muler AE, Lepesch IF, Rodrigues RR. Bamboo overabundance alters forest structure and dynamics in the Atlantic Forest hotspot. *Biological Conservation*. 2012; 147(1), 32-39. doi: 10.1016/j.biocon.2012.01.015
- Lodge AG, Whitfeld TJ, Roth AM, Reich PB. Invasive plants in Minnesota are "joining the locals": A trait-based analysis. *Journal of Vegetation Science*. 2018; 29(4), 746-755. doi: 10.1111/jvs.12659.
- Loiola PP, de Bello F, Chytrý M, Götzenberger L, Carmona CP, Pyšek P, Lososová Z. Invaders among locals: Alien species decrease phylogenetic and functional diversity while increasing dissimilarity among native community members. *Journal of Ecology*. 2018; 106(6), 2230-2241. doi: 10.1111/1365-2745.12986

- Magurran AE. Diversity indices and species abundance models. In: *Ecological Diversity and Its Measurement*. Springer, Dordrecht. 1988. doi: 10.1007/978-94-015-7358-0_2.
- Mayfield MM, Levine JM. Opposing effects of competitive exclusion on the phylogenetic structure of communities. *Ecology letters*. 2010; 13(9), 1085-1093. doi: 10.1111/j.1461-0248.2010.01509.x.
- McGill BJ, Enquist BJ, Weiher E, Westoby M. Rebuilding community ecology from functional traits. *Trends in ecology & evolution*. 2006; 21(4), 178-185. doi: 10.1016/j.tree.2006.02.002
- Montti L, Villagra M, Campanello PI, Gatti MG, Goldstein G. Functional traits enhance invasiveness of bamboos over co-occurring tree saplings in the semideciduous Atlantic Forest. *Acta oecologica*. 2014; 54, 36-44. doi: 10.1016/j.actao.2013.03.004.
- Muller-Landau HC. The tolerance–fecundity trade-off and the maintenance of diversity in seed size. *Proceedings of the National Academy of Sciences*. 2010; 200911637. doi: 10.1073/pnas.0911637107.
- Oksanen J, Blanchet FG, Kindt R, Legendre P, O’hara RB, Simpson GL, et al. *vegan: Community Ecology Package*. R package version 1.17-2. 2010. <http://cran.r-project.org>. Acesso em, 23, 2010.
- Oliveira-Filho AD, Vilela EA, Gavilanes ML, Carvalho DA. Effect of flooding regime and understorey bamboos on the physiognomy and tree species composition of a tropical semideciduous forest in Southeastern Brazil. *Vegetatio*. 1994; 113(2), 99-124. doi: 10.1007/BF00044229.
- Oliveira-Filho AT. *NeoTropTree, Flora arbórea da Região Neotropical: Um banco de dados envolvendo biogeografia, diversidade e conservação*. Universidade Federal de Minas Gerais. 2017. (<http://www.neotropree.info>).
- Paciullo DSC, Campos NR, Gomide CAM, de Castro CRT, Tavela RC, Rossiello ROP. Crescimento de capim-braquiária influenciado pelo grau de sombreamento e pela estação do ano. *Pesquisa Agropecuária Brasileira*. 2008; 43(7), 917-923.
- Pebesma EJ. Multivariable geostatistics in S: the gstat package. *Computers & Geosciences*. 2004; 30(7), 683-691. doi: 10.1016/j.cageo.2004.03.012.
- Peñer-Harguindeguy N, Díaz S, Garnier E, Lavorel S, Poorter H, Jaureguiberry P. New handbook for standardised measurement of plant functional traits worldwide. *Aust. J. Bot.* 2013; 61, 167-234. doi: <http://dx.doi.org/10.1071/BT12225>
- Pinheiro J, Bates D, DebRoy S, Sarkar D. R Core Team (2014) *nlme: linear and nonlinear mixed effects models*. R package version 3.1-117. 2014. Available at <http://CRAN.R-project.org/package=nlme>.
- Pivello VR, Vieira MV, Grombone-Guaratini MT, Matos DMS. Thinking about super-dominant populations of native species—Examples from Brazil.

- Perspectives in ecology and conservation. 2018. doi: 10.1016/j.pecon.2018.04.001
- Poorter L, Markesteijn L. Seedling traits determine drought tolerance of tropical tree species. *Biotropica*. 2008; 40(3), 321-331. doi: 10.1111/j.1744-7429.2007.00380.x.
- Pyles MV, Prado-Junior JA, Magnago LF, de Paula A, Meira-Neto JA. Loss of biodiversity and shifts in aboveground biomass drivers in tropical rainforests with different disturbance histories. *Biodiversity and Conservation*. 2018; 27(12), 3215-3231. doi: 10.1007/s10531-018-1598-7.
- Raymundo D, Prado-Junior J, de Oliveira-Neto NE, Santana LD, do Vale VS, Jacobson TB, Carvalho FA. Persistence of *Coffea arabica* and its relationship with the structure, species diversity and composition of a secondary forest in Brazil. *PloS one*. 2018; 13(3), e0194032. doi: 10.1371/journal.pone.0194032.
- Raymundo D, Prado-Junior J, Alvim Carvalho F, Santiago do Vale V, Oliveira PE, van der Sande MT. Shifting species and functional diversity due to abrupt changes in water availability in tropical dry forests. *Journal of Ecology*. 2019; 107(1), 253-264. doi: 10.1111/1365-2745.13031.
- Reich PB. The world-wide ‘fast–slow’ plant economics spectrum: a traits manifesto. *Journal of Ecology*. 2014; Mar 1;102(2):275-301. doi: 10.1111/1365-2745.12211.
- Richardson DM, Pysek P. Plant invasions: Merging the concepts of species invasiveness and community invasibility. *Progress in Physical Geography*. 2006; 30, 409–431. doi: 10.1191/0309133 306pp490pr.
- Rother DC. Chuva de sementes e estabelecimento de plântulas em ambientes com bambus na Mata Atlântica. M.Sc. Thesis, Universidade Estadual Paulista, Rio Claro, Brazil. 2006.
- Seidler TG, Plotkin JB. Seed dispersal and spatial pattern in tropical trees. *PLoS biology*. 2006; 4(11), e344. doi: 10.1371/journal.pbio.0040344.
- Simberloff D, Relva MA, Nuñez M. Introduced species and management of a *Nothofagus/Austrocedrus* forest. *Environmental Management*. 2003; 31, 263–275. doi: 10.1007/s00267-002-2794-4
- Tabarelli M, Mantovani W. Gap-phase regeneration in a tropical montane forest: the effects of gap structure and bamboo species. *Plant Ecology*. 2000; 148(2), 149-155. doi: 10.1023/A:1009823510688
- Tecco PA, Díaz S, Cabido M, Urcelay C. Functional traits of alien plants across contrasting climatic and land-use regimes: Do aliens join the locals or try harder than them? *Journal of Ecology*. 2010; 98, 17–27. [https://doi.org/10.1111/\(ISSN\)1365-2745](https://doi.org/10.1111/(ISSN)1365-2745)
- Thuiller W, Gallien L, Boulangeat I, de Bello F, Münkemüller T, Roquet C, Lavergne S. Resolving Darwin’s naturalization conundrum: A quest for evidence.

Diversity and Distributions. 2010; 16, 461–475. <https://doi.org/10.1111/j.1472-4642.2010.00645.x>

- Tilman D. The ecological consequences of changes in biodiversity: A search for general principles. *Ecology*. 1999; 80, 1455–1474. doi: 10.1890/0012-9658(1999)080[1455:TECOCI]2.0.CO;2
- Van der Sande MT, Arets EJ, Peña-Claros M, de Avila AL, Roopsind A, Mazzei L, et al. Old-growth Neotropical forests are shifting in species and trait composition. *Ecological Monographs*. 2016; 86(2), 228-243. doi: 10.1890/15-1815.1
- Van Etten J. R package gdistance: distances and routes on geographical grids. 2017.
- Villéger S, Mason NW, Mouillot D. New multidimensional functional diversity indices for a multifaceted framework in functional ecology. *Ecology*. 2008; 89(8), 2290-2301. doi: 10.1890/07-1206.1.
- Vitousek PM, Walker LR, Whiteaker LD, Mueller-Dombois D, Matson PA. Biological invasion by *Myrica faya* alters ecosystem development in Hawaii. *Science*. 1987; 238, 802–804. doi: 10.1126/science.238.4828.802.
- Warwick RM, Clarke KR. New biodiversity measures reveal a decrease in taxonomic distinctness with increasing stress. *Marine Ecology Progress Series*. 1995. 129, 301-305. doi: 10.3354/meps129301.
- Webb CO, Ackerly DD, McPeck MA, Donoghue MJ. Phylogenies and community ecology. *Ann. Rev. Ecol. Evol. Syst.* 2002; 33, 475–505. doi: 10.1146/annurev.ecolsys.33.010802.150448.
- Westoby M, Falster DS, Moles AT, Vesk PA, Wright IJ. Plant ecological strategies: some leading dimensions of variation between species. *Annual review of ecology and systematics*. 2002; 33(1), 125-159. doi: 10.1146/annurev.ecolsys.33.010802.150452.
- Wiens J, Sutter R, Anderson M, Blanchard J, Barnett A, Aguilar-Amuchastegui N, et al. Selecting and conserving lands for biodiversity: the role of remote sensing. *Remote Sensing of Environment*. 2009; 113(7), 1370-1381. doi: 10.1016/j.rse.2008.06.020
- Wright SJ, Kitajima K, Kraft NJ, Reich PB, Wright IJ, Bunker DE, et al. Functional traits and the growth–mortality trade-off in tropical trees. *Ecology*. 2010; 91(12), 3664-3674. doi: 10.1890/09-2335.1.

SUPPLEMENTARY MATERIAL

Table S1: Metrics of the 39 tree species included in the functional analysis.

Table S2: Overview of the 91 tree species used in the taxonomic analyses.

Table S3: Overview of the forest inventory parameters of 101 species.

Table S1: Metrics of the 39 tree species included in the functional analysis. Scientific name, wood density (WD, g.cm-3), specific leaf area (SLA), maximum diameter (Dmax), dispersion syndrome (DS; A= abiotic; B=biotic), seed size (SS; S=small; M=medium; L=large), and deciduousness (Dec; D=deciduous; E=evergreen) are given.

Species	WD	SLA	Dmax	DM	SS	Dec
<i>Abarema cochliacarpus</i> (Gomes) Barneby & J.W.Grimes	0.494	17.227	13.019	A	M	D
<i>Amaioua intermedia</i> Mart. ex Schult. & Schult.f.	0.536	16.959	19.487	B	S	E
<i>Aniba firmula</i> (Nees & Mart.) Mez	0.388	18.167	47.555	B	M	E
<i>Annona mucosa</i> Jacq.	0.387	13.956	22.059	B	M	D
<i>Aparisthium cordatum</i> (A.Juss.) Baill.	0.484	18.131	14.897	B	S	D
<i>Apuleia leiocarpa</i> (Vogel) J.F.Macbr.	0.610	12.402	37.059	A	S	D
<i>Bathysa australis</i> (A.St.-Hil.) K.Schum.	0.414	20.891	12.693	A	S	E
<i>Brosimum guianense</i> (Aubl.) Huber	0.504	15.949	20.690	B	M	E
<i>Byrsonima ligustrifolia</i> A.Juss.	0.467	15.724	39.630	B	M	D
<i>Casearia sylvestris</i> Sw.	0.505	20.990	19.130	B	S	E
<i>Ecclinusa ramiflora</i> Mart.	0.455	10.657	40.839	B	M	E
<i>Eugenia florida</i> DC.	0.648	14.026	15.557	B	M	E
<i>Helicostylis tomentosa</i> (Poepp. & Endl.) Rusby	0.378	12.934	18.605	B	S	E
<i>Himatanthus bracteatus</i> (A. DC.) Woodson	0.367	15.379	16.409	A	L	D
<i>Hortia brasiliana</i> Vand. ex DC.	0.483	13.809	19.767	B	M	E
<i>Hymenolobium janeirense</i> Kuhlmann	0.576	24.357	28.115	A	S	E
<i>Lacistema pubescens</i> Mart.	0.480	25.916	42.550	B	M	E
<i>Licania kunthiana</i> Hook.f.	0.689	17.058	29.603	B	M	E
<i>Mabea fistulifera</i> Mart.	0.360	19.227	32.595	B	M	D
<i>Matayba marginata</i> Radlk.	0.602	12.155	14.332	B	M	E
<i>Melanoxylon brauna</i> Schott	0.605	18.934	30.717	A	M	E
<i>Myrceugenia campestris</i> (DC.) D.Legrand & Kausel	0.603	16.011	13.584	B	M	E

<i>Myrcia anceps</i> (Spreng.) O.Berg	0.538	12.179	16.425	B	S	E
<i>Myrcia splendens</i> (Sw.) DC.	0.580	14.244	16.767	B	S	E
<i>Naucleopsis oblongifolia</i> (Kuhlm.) Carauta	0.504	13.235	24.955	B	L	E
<i>Nectandra oppositifolia</i> Nees	0.432	12.142	19.006	B	M	E
<i>Ocotea odorifera</i> (Vell.) Rohwer	0.563	12.739	24.949	B	M	E
<i>Ocotea sp.</i>	0.429	12.078	20.690	B	M	E
<i>Pourouma guianensis</i> Aubl.	0.320	12.173	19.568	B	M	E
<i>Pseudopiptadenia contorta</i> (DC.) G.P.Lewis & M.P.Lima	0.523	12.223	60.479	A	L	E
<i>Siparuna guianensis</i> Aubl.	0.444	19.001	22.138	B	S	D
<i>Sloanea guianensis</i> (Aubl.) Benth.	0.484	15.291	29.030	B	M	E
<i>Sorocea bonplandii</i> (Baill.) W.C.Burger et al.	0.491	13.170	11.580	B	M	E
<i>Tachigali rugosa</i> (Mart. ex Benth.) Zarucchi & Pipoly	0.599	10.550	36.049	A	M	E
<i>Tapirira guianensis</i> Aubl.	0.437	11.916	40.680	B	M	E
<i>Trichilia emarginata</i> (Turcz.) C.DC.	0.565	19.137	38.611	B	M	E
<i>Virola bicuhyba</i> (Schott ex Spreng.) Warb.	0.323	15.108	20.332	B	L	E
<i>Xylopia brasiliensis</i> Spreng.	0.528	19.821	35.587	B	S	E
<i>Xylopia sericea</i> A.St.-Hil.	0.421	11.784	18.904	B	S	E

Table S2: Overview of the 91 tree species used in the taxonomic analyses. Scientific name, genus, family, order, superorder, subclass and class are given.

Species	Genus	Family	Order	Superorder	Subclass	Class
<i>Abarema cochliacarpus</i> (Gomes) Barneby & J.W.Grimes	Abarema	Fabaceae	Fabales	Rosanae	Magnoliidae	Equisetopsida
<i>Amaioua intermedia</i> Mart. ex Schult. & Schult.f.	Amaioua	Rubiaceae	Gentianales	Asteranae	Magnoliidae	Equisetopsida
<i>Amaioua sp.</i>	Amaioua	Rubiaceae	Gentianales	Asteranae	Magnoliidae	Equisetopsida
<i>Aniba firmula</i> (Nees & Mart.) Mez	Aniba	Lauraceae	Lurales	Magnolianaes	Magnoliidae	Equisetopsida
<i>Annona mucosa</i> Jacq.	Annona	Annonaceae	Magnoliales	Magnolianaes	Magnoliidae	Equisetopsida
<i>Aparisthmium cordatum</i> (A.Juss.) Baill.	Aparisthmium	Euphorbiaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Apuleia leiocarpa</i> (Vogel) J.F.Macbr.	Apuleia	Fabaceae	Fabales	Rosanae	Magnoliidae	Equisetopsida
<i>Aspidosperma parvifolium</i> A.DC.	Aspidosperma	Apocynaceae	Gentianales	Asteranae	Magnoliidae	Equisetopsida
<i>Aspidosperma ramiflorum</i> Müll.Arg.	Aspidosperma	Apocynaceae	Gentianales	Asteranae	Magnoliidae	Equisetopsida
<i>Bathysa australis</i> (A.St.-Hil.) K.Schum.	Bathysa	Rubiaceae	Gentianales	Asteranae	Magnoliidae	Equisetopsida
<i>Bathysa mendoncae</i> K.Schum.	Bathysa	Rubiaceae	Gentianales	Asteranae	Magnoliidae	Equisetopsida
<i>Brosimum guianense</i> (Aubl.) Huber	Brosimum	Moraceae	Rosales	Rosanae	Magnoliidae	Equisetopsida
<i>Byrsonima ligustrifolia</i> A.Juss.	Byrsonima	Malpighiaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Campomanesia sp.</i>	Campomanesia	Myrtaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Caryocar edule</i> Casar.	Caryocar	Caryocaraceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida

<i>Casearia decandra</i> Jacq.	Casearia	Salicaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Casearia sylvestris</i> Sw.	Casearia	Salicaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Copaifera langsdorffii</i> Desf.	Copaifera	Fabaceae	Fabales	Rosanae	Magnoliidae	Equisetopsida
<i>Cordia superba</i> Cham.	Cordia	Boraginaceae	Boraginales	Asteranae	Magnoliidae	Equisetopsida
<i>Dalbergia nigra</i> (Vell.) Allemão ex Benth.	Dalbergia	Fabaceae	Fabales	Rosanae	Magnoliidae	Equisetopsida
<i>Ecclinusa ramiflora</i> Mart.	Ecclinusa	Sapotaceae	Ericales	Asteranae	Magnoliidae	Equisetopsida
<i>Endlicheria</i> sp.	Endlicheria	Lauraceae	Lurales	Magnolianae	Magnoliidae	Equisetopsida
<i>Erythroxylum</i> sp.	Erythroxylum	Erythroxylaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Eugenia florida</i> DC.	Eugenia	Myrtaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Eugenia moraviana</i> O.Berg	Eugenia	Myrtaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Eugenia</i> sp1.	Eugenia	Myrtaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Eugenia</i> sp2.	Eugenia	Myrtaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Eugenia</i> sp3.	Eugenia	Myrtaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Garcinia gardneriana</i> (Planch. & Triana) Zappi	Garcinia	Clusiaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Guatteria sellowiana</i> Schldl.	Guatteria	Annonaceae	Magnoliales	Magnolianae	Magnoliidae	Equisetopsida
<i>Handroanthus heptaphyllus</i> (Vell.) Mattos	Handroanthus	Bignoniaceae	Lamiales	Asteranae	Magnoliidae	Equisetopsida
<i>Helicostylis tomentosa</i> (Poepp. & Endl.) Rusby	Helicostylis	Moraceae	Rosales	Rosanae	Magnoliidae	Equisetopsida
<i>Himatanthus bracteatus</i> (A. DC.) Woodson	Himatanthus	Apocynaceae	Gentianales	Asteranae	Magnoliidae	Equisetopsida
<i>Hirtella hebeclada</i> Moric. ex DC.	Hirtella	Chrysobalanaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida

<i>Hirtella sp.</i>	Hirtella	Chrysobalanaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Hortia brasiliana</i> Vand. ex DC.	Hortia	Rutaceae	Sapindales	Rosanae	Magnoliidae	Equisetopsida
<i>Hymenolobium janeirense</i> Kuhlm.	Hymenolobium	Fabaceae	Fabales	Rosanae	Magnoliidae	Equisetopsida
<i>Inga cylindrica</i> (Vell.) Mart.	Inga	Fabaceae	Fabales	Rosanae	Magnoliidae	Equisetopsida
<i>Inga sp1.</i>	Inga	Fabaceae	Fabales	Rosanae	Magnoliidae	Equisetopsida
<i>Inga sp2.</i>	Inga	Fabaceae	Fabales	Rosanae	Magnoliidae	Equisetopsida
<i>Jacaranda micrantha</i> Cham.	Jacaranda	Bignoniaceae	Lamiales	Asteranae	Magnoliidae	Equisetopsida
<i>Lacistema pubescens</i> Mart.	Lacistema	Lacistemataceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
Lauraceae sp.	Lauraceae	Lauraceae	Lurales	Magnolianae	Magnoliidae	Equisetopsida
<i>Licania kunthiana</i> Hook.f.	Licania	Chrysobalanaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Licania nitida</i> Hook.f.	Licania	Chrysobalanaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Mabea fistulifera</i> Mart.	Mabea	Euphorbiaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Maprounea guianensis</i> Aubl.	Maprounea	Euphorbiaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Matayba marginata</i> Radlk.	Matayba	Sapindaceae	Sapindales	Rosanae	Magnoliidae	Equisetopsida
<i>Matayba sp.</i>	Matayba	Sapindaceae	Sapindales	Rosanae	Magnoliidae	Equisetopsida
<i>Maytenus gonoclada</i> Mart.	Maytenus	Celastraceae	Celastrales	Rosanae	Magnoliidae	Equisetopsida
<i>Melanoxylon brauna</i> Schott	Melanoxylon	Fabaceae	Fabales	Rosanae	Magnoliidae	Equisetopsida
<i>Miconia cinnamomifolia</i> (DC.) Naudin	Miconia	Melastomataceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Miconia sp.</i>	Miconia	Melastomataceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida

<i>Myrceugenia campestris</i> (DC.) D.Legrand & Kausel	Myrceugenia	Myrtaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Myrcia anceps</i> (Spreng.) O.Berg	Myrcia	Myrtaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Myrcia splendens</i> (Sw.) DC.	Myrcia	Myrtaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
Myrtaceae sp1.	Myrtaceae	Myrtaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
Myrtaceae sp2.	Myrtaceae	Myrtaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Naucleopsis oblongifolia</i> (Kuhlm.) Carauta	Naucleopsis	Moraceae	Rosales	Rosanae	Magnoliidae	Equisetopsida
<i>Nectandra oppositifolia</i> Nees	Nectandra	Lauraceae	Lurales	Magnoliana	Magnoliidae	Equisetopsida
<i>Ocotea odorifera</i> (Vell.) Rohwer	Ocotea	Lauraceae	Lurales	Magnoliana	Magnoliidae	Equisetopsida
<i>Ocotea sp1.</i>	Ocotea	Lauraceae	Lurales	Magnoliana	Magnoliidae	Equisetopsida
<i>Parinari brasiliensis</i> (Schott) Hook.f.	Parinari	Chrysobalanaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Pera glabrata</i> (Schott) Baill.	Pera	Euphorbiaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Pourouma guianensis</i> Aubl.	Pourouma	Urticaceae	Rosales	Rosanae	Magnoliidae	Equisetopsida
<i>Pouteria caimito</i> (Ruiz & Pav.) Radlk.	Pouteria	Sapotaceae	Ericales	Asteranae	Magnoliidae	Equisetopsida
<i>Pouteria sp.</i>	Pouteria	Sapotaceae	Ericales	Asteranae	Magnoliidae	Equisetopsida
<i>Pouteria torta</i> (Mart.) Radlk.	Pouteria	Sapotaceae	Ericales	Asteranae	Magnoliidae	Equisetopsida
<i>Protium sp.</i>	Protium	Burseraceae	Sapindales	Rosanae	Magnoliidae	Equisetopsida
<i>Pseudopiptadenia contorta</i> (DC.) G.P.Lewis & M.P.Lima	Pseudopiptadenia	Fabaceae	Fabales	Rosanae	Magnoliidae	Equisetopsida
<i>Quiina glaziovii</i> Engl.	Quina	Quiinaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
Rubiaceae sp.	Rubiaceae	Rubiaceae	Gentianales	Asteranae	Magnoliidae	Equisetopsida

Sapotaceae sp.	Sapotaceae	Sapotaceae	Ericales	Asteranae	Magnoliidae	Equisetopsida
<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	Schefflera	Araliaceae	Apiales	Asteranae	Magnoliidae	Equisetopsida
<i>Siparuna guianensis</i> Aubl.	Siparuna	Siparunaceae	Laurales	Magnolianaes	Magnoliidae	Equisetopsida
<i>Sloanea guianensis</i> (Aubl.) Benth.	Sloanea	Elaeocarpaceae	Oxalidales	Rosanae	Magnoliidae	Equisetopsida
<i>Sloanea sp1.</i>	Sloanea	Elaeocarpaceae	Oxalidales	Rosanae	Magnoliidae	Equisetopsida
<i>Sorocea bonplandii</i> (Baill.) W.C.Burger et al.	Sorocea	Moraceae	Rosales	Rosanae	Magnoliidae	Equisetopsida
<i>Tachigali rugosa</i> (Mart. ex Benth.) Zarucchi & Pipoly	Tachigali	Fabaceae	Fabales	Rosanae	Magnoliidae	Equisetopsida
<i>Tapirira guianensis</i> Aubl.	Tapirira	Anacardiaceae	Sapindales	Rosanae	Magnoliidae	Equisetopsida
<i>Terminalia fagifolia</i> Mart.	Terminalia	Combretaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Tovomita sp.</i>	Tovomita	Clusiaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Triatinichia sp.</i>	Trattinnickia	Burseraceae	Sapindales	Rosanae	Magnoliidae	Equisetopsida
<i>Trichilia emarginata</i> (Turcz.) C.DC.	Trichilia	Meliaceae	Sapindales	Rosanae	Magnoliidae	Equisetopsida
<i>Virola bicuhyba</i> (Schott ex Spreng.) Warb.	Virola	Myristicaceae	Magnoliales	Magnolianaes	Magnoliidae	Equisetopsida
<i>Virola sp.</i>	Virola	Myristicaceae	Magnoliales	Magnolianaes	Magnoliidae	Equisetopsida
<i>Vismia guianensis</i> (Aubl.) Choisy	Vismia	Hypericaceae	Malpighiales	Rosanae	Magnoliidae	Equisetopsida
<i>Vochysia laurifolia</i> Warm.	Vochysia	Vochysiaceae	Myrtales	Rosanae	Magnoliidae	Equisetopsida
<i>Xylopia brasiliensis</i> Spreng.	Xylopia	Annonaceae	Magnoliales	Magnolianaes	Magnoliidae	Equisetopsida
<i>Xylopia sericea</i> A.St.-Hil.	Xylopia	Annonaceae	Magnoliales	Magnolianaes	Magnoliidae	Equisetopsida

Table S3: Forest inventory parameters of the 101 sampled species. Scientific name, absolute density (AD, 0,6 ha), basal area (BA, m².ha⁻¹), absolute frequency (AF), relative density (%), relative dominance (%), and relative frequency (%) are given

Species	AD	BA	AF	RD	RDo	RF
<i>Abarema cochliacarpus</i> (Gomes) Barneby & J.W.Grimes	9	651.96	9	1.181	0.396	1.557
<i>Amaioua intermedia</i> Mart. ex Schult. & Schult.f.	9	1296.81	6	1.181	0.788	1.038
<i>Amaioua sp.</i>	1	45.84	1	0.131	0.028	0.173
<i>Aniba firmula</i> (Nees & Mart.) Mez	15	7088.54	10	1.969	4.309	1.730
<i>Aniba sp2.</i>	5	824.26	5	0.656	0.501	0.865
<i>Annona mucosa</i> Jacq.	33	4198.31	26	4.331	2.552	4.498
<i>Aparisthium cordatum</i> (A.Juss.) Baill.	5	467.40	4	0.656	0.284	0.692
<i>Apuleia leiocarpa</i> (Vogel) J.F.Macbr.	22	6811.20	18	2.887	4.140	3.114
<i>Aspidosperma parvifolium</i> A.DC.	1	38.52	1	0.131	0.023	0.173
<i>Aspidosperma ramiflorum</i> Müll.Arg.	4	1413.26	4	0.525	0.859	0.692
<i>Bathysa australis</i> (A.St.-Hil.) K.Schum.	6	323.20	6	0.787	0.196	1.038
<i>Bathysa mendoncae</i> K.Schum.	1	91.99	1	0.131	0.056	0.173
<i>Brosimum guianense</i> (Aubl.) Huber	41	4592.57	25	5.381	2.792	4.325
<i>Byrsonima ligustrifolia</i> A.Juss.	6	5376.11	6	0.787	3.268	1.038

<i>Campomanesia sp.</i>	3	107.89	3	0.394	0.066	0.519
<i>Caryocar edule</i> Casar.	1	84.05	1	0.131	0.051	0.173
<i>Casearia decandra</i> Jacq.	3	650.98	3	0.394	0.396	0.519
<i>Casearia sylvestris</i> Sw.	15	1563.60	12	1.969	0.950	2.076
<i>Copaifera langsdorffii</i> Desf.	4	195.72	4	0.525	0.119	0.692
<i>Cordia superba</i> Cham.	1	69.25	1	0.131	0.042	0.173
<i>Dalbergia nigra</i> (Vell.) Allemão ex Benth.	2	99.63	2	0.262	0.061	0.346
Dead trees	78	13011.89	41	10.236	7.909	7.093
<i>Ecclinusa ramiflora</i> Mart.	5	2172.58	4	0.656	1.321	0.692
<i>Endlicheria sp.</i>	1	23.00	1	0.131	0.014	0.173
<i>Erythroxylum sp.</i>	2	48.74	2	0.262	0.030	0.346
<i>Eugenia florida</i> DC.	6	520.24	6	0.787	0.316	1.038
<i>Eugenia moraviana</i> O.Berg	3	205.01	3	0.394	0.125	0.519
<i>Eugenia sp1.</i>	3	564.30	3	0.394	0.343	0.519
<i>Eugenia sp2.</i>	2	95.99	2	0.262	0.058	0.346
<i>Eugenia sp3.</i>	1	35.09	1	0.131	0.021	0.173
<i>Garcinia gardneriana</i> (Planch. & Triana) Zappi	2	139.20	2	0.262	0.085	0.346

<i>Guatteria sellowiana</i> Schltld.	1	31.83	1	0.131	0.019	0.173
<i>Handroanthus heptaphyllus</i> (Vell.) Mattos	1	91.99	1	0.131	0.056	0.173
<i>Helicostylis tomentosa</i> (Poepp. & Endl.) Rusby	7	961.61	6	0.919	0.585	1.038
<i>Himatanthus bracteatus</i> (A. DC.) Woodson	7	859.74	7	0.919	0.523	1.211
<i>Hirtella hebeclada</i> Moric. ex DC.	1	40.29	1	0.131	0.024	0.173
<i>Hirtella</i> sp.	1	320.88	1	0.131	0.195	0.173
<i>Hortia brasiliiana</i> Vand. ex DC.	7	1113.13	7	0.919	0.677	1.211
<i>Hymenolobium janeirense</i> Kuhlmann	8	1449.28	8	1.050	0.881	1.384
Indet sp1	3	2791.90	3	0.394	1.697	0.519
Indet sp2	7	487.23	6	0.919	0.296	1.038
Indet sp3	1	95.27	1	0.131	0.058	0.173
Indet sp4	1	703.15	1	0.131	0.427	0.173
Indet sp5	1	447.62	1	0.131	0.272	0.173
Indet sp6	1	154.06	1	0.131	0.094	0.173
Indet sp7	1	435.77	1	0.131	0.265	0.173
Indet sp8	1	362.57	1	0.131	0.220	0.173
Indet sp9	1	91.99	1	0.131	0.056	0.173

<i>Inga cylindrica</i> (Vell.) Mart.	1	78.80	1	0.131	0.048	0.173
<i>Inga sp1.</i>	3	125.27	3	0.394	0.076	0.519
<i>Inga sp2.</i>	2	284.33	2	0.262	0.173	0.346
<i>Jacaranda micrantha</i> Cham.	7	1298.51	7	0.919	0.789	1.211
<i>Lacistema pubescens</i> Mart.	13	4525.39	11	1.706	2.751	1.903
Lauraceae sp.	1	25.78	1	0.131	0.016	0.173
<i>Licania kunthiana</i> Hook.f.	6	1337.64	6	0.787	0.813	1.038
<i>Licania nitida</i> Hook.f.	1	91.99	1	0.131	0.056	0.173
<i>Mabea fistulifera</i> Mart.	69	28199.74	41	9.055	17.141	7.093
<i>Maprounea guianensis</i> Aubl.	2	711.21	2	0.262	0.432	0.346
<i>Matayba marginata</i> Radlk.	10	773.73	9	1.312	0.470	1.557
<i>Matayba sp.</i>	1	147.14	1	0.131	0.089	0.173
<i>Maytenus gonoclada</i> Mart.	1	223.53	1	0.131	0.136	0.173
<i>Melanoxylon brauna</i> Schott	5	1457.18	5	0.656	0.886	0.865
<i>Miconia cinnamomifolia</i> (DC.) Naudin	1	522.11	1	0.131	0.317	0.173
<i>Miconia sp.</i>	1	51.75	1	0.131	0.031	0.173
<i>Myrceugenia campestris</i> (DC.) D.Legrand & Kausel	12	826.89	10	1.575	0.503	1.730

<i>Myrcia anceps</i> (Spreng.) O.Berg	19	1502.14	12	2.493	0.913	2.076
<i>Myrcia splendens</i> (Sw.) DC.	32	2778.47	21	4.199	1.689	3.633
Myrtaceae sp1.	1	389.93	1	0.131	0.237	0.173
Myrtaceae sp2.	2	150.32	2	0.262	0.091	0.346
<i>Naucleopsis oblongifolia</i> (Kuhlm.) Carauta	17	1949.69	14	2.231	1.185	2.422
<i>Nectandra oppositifolia</i> Nees	4	671.53	4	0.525	0.408	0.692
<i>Ocotea odorifera</i> (Vell.) Rohwer	13	2006.19	10	1.706	1.219	1.730
<i>Ocotea</i> sp.	3	175.50	3	0.394	0.107	0.519
<i>Parinari brasiliensis</i> (Schott) Hook.f.	2	377.69	2	0.262	0.230	0.346
<i>Pera glabrata</i> (Schott) Baill.	1	168.39	1	0.131	0.102	0.173
<i>Pourouma guianensis</i> Aubl.	10	1379.04	9	1.312	0.838	1.557
<i>Pouteria caimito</i> (Ruiz & Pav.) Radlk.	1	315.84	1	0.131	0.192	0.173
<i>Pouteria</i> sp.	5	2327.26	5	0.656	1.415	0.865
<i>Pouteria torta</i> (Mart.) Radlk.	2	155.91	2	0.262	0.095	0.346
<i>Protium</i> sp.	1	81.49	1	0.131	0.050	0.173
<i>Pseudopiptadenia contorta</i> (DC.) G.P.Lewis & M.P.Lima	16	15627.07	11	2.100	9.499	1.903
<i>Quiina glaziovii</i> Engl.	2	140.87	2	0.262	0.086	0.346

Rubiaceae sp.	1	25.78	1	0.131	0.016	0.173
Sapotaceae sp.	1	78.96	1	0.131	0.048	0.173
<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	1	42.10	1	0.131	0.026	0.173
<i>Siparuna guianensis</i> Aubl.	70	7260.69	40	9.186	4.413	6.920
<i>Sloanea guianensis</i> (Aubl.) Benth.	17	4133.25	12	2.231	2.512	2.076
<i>Sloanea sp1.</i>	1	45.84	1	0.131	0.028	0.173
<i>Sorocea bonplandii</i> (Baill.) W.C.Burger et al.	9	397.44	8	1.181	0.242	1.384
<i>Tachigali rugosa</i> (Mart. ex Benth.) Zarucchi & Pipoly	11	3620.46	7	1.444	2.201	1.211
<i>Tapirira guianensis</i> Aubl.	5	2932.15	5	0.656	1.782	0.865
<i>Terminalia fagifolia</i> Mart.	1	38.52	1	0.131	0.023	0.173
<i>Tovomita sp.</i>	1	459.64	1	0.131	0.279	0.173
<i>Triatinichia sp.</i>	2	415.73	1	0.262	0.253	0.173
<i>Trichilia emarginata</i> (Turcz.) C.DC.	4	1768.23	4	0.525	1.075	0.692
<i>Virola bicuhyba</i> (Schott ex Spreng.) Warb.	6	705.59	6	0.787	0.429	1.038
<i>Virola sp.</i>	1	179.55	1	0.131	0.109	0.173
<i>Vismia guianensis</i> (Aubl.) Choisy	1	161.14	1	0.131	0.098	0.173
<i>Vochysia laurifolia</i> Warm.	2	1002.14	2	0.262	0.609	0.346

<i>Xylopi</i>	13	5735.63	13	1.706	3.486	2.249
<i>Xylopi</i>	8	1391.48	7	1.050	0.846	1.211
